TECHNICAL REPORT

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Information technology — Multimedia content description interface —

Part 8: Extraction and use of MPEG-7 descriptions

Technologies de l'information — Interface de description du contenu multimédia —

Partie 8: Extraction et utilisation des descriptions MPEG-7

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

In exceptional circumstances, the joint technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when the joint technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/IEC TR 15938-8, which is a Technical Report of type 3, was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information*.

ISO/IEC 15938 consists of the following parts, under the general title *Information technology — Multimedia content description interface*:

— *Part 1: Systems*

— *Part 2: Description definition language*

— *Part 3: Visual*

— *Part 4: Audio*

— *Part 5: Multimedia description schemes*

— *Part 6: Reference software*

— *Part 7: Conformance testing*

— *Part 8: Extraction and use of MPEG-7 descriptions*

Introduction

This standard, also known as "Multimedia Content Description Interface," provides a standardized set of technologies for describing multimedia content. The standard addresses a broad spectrum of multimedia applications and requirements by providing a metadata system for describing the features of multimedia content.

The following are specified in this standard:

- **Description Schemes (DS)** describe entities or relationships pertaining to multimedia content. Description Schemes specify the structure and semantics of their components, which may be Description Schemes, Descriptors, or datatypes.
- **Descriptors (D)** describe features, attributes, or groups of attributes of multimedia content.
- **Datatypes** are the basic reusable datatypes employed by Description Schemes and Descriptors
- **Systems tools** support delivery of descriptions, multiplexing of descriptions with multimedia content, synchronization, file format, and so forth.

This standard is subdivided into eight parts:

Part 1 – Systems: specifies the tools for preparing descriptions for efficient transport and storage, compressing descriptions, and allowing synchronization between content and descriptions.

Part 2 – Description definition language: specifies the language for defining the standard set of description tools (DSs, Ds, and datatypes) and for defining new description tools.

Part 3 – Visual: specifies the description tools pertaining to visual content.

Part 4 – Audio: specifies the description tools pertaining to audio content.

Part 5 – Multimedia description schemes: specifies the generic description tools pertaining to multimedia including audio and visual content.

Part 6 – Reference software: provides a software implementation of the standard.

Part 7 – Conformance testing: specifies the guidelines and procedures for testing conformance of implementations of the standard.

Part 8 – Extraction and use of MPEG-7 descriptions: provides guidelines and examples of the extraction and use of descriptions.

Information technology — Multimedia content description interface —

Part 8: Extraction and use of MPEG-7 descriptions

1 Scope

This International Standard specifies a metadata system for describing multimedia content. This document gives examples of extraction and use of descriptions using Description Schemes, Descriptors, and datatypes specified in ISO/IEC 15938. The following set of subclauses are provided for each description tool, where optional subclauses are indicated as (optional):

- Informative examples (optional): provides informative examples that illustrate the instantiation of the description tool in creating descriptions.
- Extraction (optional): provides informative examples that illustrate the extraction of descriptions from multimedia content.
- Use (optional): provides informative examples that illustrate the use of descriptions.

This document is meant to be a companion technical report for Part 5 (Multimedia Description Schemes) and Part 3 (Visual) of ISO/IEC 15938. As such, the content of this technical report is not easily understood without the technical specifications. In this technical report, effort has been made to preserve the specific subclause numbering of ISO/IEC 15938-5 and ISO/IEC 15938-3 to allow easy correlation of the content on extraction and use in the technical report with the technical specifications.

2 Terms and definitions

2.1 Conventions

2.1.1 Description tools

This part of ISO/IEC 15938 specifies the multimedia description tools as follows:

- **Description Scheme (DS)** – a description tool that describes entities or relationships pertaining to multimedia content. DSs specify the structure and semantics of their components, which may be Description Schemes, Descriptors, or datatypes.
- **Descriptor (D)** – a description tool that describes a feature, attribute, or group of attributes of multimedia content.
- **Datatype** – a basic reusable datatype employed by Description Schemes and Descriptors.
- **Description Tool (or tool)** – refers to a Description Scheme, Descriptor, or Datatype.

2.1.2 Naming convention

In order to specify the multimedia description tools, this part of ISO/IEC 15938 uses constructs provided by the Description Definition Language (DDL) specified in ISO/IEC 15938-2, such as "element", "attribute", "simpleType" and "complexType". The names associated to these constructs are created on the basis of the following conventions:

- If the name is composed of multiple words, the first letter of each word is capitalized, with the exception that the capitalization of the first word depends on the type of construct as follows:
- Element naming: the first letter of the first word is capitalized (e.g. `TimePoint` element of `TimeType`).
- Attribute naming: the first letter of the first word is not capitalized (e.g. `timeUnit` attribute of `IncrDurationType`).
- complexType naming: the first letter of the first word is capitalized, and the suffix "Type" is used at the end of the name (e.g. `PersonType`).

- simpleType naming: the first letter of the first word is not capitalized, the suffix "Type" may be used at the end of the name (e.g. `timePointType`).

Note that when referencing a complexType or simpleType in the definition of a description tool, the "Type" suffix is not used. For instance, the text refers to the "`Time datatype`" (instead of "`TimeType` datatype"), to the "`MediaLocator D`" (instead of "`MediaLocatorType D`") and to the "`Person DS`" (instead of "`PersonType DS`").

2.2 Terminology

For the purposes of this part of ISO/IEC 15938, the following terms and definitions apply.

2.2.1 Schema-related terminology

2.2.1.1
Attribute
A field of a **description tool** which is of simple type.

2.2.1.2
Base type
A **type** that serves as the root **type** of a derivation hierarchy for other **types**.

2.2.1.3
Datatype
A primitive reusable **type** employed by **Description Schemes** and **Descriptors**.

2.2.1.4
Derived type
A **type** that is defined in terms of extension or restriction of other **types**.

2.2.1.5
Description
An instantiation of one or more **description tools**.

2.2.1.6
Description Scheme
A **description tool** that describes entities or relationships pertaining to **multimedia content**. **Description Schemes** specify the structure and semantics of their components, which may be **Description Schemes**, **Descriptors**, or **datatypes**.

2.2.1.7
Description Tool
A **Description Scheme**, **Descriptor**, or **datatype**.

2.2.1.8
Descriptor
A description tool that describes a feature, **attribute**, or group of attributes of multimedia content**.**

2.2.1.9
Instantiation
Assignment of values to the fields (elements, attributes) of one or more **description tools**.

2.2.1.10
Element
A field of a **description tool** which is of complex type.

2.2.1.11
Schema
The set of related **description tools**, for example, those specified in ISO/IEC 15938.

2.2.1.12
Type
The format used for collection of letters, digits, and/or symbols, to depict values of an element or attribute of **description tool**. A **type** consists of a set of distinct values, a set of lexical representations, and a set of facets that characterize properties of the value space, individual values, or lexical items.

2.2.2 Content-related terminology

2.2.2.1
Abstraction
A secondary representation that is created from or is related to the **content**. For example, a **summary** of a **video** or a **model** of a **feature**.

2.2.2.2
AC coefficient
Any DCT coefficient for which the frequency in one or both dimensions is non-zero.

2.2.2.3
Acquisition
The process of acquiring **audio** or **visual** data from a source.

2.2.2.4
Action
A semantically identifiable behavior of an object or group of objects, for example, a soccer player kicking ball.

2.2.2.5
Agent
A person, organization, or group of persons.

2.2.2.6
Audio
Time-varying **data** or signal intended for listening or hearing. Also, related to the aural modality.

2.2.2.7
Audio-visual
content consisting of both **audio** and **video** data.

2.2.2.8
Automatic
Processing of **multimedia data**, **content**, or **metadata** by means of computer, hardware, or other software device.

2.2.2.9
Classification Scheme
A list of defined terms and their meanings.

2.2.2.10
Content
Multimedia content
A representation of the information contained in or related to **multimedia data** in a formalized manner suitable for interpretation by human means. **Content** refers to the **data** and the **metadata**.

2.2.2.11
Copyright
A right that establishes the ownership of **data**, **content**, or **metadata**.

2.2.2.12
Data
Essence
Multimedia Data
A representation of **multimedia** in a formalized manner suitable for communication, interpretation, or processing by automatic means.

2.2.2.13
DC coefficient
The DCT coefficient for which the frequency in both dimensions is zero.

2.2.2.14
DCT coefficient
The signed amplitude of a specific cosine basis function.

2.2.2.15
Editing
The process of combining, extracting, and refining **multimedia data**.

2.2.2.16
Eigenface
An eigenvector obtained from the principal component analysis of facial images.

2.2.2.17
Entity
Any concrete or abstract thing of interest related to the **multimedia content**.

2.2.2.18
Event
A noteworthy occurrence that happens at a point in time or during a temporal interval. Alternatively used as a change in state.

2.2.2.19
Feature
A distinctive characteristic of **multimedia content** that signifies something to a human observer, such as the "color" or "texture" of an image.

2.2.2.20
Filtering
A process for selecting multimedia content that satisfies certain criteria. This process may include ranking the content according to the extent that it satisfies the criteria.

2.2.2.21
Format
The characteristics of the stored or physical representation of the **data**.

2.2.2.22
Frame
A single **image** from a **video**.

2.2.2.23
Image
2D spatially-varying visual data acquired from a visual source.

2.2.2.24
Key frame
A representative **frame** of a **video** or a **segment**.

2.2.2.25
Locator
Specifies the location or address of **multimedia data** or a **segment**.

2.2.2.26
Model
A parametric or statistical representation of multimedia **content** or **features**.

2.2.2.27
Manual
Processing of **multimedia data**, **content**, or **metadata** by human means.

2.2.2.28
Metadata
The information and documentation which makes **multimedia data** understandable and shareable to users over time.

2.2.2.29
Multimedia
Data comprising one or modalities, such as images, audio, video, 3D models, ink content, and so forth.

2.2.2.30
Navigation
A process by which a **user** accesses **multimedia content** and steers a course through the content in a controlled manner.

2.2.2.31
Object
An object with a physical representation in the natural world.

2.2.2.32
Region
A spatial unit of **multimedia**, for example, a 2D spatial **region** of an **image**, or a moving region of **video**.

2.2.2.33
Relation
Any association among entities.

2.2.2.34
Rights
Information that determines the ownership and terms of use of **multimedia data**, **content**, or **metadata**. Refers to Intellectual Property Rights, Copyrights, and the Access Rights.

2.2.2.35
Scene
An episode or sequence of events representing continuous action in one location.

2.2.2.36
Search
A process for searching **multimedia content** that satisfies certain criteria. This process may include ranking the content according to the extent that it satisfies the criteria.

2.2.2.37
Segment
A spatial or temporal unit of **multimedia**, for example, a temporal **segment** of **video**, or a **segment** of an **image**.

2.2.2.38
Semantics
Information relating to the underlying meaning or understanding of **multimedia content**. Alternatively, refers to the specification of the meaning of **description tools**.

2.2.2.39
Summary
An abstraction of **multimedia content** that summarizes the **content**.

2.2.2.40
User
An end-user or consumer of **multimedia content**.

2.2.2.41
User Preferences
The preferences of a **user** pertaining to **multimedia content**. This includes the user's tastes, likes and dislikes with respect to the content and its properties, as well as preferences with respect to the consumption process.

2.2.2.42
Usage History
A history of actions that a **user** of **multimedia content** has carried out over a certain period of time, such as recording a specific piece of content, or playing back recorded content at a specific time.

2.2.2.43
Variation
An alternative version of **multimedia content**., which may be derived through transcoding, summarization, translation, reduction, and so forth.

2.2.2.44
Video
A space- and time-varying visual **data** or **signal** intended for viewing; commonly represented as a discrete sequence of **images** or **frames**.

2.2.2.45
View
A portion of an **image**, **video** or **audio** signal, defined in terms of a partition. A partition is a multi-dimensional region defined in the space, time and/or frequency plane.

2.2.2.46
Visual
Related to the visual modality.

2.2.2.47
View Decomposition
An organized set of **views** that provides a structured decomposition of an **image**, **video** or **audio** signal in multi-dimensional space, time and/or frequency.

2.2.2.48
3D mesh model
Representation model of the surface of 3D objects using a set of faces and nodes. (i.e. polygonal meshes)

2.3 Symbols and abbreviated terms

2.3.1 Generic

For the purposes of this part of ISO/IEC 15938, the symbols and abbreviated terms given in the following apply:

ART: Angular-Radial Transform
AV: Audio-visual
CSS: Curvature Scale Space
CIE: International Commission on Illumination
CIF: Common Intermediate Format
CS: Classification Scheme
D: Descriptor
Ds: Descriptors
DCT: Discrete Cosine Transform
DDL: Description Definition Language
DS: Description Scheme
DSs: Description Schemes
FOC: Focus of Contraction
FOE: Focus of Expansion
GLA: Generalized Lloyd Algorithm
GoF: Group of Frames
GoP: Group of Pictures
HMMD: Hue-Min-Max-Difference
HSV: Hue-Saturation-Value
IANA: Internet Assigned Numbers Authority
IETF: Internet Engineering Task Force
IPMP: Intellectual Property Management and Protection
ISO: International Organization for Standardization
JPEG: Joint Photographic Experts Group
MDS: Multimedia Description Scheme
MNV: Mean Normal Vector
MPEG: Moving Picture Experts Group
MPEG-2: Generic coding of moving pictures and associated audio information (see ISO/IEC 13818)
MPEG-4: Coding of audio-visual objects (see ISO/IEC 14496)
MPEG-7: Multimedia Content Description Interface Standard (see ISO/IEC 15938)
MP3: MPEG-2 layer 3 audio coding
NAC: Normalized Auto-Correlation
QCIF: Quarter Common Intermediate Format
PWM: Pseudo Weighted Measure
RGB: Red-Green-Blue
SMPTE: Society of Motion Picture and Television Engineers
SSD: Shape Spectrum Descriptor
TZ: Time Zone
TZD: Time Zone Difference
URI: Uniform Resource Identifier (see RFC 2396)
URL: Uniform Resource Locator (see RFC 2396)
W3C: World Wide Web Consortium
XML: Extensible Markup Language
XOR : eXclusive-OR

2.3.2 Arithmetic operators

\+ Addition
\- Subtraction (as a binary operator) or negation (as a unary operator)
++ Increment, i.e. x++ is equivalent to x=x+1
-- Decrement, i.e. x-- is equivalent to x=x-1
+= Accumulation, i.e. x+=2 is equivalent to x=x+2
/= divide and substitute, i.e. x/=2 is equivalent to x=x/2
* Multiplication
x Multiplication
^ Power

/ Integer division with truncation of the result towards zero. For example, 7/4 and -7/-4 are truncated to 1, -7/4 and 7/-4 are truncated to -1.
// Integer division with rounding to the nearest integer. Half-integer values are rounded away from zero unless otherwise specified. For example, 3//2 is rounded to 2, and -3//2 is rounded to -2.
÷ Used to indicate division in mathematical equations where no rounding is intended
% Modulus operator, defined only for positive numbers
ld Logarithm base 2
ceil Minimum integer number greater or equal than the given floating point number

Sign() $Sign(x) = \begin{cases} 1 & x \geq 0 \\ -1 & x < 0 \end{cases}$

Abs() $Abs(x) = \begin{cases} x & x \geq 0 \\ -x & x < 0 \end{cases}$

$\sum_{i=a}^{i<b} f(i)$ Summation of $f(i)$ with *i* taking integer values from *a* up to, but not including *b*.

2.3.3 Logical operators

|| Logical OR
&& Logical AND
! Logical NOT

2.3.4 Relational operators

> Greater than
>= Greater than or equal to
≥ Greater than or equal to
< Less than
<= Less than or equal to
≤ Less than or equal to
== Equal to
!= Not equal to
max[] Maximum value in argument list
min[] Minimum value in argument list
median[] median value in argument list

2.3.5 Bitwise operators

| OR
& AND
>> Shift right with sign extension
<< Shift left with zero fill

2.3.6 Conditional operators

?: $condition?a:b = \begin{cases} a & if\ (condition) \\ b & otherwise \end{cases}$

2.3.7 Assignment

= Assignment operator

2.3.8 Constants

π 3.141 592 653 58…
e 2.718 281 828 45…

2.3.9 Functions

max() Maximum value in argument list
min() Minimum value in argument list

Sign() $Sign(x) = \begin{cases} 1 & x \geq 0 \\ -1 & x < 0 \end{cases}$

Abs() $Abs(x) = \begin{cases} x & x \geq 0 \\ -x & x < 0 \end{cases}$

$\sum_{i=a}^{i<b} f(i)$ Summation of $f(i)$ with *i* taking integer values from *a* up to, but not including *b*.

Distances between N-dimentional vectors **x** and **y**

L1 norm $L1(\mathbf{x},\mathbf{y}) = \sum_{i}^{N} |x_i - y_i|$

L2 norm $L2(\mathbf{x},\mathbf{y}) = \sum_{i} (x_i - y_i)^2$

Euclidean distance $D(\mathbf{x},\mathbf{y}) = sqrt\left(\sum_{i} (x_i - y_i)^2\right)$

2.4 Default reference axis

The default reference axis for angle calculation is the positive *x* (horizontal) axis. Positive angle is calculated anti-clockwise.

3 MDS tools

3.1 Introduction

Clause 3.1 provides guidelines and examples of the extraction and use of descriptions for tools defined in ISO/IEC 15938-5.

3.2 Schema tools

3.2.1 Introduction

This clause specifies the schema tools that facilitate the making of descriptions. The following description tools are specified: (1) the base type hierarchy of the description tools defined in ISO/IEC 15938, (2) the root element, (3) the top-level tools, (4) the multimedia content entity tools, (5) package tool, and (6) description metadata tool. The functionality of these tools is given as follows:

Table 1 - Overview of Schema Tools.

Tool	*Functionality*
Base types	Form the type hierarchy for description tools.
Root element	The initial wrapper or root element of descriptions.
Top-level tools	The elements that follow the root element in descriptions.
Multimedia content entity tools	Tools for describing different types of multimedia content such as images, video, audio, mixed multimedia, collections, and so forth.
Package	Tool for organizating or packaging of description tools.
Description metadata	Tool for describing metadata about descriptions.

3.2.2 Base types

No additional informative material for extraction and use is provided.

3.2.3 Root element

3.2.3.1 Root element examples

The following example shows the use of the root element for describing an instance of the `ScalableColorD` (defined in ISO/IEC 15398-3) using `DescriptionUnit`.

```
<Mpeg7>
    <DescriptionMetadata>
        <Version>1.0</Version>
        <PrivateIdentifier>descriptionUnitExample</PrivateIdentifier>
    </DescriptionMetadata>
    <DescriptionUnit xsi:type="ScalableColorType" numOfCoeff="16"
        numOfBitplanesDiscarded="0">
        <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
    </DescriptionUnit>
</Mpeg7>
```

The following example shows the use of root element for describing an image using `Description`.

```
<Mpeg7>
    <DescriptionMetadata>
        <Confidence>1.0</Confidence>
        <Version>1.1</Version>
        <LastUpdate>2001-09-20T03:20:25+09:00</LastUpdate>
        <PublicIdentifier>
            <IDOrganization>
                <Name>ISO</Name>
            </IDOrganization>
            <IDName>
                <Name>International Organization of Standardization</Name>
            </IDName>
            <UniqueID>098f2470-bae0-11cd-b579-08002b30bfeb</UniqueID>
        </PublicIdentifier>
        <PrivateIdentifier>completeDescriptionExample</PrivateIdentifier>
        <Creator>
            <Role href="creatorCS"><Name>Creator</Name><Role>
            <Person>
                <Name>
                    <GivenName>Yoshiaki</GivenName>
                    <FamilyName>Shibata</FamilyName>
                </Name>
            </Person>
        </Creator>
        <CreationLocation>
            <Country>jp</Country>
            <AdministrativeUnit>Tokyo</AdministrativeUnit>
        </CreationLocation>
        <CreationTime>2000-10-10T19:45:00+09:00</CreationTime>
        <Instrument>
            <Tool>
                <Name>Wizzo Extracto ver. 2</Name>
            </Tool>
            <Setting name="sensitivity" value="0.5"/>
        </Instrument>
        <Rights> RID# </Rights>
    </DescriptionMetadata>
    <Description xsi:type="ContentEntityType">
        <MultimediaContent xsi:type="ImageType">
            <Image>
                <!-- more elements here -->
            </Image>
        </MultimediaContent>
    </Description>
</Mpeg7>
```

3.2.4 Top-level types

3.2.4.1 Complete description types

3.2.4.1.1 Content description types examples

The following example shows the use of the content description type `ContentEntityType` for describing a photographic image depicting a sunset. The image description includes a text annotation and a description of the image color using `ScalableColor D` (defined in ISO/IEC 15938-3).

```
<Mpeg7>
    <Description xsi:type="ContentEntityType">
        <MultimediaContent xsi:type="ImageType">
            <Image>
                <MediaLocator>
                    <MediaUri>image.jpg</MediaUri>
                </MediaLocator>
                <TextAnnotation>
                    <FreeTextAnnotation> Sunset scene </FreeTextAnnotation>
                </TextAnnotation>
                <VisualDescriptor xsi:type="ScalableColorType" numOfCoeff="16"
                    numOfBitplanesDiscarded="0">
                    <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                </VisualDescriptor>
            </Image>
        </MultimediaContent>
    </Description>
</Mpeg7>
```

The following example shows the use of the content description type `SemanticDescriptionType` for describing a car that is depicted in an image (image.jpg). The `Semantic DS` is defined in 3.10.3.3.

```
<Mpeg7>
    <Description xsi:type="SemanticDescriptionType">
        <Semantics>
            <Label>
                <Name> Car </Name>
            </Label>
            <Definition>
                <FreeTextAnnotation>
                    Four wheel motorized vehicle
                </FreeTextAnnotation>
            </Definition>
            <MediaOccurrence>
                <MediaLocator>
                    <MediaUri> image.jpg </MediaUri>
                </MediaLocator>
            </MediaOccurrence>
        </Semantics>
    </Description>
</Mpeg7>
```

The following example shows the use of the content description type `ModelDescriptionType` for describing a collection model of "sunsets" that contains two images depicting sunset scenes. The `CollectionModel DS` is defined in 3.12.5.2.

```
<Mpeg7>
    <Description xsi:type="ModelDescriptionType">
        <Model xsi:type="CollectionModelType" confidence="0.75" reliability="0.5"
            function="described">
            <Label>
                <Name>Sunsets</Name>
            </Label>
            <Collection xsi:type="ContentCollectionType">
```

```
            <Content xsi:type="ImageType">
               <Image>
                  <MediaLocator xsi:type="ImageLocatorType">
                     <MediaUri>sunset1.jpg</MediaUri>
                  </MediaLocator>
               </Image>
            </Content>
            <Content xsi:type="ImageType">
               <Image>
                  <MediaLocator xsi:type="ImageLocatorType">
                     <MediaUri>sunset2.jpg</MediaUri>
                  </MediaLocator>
               </Image>
            </Content>
         </Collection>
      </Model>
   </Description>
</Mpeg7>
```

The following example shows the use of the content description type SummaryDescriptionType for describing a hierarchical summary of video. The hierarchical summary has two levels: level 0 consists of three summary segments, and level 1 consists of one summary segment. The HierarchicalSummary DS is defined in 3.11.2.3.

```
<Mpeg7>
   <Description xsi:type="SummaryDescriptionType">
      <Summarization>
         <Summary xsi:type="HierarchicalSummaryType"
            components="keyVideoClips" hierarchy="dependent">
            <SourceLocator>
               <MediaUri>file://disk/video001.mpg</MediaUri>
            </SourceLocator>
            <SummarySegmentGroup level="0">
               <SummarySegment> <!-- segment #1 at level 0 -->
</SummarySegment>
               <SummarySegment> <!-- segment #2 at level 0 -->
</SummarySegment>
               <SummarySegment> <!-- segment #3 at level 0 -->
</SummarySegment>
               <SummarySegmentGroup level="1">
                  <SummarySegment> <!-- segment #1 at level 1 -->
</SummarySegment>
               </SummarySegmentGroup>
            </SummarySegmentGroup>
         </Summary>
      </Summarization>
   </Description>
</Mpeg7>
```

The following example shows the use of the content description type ViewDescriptionType for describing a spatial view of an image, which corresponds to the upper-right quarter of the image. The SpaceView DS is defined in 3.11.3.5.

```
<Mpeg7>
   <Description xsi:type="ViewDescriptionType">
      <View xsi:type="SpaceViewType">
         <Target>
            <ImageSignal>
               <MediaLocator>
                  <MediaUri> view.jpg </MediaUri>
               </MediaLocator>
            </ImageSignal>
         </Target>
```

```
            <Source>
               <ImageSignal>
                  <MediaLocator>
                     <MediaUri> image.jpg </MediaUri>
                  </MediaLocator>
               </ImageSignal>
            </Source>
            <SpacePartition>
               <Origin xOrigin="left" yOrigin="top"/>
               <Start xsi:type="SignalPlaneFractionType" x="0.5" y="0"/>
               <End xsi:type="SignalPlaneFractionType" x="0.5" y="0.5"/>
            </SpacePartition>
         </View>
      </Description>
</Mpeg7>
```

The following example shows the use of the content description type VariationDescriptionType for describing an image that is a variation of a video in which the image has been extracted from the video. The VariationSet DS is defined in 3.11.4.1.

```
<Mpeg7>
   <Description xsi:type="VariationDescriptionType">
      <VariationSet>
         <Source xsi:type="mpeg7:VideoType">
            <Video>
               <MediaLocator>
                  <MediaUri>file://video-A.mpg</MediaUri>
               </MediaLocator>
            </Video>
         </Source>
         <Variation fidelity="0.85" priority="1">
            <Content xsi:type="ImageType">
               <Image>
                  <MediaLocator>
                     <MediaUri>file://image-B.jpg</MediaUri>
                  </MediaLocator>
               </Image>
            </Content>
            <VariationRelationship>extraction</VariationRelationship>
         </Variation>
      </VariationSet>
   </Description>
</Mpeg7>
```

3.2.4.2 Content management types

3.2.4.2.1 Content management types example

The following example shows the use of the content management type UserDescriptionType for describing the user preferences of a user of a multimedia system. The UserPreferences DS is defined in 3.13.2.1.

```
<Mpeg7>
   <Description xsi:type="UserDescriptionType">
      <User xsi:type="PersonType">
         <Name xml:lang="en">
            <GivenName> John </GivenName>
            <FamilyName> Smith </FamilyName>
         </Name>
      </User>
      <UserPreferences>
         <UserIdentifier>
            <Name> jrsmith </Name>
```

```
            </UserIdentifier>
            <FilteringAndSearchPreferences>
               <!-- more elements here -->
            </FilteringAndSearchPreferences>
         </UserPreferences>
      </Description>
</Mpeg7>
```

The following example shows the use of the content management type MediaDescriptionType for describing the media information of a news video. The MediaInformation DS is defined in 3.6.2.1.

```
<Mpeg7>
   <Description xsi:type="MediaDescriptionType">
      <MediaInformation id="news1_media">
         <MediaIdentification>
            <EntityIdentifier organization="MPEG" type="MPEG7ContentSetId">
                  mpeg7_content:news1
               </EntityIdentifier>
            <VideoDomain href="urn:mpeg:mpeg7:cs:VideoDomainCS:2001:1.2">
               <Name xml:lang="en">Natural</Name>
            </VideoDomain>
         </MediaIdentification>
         <MediaProfile>
            <MediaFormat>
               <Content href="MPEG7ContentCS">
                  <Name>audiovisual</Name>
               </Content>
               <Medium href="urn:mpeg:mpeg7:cs:MediumCS:2001:1.1">
                  <Name xml:lang="en">CD</Name>
               </Medium>
               <FileFormat href="urn:mpeg:mpeg7:cs:FileFormatCS:2001:3">
                  <Name xml:lang="en">mpeg</Name>
               </FileFormat>
               <FileSize>666478608</FileSize>
               <VisualCoding>
                  <Format href="urn:mpeg:mpeg7:cs:VisualCodingFormatCS:2001:1"
                     colorDomain="color">
                     <Name xml:lang="en">MPEG-1 Video</Name>
                  </Format>
                  <Pixel aspectRatio="0.75" bitsPer="8"/>
                  <Frame height="288" width="352" rate="25"/>
               </VisualCoding>
            </MediaFormat>
         </MediaProfile>
      </MediaInformation>
   </Description>
</Mpeg7>
```

The following example shows the use of the content management type CreationDescriptionType for describing the creation information for a sports video. The CreationInformation DS is defined in 3.7.2.1.

```
<Mpeg7>
   <Description xsi:type="CreationDescriptionType">
      <CreationInformation>
         <Creation>
            <Title xml:lang="en" type="popular">Subway series</Title>
            <Abstract>
               <FreeTextAnnotation> Game among city rivals
                     </FreeTextAnnotation>
            </Abstract>
            <Creator>
               <Role href="urn:mpeg:mpeg7:cs:RoleCS:2001:PUBLISHER"/>
```

```
                <Agent xsi:type="OrganizationType">
                   <Name>Sports Channel</Name>
                </Agent>
             </Creator>
          </Creation>
       </CreationInformation>
    </Description>
</Mpeg7>
```

The following example shows the use of the content management type `UsageDescriptionType` for describing the usage information for a sport video released for the Internet. The `UsageInforamtion DS` is defined in 3.8.2.1.

```
<Mpeg7>
    <Description xsi:type="UsageDescriptionType">
       <UsageInformation>
          <Rights>
             <RightsID organization="NBC" type="NBCCopyRightsID">
                      nbc:20010618:td2
                   </RightsID>
          </Rights>
          <Availability id="sports">
             <InstanceRef href="onlinemp7cs17sports1"/>
             <Dissemination>
                <Format href="urn:mpeg:mpeg7:cs:DisseminationFormatCS:2001:4">
                   <Name xml:lang="en">Internet</Name>
                </Format>
                <Location>
                   <Region>us</Region>
                </Location>
             </Dissemination>
             <AvailabilityPeriod type="payPerUse">
                <TimePoint>2001-06-16T21:00+01:00</TimePoint>
                <Duration>PT30M</Duration>
             </AvailabilityPeriod>
          </Availability>
       </UsageInformation>
    </Description>
</Mpeg7>
```

The following example shows the use of the content management type `ClassificationSchemeDescriptionType` for describing a classification scheme for audio domain. The `ClassificationScheme DS` is defined in 3.5.4.1.

```
<Mpeg7>
    <Description xsi:type="ClassificationSchemeDescriptionType">
       <ClassificationScheme uri="urn:mpeg:mpeg7:cs:MyAudioDomainCS"

    domain="//MediaInformation/MediaProfile/MediaIdentification/AudioDomain">
          <Header xsi:type="DescriptionMetadataType">
             <Version>1.0</Version>
          </Header>
          <Term termID="1">
             <Name xml:lang="en">Source</Name>
             <Definition xml:lang="en">Type of audio source</Definition>
             <Term termID="1.1">
                <Name xml:lang="en">Synthetic</Name>
             </Term>
             <Term termID="1.2">
                <Name xml:lang="en">Natural</Name>
             </Term>
          </Term>
       </ClassificationScheme>
```

```
    </Description>
</Mpeg7>
```

3.2.4.3 Multimedia content entity description tools

3.2.4.3.1 Multimedia content entity description tools examples

The following example shows the use of the multimedia content entity `ImageType` for describing an image.

```
<Mpeg7>
    <Description xsi:type="ContentEntityType">
        <MultimediaContent xsi:type="ImageType">
            <Image>
                <MediaLocator>
                    <MediaUri>image.jpg</MediaUri>
                </MediaLocator>
                <CreationInformation>
                    <Creation>
                        <Title> World Series Game 3 </Title>
                    </Creation>
                </CreationInformation>
                <TextAnnotation>
                    <FreeTextAnnotation> Game winning homerun </FreeTextAnnotation>
                </TextAnnotation>
                <Semantic>
                    <Label>
                        <Name>Last inning</Name>
                    </Label>
                    <SemanticBase xsi:type="EventType">
                        <Label>
                            <Name>Game winning homerun </Name>
                        </Label>
                    </SemanticBase>
                </Semantic>
                <VisualDescriptor xsi:type="ScalableColorType" numOfCoeff="16"
                    numOfBitplanesDiscarded="0">
                    <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                </VisualDescriptor>
            </Image>
        </MultimediaContent>
    </Description>
</Mpeg7>
```

The following example shows the use of the multimedia content entity `VideoType` for describing a video.

```
<Mpeg7>
    <Description xsi:type="ContentEntityType">
        <MultimediaContent xsi:type="VideoType">
            <Video>
                <CreationInformation>
                    <Creation>
                        <Title> Worldcup Soccer </Title>
                    </Creation>
                </CreationInformation>
                <MediaTime>
                    <MediaTimePoint>T00:00:00</MediaTimePoint>
                    <MediaDuration>PT1M30S</MediaDuration>
                </MediaTime>
                <VisualDescriptor xsi:type="GoFGoPColorType"
aggregation="Average">
                    <ScalableColor numOfCoeff="16" numOfBitplanesDiscarded="0">
                        <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                    </ScalableColor>
                </VisualDescriptor>
```

```
          </Video>
       </MultimediaContent>
   </Description>
</Mpeg7>
```

The following example shows the use of the multimedia content entity AudioType for describing audio content.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="AudioType">
         <Audio>
            <CreationInformation>
               <Creation>
                  <Title> Morning Radio </Title>
               </Creation>
            </CreationInformation>
            <MediaTime>
               <MediaTimePoint>T00:00:00</MediaTimePoint>
               <MediaDuration>PT30M00S</MediaDuration>
            </MediaTime>
         </Audio>
      </MultimediaContent>
   </Description>
</Mpeg7>
```

The following example shows the use of the multimedia content entity AudioVisualType for describing audiovisual content.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="AudioVisualType">
         <AudioVisual>
            <MediaLocator>
               <MediaUri>program.mpg</MediaUri>
            </MediaLocator>
            <CreationInformation>
               <Creation>
                  <Title> News Flash</Title>
               </Creation>
            </CreationInformation>
            <TextAnnotation>
               <FreeTextAnnotation> Afternoon news program
</FreeTextAnnotation>
            </TextAnnotation>
            <MediaTime>
               <MediaTimePoint>T00:00:00</MediaTimePoint>
               <MediaDuration>PT10M300S</MediaDuration>
            </MediaTime>
         </AudioVisual>
      </MultimediaContent>
   </Description>
</Mpeg7>
```

The following example shows the use of the multimedia content entity MultimediaType for describing multimedia content.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="MultimediaType">
         <Multimedia>
            <MediaSourceDecomposition gap="false" overlap="false">
               <Segment xsi:type="StillRegionType">
```

```
                    <TextAnnotation>
                        <FreeTextAnnotation> image </FreeTextAnnotation>
                    </TextAnnotation>
                </Segment>
                <Segment xsi:type="VideoSegmentType">
                    <TextAnnotation>
                        <FreeTextAnnotation> video </FreeTextAnnotation>
                    </TextAnnotation>
                    <MediaTime>
                        <MediaTimePoint>T00:00:00</MediaTimePoint>
                        <MediaDuration>PT0M15S</MediaDuration>
                    </MediaTime>
                </Segment>
                <Segment xsi:type="AudioSegmentType">
                    <TextAnnotation>
                        <FreeTextAnnotation> audio </FreeTextAnnotation>
                    </TextAnnotation>
                </Segment>
            </MediaSourceDecomposition>
        </Multimedia>
    </MultimediaContent>
</Description>
</Mpeg7>
```

The following example shows the use of the multimedia content entity `MultimediaCollectionType` for describing a collection consisting of one image and one video.

```
<Mpeg7>
    <Description xsi:type="ContentEntityType">
        <MultimediaContent xsi:type="MultimediaCollectionType">
            <Collection xsi:type="ContentCollectionType">
                <Content xsi:type="ImageType">
                    <Image>
                        <MediaLocator xsi:type="ImageLocatorType">
                            <MediaUri>image.jpg</MediaUri>
                        </MediaLocator>
                    </Image>
                </Content>
                <Content xsi:type="VideoType">
                    <Video>
                        <MediaLocator xsi:type="TemporalSegmentLocatorType">
                            <MediaUri>video.mpg</MediaUri>
                        </MediaLocator>
                    </Video>
                </Content>
            </Collection>
        </MultimediaContent>
    </Description>
</Mpeg7>
```

The following example shows the use of the multimedia content entity `SignalType` for describing an image signal.

```
<Mpeg7>
    <Description xsi:type="ContentEntityType">
        <MultimediaContent xsi:type="SignalType">
            <ImageSignal>
                <MediaLocator xsi:type="ImageLocatorType">
                    <MediaUri>video.mpg</MediaUri>
                </MediaLocator>
            </ImageSignal>
        </MultimediaContent>
    </Description>
```

```
</Mpeg7>
```

The following example shows the use of the multimedia content entity `InkContentType` for describing ink content.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="InkContentType">
         <InkContent>
            <MediaLocator>
               <MediaUri>ink.mpg</MediaUri>
            </MediaLocator>
            <InkMediaInformation>
               <InputDevice resolutionS="133">
                  <Device>
                     <Name xml:lang="en">PenDevice</Name>
                  </Device>
               </InputDevice>
               <Handedness>right</Handedness>
               <Style>mixed</Style>
            </InkMediaInformation>
         </InkContent>
      </MultimediaContent>
   </Description>
</Mpeg7>
```

The following example shows the use of the multimedia content entity `AnalyticEditedVideoType` for describing an edited video.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="AnalyticEditedVideoType">
         <AnalyticEditedVideo xsi:type="EditedVideoType">
            <MediaLocator>
               <MediaUri> video.mpg </MediaUri>
            </MediaLocator>
            <CreationInformation>
               <Creation>
                  <Title> Worldcup Soccer </Title>
               </Creation>
            </CreationInformation>
            <MediaTime>
               <MediaTimePoint>T00:00:00</MediaTimePoint>
               <MediaDuration>PT1M30S</MediaDuration>
            </MediaTime>
         </AnalyticEditedVideo>
      </MultimediaContent>
   </Description>
</Mpeg7>
```


3.2.5 Description metadata tools

3.2.5.1 Package DS

3.2.5.1.1 Package DS examples

The following example shows the use of the `Package DS` for describing a package of description tools for collections and models. The package consists of one package named "Content Organization", which consists of another package that lists four tools: `ContentCollectionType`, `DescriptorCollectionType`, `ConceptCollectionType`, and `MixedCollectionType`, and another package named "Probability Models", which consists of two additional packages named: "Probability Distributions", "Continuous Probability Distribution", and "Finite State Models"

```
<Mpeg7>
   <DescriptionMetadata>
      <Version>1.0</Version>
      <Package name="Content Organization">
         <Package name="Collections">
            <Scheme name="ContentCollectionType"/>
            <Scheme name="DescriptorCollectionType"/>
            <Scheme name="ConceptCollectionType"/>
            <Scheme name="MixedCollectionType"/>
         </Package>
         <Package name="Models">
            <Package name="Probability Models">
               <Package name="Probability Distributions">
                  <Package name="Discrete Probability Distributions">
                     <Scheme name="HistogramProbabilityType"/>
                     <Scheme name="BinomialDistributionType"/>
                     <Scheme name="PoissonDistributionType"/>
                  </Package>
                  <Package name="Continuous Probability Distributions">
                     <Scheme name="GaussianDistributionType"/>
                     <Scheme name="GeneralizedGaussianDistributionType"/>
                  </Package>
               </Package>
               <Package name="Finite State Models">
                  <Scheme name="StateTransitionModelType"/>
                  <Scheme name="HiddenMarkovModelType"/>
               </Package>
            </Package>
         </Package>
      </Package>
   </DescriptionMetadata>
   <!-- more elements here -->
</Mpeg7>
```

3.2.5.2 DescriptionMetadata Header

3.2.5.2.1 DescriptionMetadata Header examples

The following example shows the use of the `DescriptionMetadata Header` for describing a video segment. Note that this example shows how description metadata can be attached to one component of the description — in this case the segment contained within the video segment temporal decomposition.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="VideoType">
         <Video>
            <MediaLocator>
               <MediaUri>video.mpg</MediaUri>
            </MediaLocator>
            <TextAnnotation>
               <FreeTextAnnotation> Soccer scene </FreeTextAnnotation>
            </TextAnnotation>
            <TemporalDecomposition gap="false" overlap="false"
               decompositionType="temporal">
               <VideoSegment xsi:type="VideoSegmentType">
                  <Header xsi:type="DescriptionMetadataType">
                     <Confidence>0.75</Confidence>
                     <Version>1.4</Version>
                     <LastUpdate>2001-03-11T10:00:00+00:00</LastUpdate>
                     <Comment>
                        <FreeTextAnnotation>Extracted video segment
                        </FreeTextAnnotation>
                     </Comment>
                     <PublicIdentifier type="UUID" organization="ISO">
```

```
                        0f93sjd8-h38f-20dk-kjf9-02kj78li
                    </PublicIdentifier>
                    <PrivateIdentifier>Monster Jr.</PrivateIdentifier>
                    <Creator>
                        <Role href="creatorCS">
                            <Name>Creator</Name>
                        </Role>
                        <Agent xsi:type="OrganizationType">
                            <Name>MPEG-7 MDS Group</Name>
                            <Kind>
                                <Name>ISO MPEG subgroup</Name>
                            </Kind>
                            <Contact xsi:type="PersonType">
                                <Name>
                                    <GivenName>John</GivenName>
                                    <FamilyName>Smith</FamilyName>
                                </Name>
                                <ElectronicAddress>
                                    <Email>nobody@nowhere.com</Email>
                                </ElectronicAddress>
                            </Contact>
                            <ElectronicAddress>
                                <Url>http://www.cselt.it/mpeg/</Url>
                            </ElectronicAddress>
                        </Agent>
                    </Creator>
                    <CreationLocation>
                        <Region>en</Region>
                        <AdministrativeUnit>New York</AdministrativeUnit>
                    </CreationLocation>
                    <CreationTime>2001-02-20T10:00:00+00:00</CreationTime>
                    <Instrument>
                        <Tool>
                            <Name>MPEG-7 WizzoExtracto Tool</Name>
                        </Tool>
                        <Setting name="precision" value="highest"/>
                    </Instrument>
                    <Rights>
                        <RightsID organization="MPEG" type="MPEGcopyright">
                            mpeg7:98shdj28:021
                        </RightsID>
                    </Rights>
                    <Package name="Sports - Soccer Package">
                        <Scheme name="GraphType"/>
                        <Scheme name="StructuredAnnotationType"/>
                        <Scheme name="PointOfViewType"/>
                        <Scheme name="VideoSegmentType"/>
                        <Scheme name="SummarizationType"/>
                        <Scheme name="ViewType"/>
                        <Scheme name="SemanticsType"/>
                        <Scheme name="UserPreferencesType"/>
                    </Package>
                </Header>
                <!-- more elements here -->
            </VideoSegment>
            <!-- more elements here -->
        </TemporalDecomposition>
        <!-- more elements here -->
    </Video>
  </MultimediaContent>
</Description>
</Mpeg7>
```

3.3 Basic datatypes

3.3.1 Introduction

This clause specifies a set of basic datatypes that are used to by the ISO/IEC 15938 description tools. While the DDL provides some built-in datatypes, additional datatypes required for the description of multimedia content are defined in this clause:

Table 2 - Overview of Basic Datatypes.

Tool	*Functionality*
Integer & Real datatypes	Tools for representing constrained integer and real values. A set of unsigned integer datatypes "`unsignedXX`" (where XX is the number of bits in the representation) represent integer values from 1 to 32 bits in length. In addition, several different datatypes representing constrained ranges of real values are specified: `minusOneToOne`, `zeroToOne`, and so on.
Vectors & Matrix datatypes	Tools for representing arbitrary sized vectors and matrices of integer or real values. For vectors, the `IntegerVector`, `FloatVector`, and `DoubleVector` datatypes represent vectors of integer, float, and double values respectively. For matrices, the `IntegerMatrix`, `FloatMatrix`, and `DoubleMatrix` datatypes represent matrices of `integer`, `float`, and `double` values respectively.
Probability Vectors & Matrix datatypes	Tools for representing probability distributions using vectors (`ProbabilityVector`) and matrices (`ProbabilityMatrix`).
String Datatypes	Tools for identifying content type (mimeType), countries (`countryCode`), regions (`regionCode`), currencies (`currencyCode`), and character sets (`characterSetCode`).

3.3.2 Integer datatypes

3.3.2.1 Unsigned datatypes

Information on extraction and use is not provided.

3.3.3 Real datatypes

3.3.3.1 zeroToOne datatype

Information on extraction and use is not provided.

3.3.3.2 minusOneToOne datatype

Information on extraction and use is not provided.

3.3.3.3 nonNegativeReal datatype

Information on extraction and use is not provided.

3.3.4 Vectors and matrices

3.3.4.1 Representing vector and matrix values

The datatypes representing vectors (`integerVector`, `floatVector`, `doubleVector`) and the datatypes representing matrix values (`IntegerMatrixType`, `FloatMatrixType`, `DoubleMatrix`) follow the specification found in ISO/IEC 15938 Part 2 (DDL) (see 5.1). The following is a brief summary of that subclause, which is needed to understand how the vector and matrix datatypes are defined and used.

In this standard, vectors and matrices differ in several respects. First, matrices are more general and can have any dimension, of one or higher. On the other hand vectors are a special kind of matrix that is limited to being one-dimensional. Second,the implementation of these datatypes differ. The *vector* datatypes (`integerVector`, `floatVector`, `doubleVector`) are represented using a *list* simple datatype. Each entry in the vector is represented as one item in the list. The entries appear in the list in the same order as they occur in the vector. On the other hand, the matrix datatypes are represented using a complex datatype

whose content is a *list* simple datatype. The two datatypes overlap in that a matrix can represent a one-dimensional matrix, i.e. a vector.

To support variable-sized matrices the special attribute `mpeg7:dim` is used to specify the size of the dimensions of a matrix instance. The `mpeg7:dim` attribute is defined in DDL (see ISO/IEC 15938-2) as a list of positive integers. Each element in the list indicates the size of one dimension of the matrix. `mpeg7:dim` is a reserved attribute that shall be used to specify matrix dimensions and shall not be used for other purposes. For example, a value of "2 4" for `mpeg7:dim` indicates a 2-by-4 matrix having 2 rows and 4 columns. The `mpeg7:dim` attribute is only used for the matrix datatypes and not for the vector datatypes.

For describing a vector, the `Vector` datatypes (e.g. `integerVector`) or a 1-D Matrix (e.g. `IntegerMatrix`) can be used. For the matrix datatypes, mpeg7:dim is required. For the vector datatypes, mpeg7:dim is not allowed. Deciding which of these datatypes is appropriate depends on the needs of the application using the datatype.

3.3.4.2 vector datatypes

Information on extraction and use is not provided.

3.3.4.3 minusOneToOneVector datatype

3.3.4.4 Matrix datatypes

3.3.4.4.1 Matrix datatypes examples

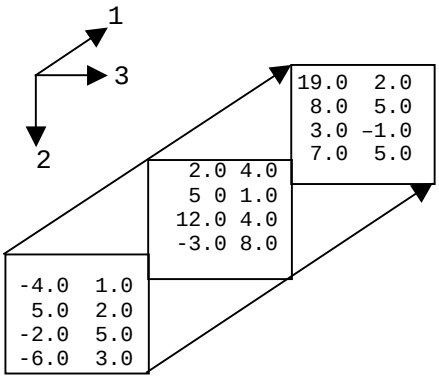
Consider the two-dimensional 4x4 matrix shown below:

$$\begin{bmatrix} 1.0 & 12.0 & 0.0 & 0.1 \\ 0.0 & 2.0 & 0.0 & 0.0 \\ 13.0 & 0.0 & -1.0 & 0.0 \\ 4.0 & 0.0 & 0.0 & 1.2 \end{bmatrix}$$

This matrix can be represented as the following instance of the `DoubleMatrix` datatype:

```
<DoubleMatrix mpeg7:dim="4 4">
    1.0 12.0  0.0 0.1
    0.0  2.0  0.0 0.0
   13.0  0.0 -1.0 0.0
    4.0  0.0  0.0 1.2
</DoubleMatrix>
```

Consider the following 3-dimensional matrix of size 3x4x2:



This 3-dimensional matrix can be represented as an instance of `IntegerMatrix` as follows:

```
<IntegerMatrix mpeg7:dim="3 4 2">
   <!-- The order of elements is
      (1,1,1), (1,1,2),
      (1,2,1), (1,2,2),
      (1,3,1), (1,3,2),
      (1,4,1), (1,4,2), . . .
```

```
      (2,1,1), (2,1,2), . . .

      (3,1,1), (3,1,2), . . .

      (3,4,1), (3,4,2),  -->
   -4  1  5  2 -2  5 -6  3
    2  4  5  1 12  4 -3  8
   19  2  8  5  3 -1  7  5
</IntegerMatrix>
```

3.3.4.5 Diagonal matrix datatypes

3.3.4.5.1 Diagonal matrix datatypes examples

Consider the diagonal matrix shown below:

$$\begin{bmatrix} 1.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 2.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & -1.0 & 0.0 \\ 0.0 & 0.0 & 0.0 & 1.2 \end{bmatrix}$$

Because this matrix is a diagonal matrix, it can be represented using the `DoubleDiagonalMatrix` datatype as follows:

```
<DoubleDiagonalMatrix mpeg7:dim="4">
   1.0 2.0 -1.0 1.2
</DoubleDiagonalMatrix>
```

3.3.4.6 MinusOneToOneMatrix datatype

Information on extraction and use is not provided.

3.3.5 Probability datatypes

3.3.5.1 probabilityVector datatype

Information on extraction and use is not provided.

3.3.5.2 ProbabilityMatrix datatype

3.3.5.2.1 ProbabilityMatrix datatype examples

Consider a conditional probability distribution involving three random variables *S*, *R*, and *W* each of which can have the value true or false. The conditional probability table for *P(W|S,R)* is defined as follows:

Table 3- Example of conditional probabilities.

R	*S*	*P(W=false|R,S)*	*P(W=true|R,S)*
false	*false*	1.00	0.00
false	*true*	0.10	0.90
true	*false*	0.80	0.20
true	*true*	0.01	0.99

Then this conditional probability table is represented as a `ProbabilityMatrix` value as follows. In this example, *false* is represented as index 1 and *true* as index 2 and the random variables have been assigned to matrix dimensions as follows: *R* to dimension 1, *S* to dimension 2 and *W* to dimension 3. This results in the following value for `ProbabilityMatrix`:

```
<ProbabilityMatrix mpeg7:dim="2 2 2">
   1.0 0.0 <!-- P(W=false|R=false,S=false), P(W=true|R=false,S=false) -->
   0.1 0.9 <!-- P(W=false|R=false,S=true), P(W=true|R=false,S=true) -->
   0.8 0.2 <!-- P(W=false|R=true,S=false), P(W=true|R=true,S=false) -->
   0.01 0.99 <!-- P(W=false|R=true,S=true), P(W=true|R=true,S=true) -->
```

```
</ProbabilityMatrix>
```

Note that one could have used another assignment of variables to indexes rather than the one used in the example above.

3.3.6 String datatypes

3.3.6.1 mimeType datatype

Information on extraction and use is not provided.

3.3.6.2 countryCode datatype

3.3.6.2.1 countryCode datatype example

The following shows an example of using a `countryCode`. In this example, the country "Spain" is identified by its code "es".

```
<Country>es</Country>
```

3.3.6.3 regionCode datatype

3.3.6.3.1 regionCode datatype example

The following show examples of encoding places using region codes. Note that region codes are case insensitive.

```
<Place>
   <Name>Italian province of Milano</Name>
   <Region>IT-MI</Region>
</Place>

<Place>
   <Name>Danish county Roskilde</Name>
   <Region>dk-025</Region>
</Place>

<!-- This example purposely uses mixed case to show case-insensitivity of
country/region codes -->
<Place>
   <Name>Antananarivo province in Madagascar</Name>
   <Region>mG-t</Region>
</Place>
```

3.3.6.4 currencyCode datatype

3.3.6.4.1 currencyCode datatype example

The following shows several examples of different currency codes:

Currency Name	*Currency Code*
Hong Kong Dollar	HKD
Euro	EUR

3.3.6.5 characterSetCode datatype

3.3.6.5.1 characterSetCode datatype example

The following table shows several examples of character set codes:

Table 4 - Examples of character set codes.

Character Set	*Code*
Shift JIS encoding of Japanese character	Shift_JIS
RFC 2279 defined encoding of the ISO/IEC 10646 (Unicode) character set.	UTF-8

3.4 Linking, identification and localization tools

3.4.1 Introduction

This clause specifies a set of basic datatypes that are used for referencing within descriptions and linking of descriptions to multimedia content. While the DDL already includes a large library of built-in datatypes, the linking to multimedia data requires some additional datatypes, which are defined in this clause.

Table 5 - Overview of Linking Tools.

Tool	*Functionality*
References to Ds and DSs	Tool for representing references to parts of a description. The `ReferenceType` is defined as a referencing mechanism based on `anyURI`, `IDREF` or `xPathRefType` datatypes.
Unique Identifier	Tool for representing unique identifiers of content.
Time description tools	Tools for representing time specifications. Two formats are distinguished: the `TimeType` for time and date specifications according to the real world time and `MediaTimeType` for time and date specifications as they are used within media.
Media Locators	Tools for representing links to multimedia data.

3.4.2 References to Ds and DSs

3.4.2.1 Reference datatype

3.4.2.1.1 Reference datatype examples

The `Reference` datatype is used by description tools to make reference to other elements of a description. For example, the `Reference` datatype is used in relation graphs, and to describe summaries of multimedia content, and to relate descriptions of content structure and semantics (for examples, see clause 3.9 and clause 3.11). The examples below show the use of the `Reference` datatype for describing references using the three different mechanisms.

The first example shows the use of `idref` for referencing an element with the ID "id3" in the current description. A parser would be able to check if an attribute "id3" of type ID is present in the description.

```
<MyElement idref="id3">...</MyElement>
```

The second example shows the use of `xpath` for referencing the first `MyTargetElement` contained as a child after going up three times in the description tree along the parent axis from the current element which contains the specified `xpath` attribute.

```
<MyElement xpath="../../../MyTargetElement[1]">...</MyElement>
```

The following example shows the use of `href` for referencing to an element with the ID "id1" in "anotherdescription.mp7".

```
<MyElement href="www.example.com/anotherdescription.mp7#id1"/>
```

3.4.2.2 XPath datatypes

Information on extraction and use is not provided.

3.4.3 Unique Identifier

3.4.3.1 UniqueID datatype

3.4.3.1.1 UniqueID datatype examples

The Unique Identifier datatype can be used when an identification of content is required, either the content or an instance of it. It can also be used as a unique reference to external entities, for example, to identify the rights associated with the content via a rights identifier belonging to an external IPMP system.

The following example show the use of the `UniqueID` datatype for identifying content. The first example shows the use of `UniqueID` datatype for identifying a book using the International Standard Book Number (ISBN).

```
<MyID type="ISBN">0-7803-5610-1</MyID>
```

The following examples shows the use of `UniqueID` datatype for describing an International Standard Work Code (ISWC).

```
<MyID organization="ISO" type="ISWC">T-034.524.680-1</MyID>
```

The following examples shows the use of `UniqueID` datatype for describing a URN as a unique identifier.

```
<MyID>urn:ietf:std:50</MyID>
```

Note that in this case the type and the organization are not specified in the attributes as they are already encoded in the identifier value itself. Furthermore, in this case the type of the identifier (URI) is the default value of "type" and does not need to be specified.

3.4.4 Time description tools

3.4.4.1 Time datatype

Information on extraction and use is not provided.

3.4.4.2 TimePoint datatype

Information on extraction and use is not provided.

3.4.4.3 Duration datatype

Information on extraction and use is not provided.

3.4.4.4 IncrDuration datatype

Information on extraction and use is not provided.

3.4.4.5 RelTimePoint datatype

Information on extraction and use is not provided.

3.4.4.6 RelIncrTimePoint datatype

Information on extraction and use is not provided.

3.4.4.7 TimeProperty attribute group

Information on extraction and use is not provided.

3.4.4.8 Time datatype examples

The following examples show the use of the `Time` datatypes. In a first example an event that started on the 3rd October 1987 at 14:13 in Germany and that has a duration of 10 days is described by:

```
<Time>
    <TimePoint>1987-10-03T14:13+01:00</TimePoint>
    <Duration>P10D</Duration>
</Time>
```

The following example describes the time at which a 3rd picture is taken given that one picture is taken each day:

```
<Time>
   <RelIncrTimePoint timeUnit="P1D"
timeBase="../../../Time[1]">3</RelIncrTimePoint>
</Time>
```

The following example counts time units of one day and refers to the start time of the event as a `timeBase` (e.g. first time point specification in the description).

The period of five days after the initial event is described as follows:

```
<Time>
   <RelIncrTimePoint timeUnit="P1D"
timeBase="../../../Time[1]">0</RelIncrTimePoint>
   <IncrDuration timeUnit="P1D">5</IncrDuration>
</Time>
```

The following example describes the time of an event occurring in England, two hours and 20 minutes after the initial one:

```
<Time>
   <RelTimePoint timeBase="../../../Time[1]">PT2H20M-01:00Z</RelTimePoint>
</Time>
```

This specification is similar to the example using `RelIncrTimePoint`. But here the time offset is specified by using a number of hours and minutes instead of counting time units. Additionally it is specified that the time zone is different. Thus the local time is not +01:00 as it was the case for the initial event but +00:00 UTC.

Further examples of time expressions can be found in the clause on `MediaTime`. The `Time` datatype can be used whenever there is a need to describe a time segment whether it is a time point or a whole period.

3.4.4.9 MediaTime datatype examples

The `MediaTime` datatype can be used to describe a time segment whether it is a time point or a whole period using the time information of the AV content. For example the `MediaTime` datatype can be used within the `MediaLocator` datatype.

Consider a video consisting of the following segments:

- Segment1: 0-0.1(sec)
- Segment2: 0.1-1(sec)
- Segment3: 1-10 (sec)
- Segment4: 10-20 (sec)
- Segment5: 20-1000 (sec)

The video and these segments are described using the `MediaTime` datatype in different ways in these examples. Remind that this is done to explain the possibilities of the `MediaTime` datatype. In a description usually only one of these possibilities are used throughout the document.

Segment 1 is described by using the start time of the video as time base: the XPath expression is applied relative to the context node which is the element in which the `mediaTimeBase` attribute is contained. For instance "../../MediaLocator[1]" specifies the first MediaLocator contained in the parent node in which also the MediaTime element is contained. Accordingly the time line of the located media element is used to specify the video segment by the start time and the duration of the segment.

```
<!-- Specification of the video location -->
<MediaLocator>
   <MediaUri>http://www.mpeg7.org/the_video.mpg</MediaUri>
</MediaLocator>

<!-- MediaTime for Segment1(0-0.1sec) -->
<MediaTime>
```

```
    <MediaRelTimePoint
mediaTimeBase="../../MediaLocator[1]">PT0S</MediaRelTimePoint>
    <MediaDuration>PT1N10F</MediaDuration>
</MediaTime>
```

Segment 2 is also specified by the start time of the segment and the duration.

```
<!-- MediaTime for Segment2(0.1-1sec) -->
<MediaTime>
    <MediaRelTimePoint
       mediaTimeBase="../../MediaLocator[1]">PT1N10F</MediaRelTimePoint>
    <MediaDuration>PT9N10F</MediaDuration>
</MediaTime>
```

For segment 3 counting mediaTimeUnits are used for the specification of the start time and the duration. The `mediaTimeUnit` is specified as 1N which is 1/30 of a second according to 30F. But if needed a `mediaTimeUnit` for the exact sampling rate of NTSC of 29.97...Hz is also possible with: `mediaTimeUnit`="PT1001N30000F". For the representation of the exact sampling rate of 25Hz in the case of the PAL or SECAM video format the time unit shall be instatiated by `mediaTimeUnit`="PT1N25F".

```
<!-- MediaTime for Segment3(1-10sec) -->
<MediaTime>
    <MediaRelIncrTimePoint mediaTimeUnit="PT1N30F"
       mediaTimeBase="../../MediaLocator[1]">30</MediaRelIncrTimePoint>
    <MediaIncrDuration mediaTimeUnit="PT1N30F">270</MediaIncrDuration>
</MediaTime>
```

The last segment again specifies the time using seconds and minutes.

```
<!-- MediaTime for Segment4(10-20sec) -->
<MediaTime>
    <MediaRelIncrTimePoint mediaTimeUnit="PT1N30F"
       mediaTimeBase="../../MediaLocator[1]">300</MediaRelIncrTimePoint>
    <MediaIncrDuration mediaTimeUnit="PT1N30F">300</MediaIncrDuration>
</MediaTime>
```

```
<!-- MediaTime for Segment5(20-1000sec) -->
<MediaTime>
    <MediaRelTimePoint
mediaTimeBase="../../MediaLocator[1]">PT20S</MediaRelTimePoint>
    <MediaDuration>PT16M20S</MediaDuration>
</MediaTime>
```

The duration may be described by counting `mediaTimeUnits` (in this case seconds) using `MediaIncrDuration` as follows:

```
<MediaIncrDuration mediaTimeUnit="PT1S">980</MediaIncrDuration>
```

For another example, consider a description of a video segment with its root segment specified with:

```
<MediaTime>
    <MediaTimePoint>1989-10-03T14:13:02:0F30</MediaTimePoint>
    <MediaIncrDuration mediaTimeUnit="PT1N30F">1340</MediaIncrDuration>
</MediaTime>
```

Since the video itself is assumed to have a frame rate of 30 frames per second, fractions of one second is set to 30F and the `mediaTimeUnit` is set to 1N. Thus, by specifying a segment of 1340 frames, the duration of the segment is also described. If needed the date can also be specified within the MediaTime. To specify a single frame in a video sequence, the frame numbers or the timestamps can be used in the following way:

```
<MediaTime>
   <MediaRelIncrTimePoint mediaTimeUnit="PT1N30F"
      mediaTimeBase="../../MediaTime[1]">561</MediaRelIncrTimePoint>
</MediaTime>
```

In this last case, the 561st frame is referenced using the very beginning of the described segment as a start point (it is assumed that this is the first occurrence of a MediaTime Element). The video itself is displayed at a frame rate of 30 frames per second. In the example each frame is counted (1N) thus the timestamp is 18s:21.

Alternatively, timestamps can be used directly to relate elapsed time to the counted frames as follows:

```
<MediaTime>
   <MediaRelTimePoint mediaTimeBase="../../MediaTime[1]">PT18S21N30F
   </MediaRelTimePoint>
</MediaTime>
```

Consider the case in which the video is divided into subsegments (e.g. a shot from 500 to 600) as follows:

```
<MediaTime>
   <MediaRelIncrTimePoint mediaTimeUnit="PT1N30F"
      mediaTimeBase="../../MediaTime[1]">500</MediaRelIncrTimePoint>
   <MediaIncrDuration mediaTimeUnit="PT1N30F">100</MediaIncrDuration>
</MediaTime>
```

A frame can be addressed within this segment as follows:

```
<MediaTime>
   <MediaRelIncrTimePoint mediaTimeUnit="PT1N30F"
      mediaTimeBase="../../../MediaTime">61</MediaRelIncrTimePoint>
</MediaTime>
```

In this case the start time of the shot (e.g. the parent node of the node which contains the present `MediaTime` datatype) is referenced as `mediaTimeBase`.

To avoid having to repeatedly describe the `mediaTimeUnit` and the `mediaTimeBase`, the `mediaTimeUnit` and `mediaTimeBase` attribute can be used in `VideoSegment` as follows:

```
<VideoSegment mediaTimeUnit="PT1N30F" mediaTimeBase="MediaLocator">
   <!-- more elements here -->
</VideoSegment>
```

If the specified `mediaTimeUnit` and `mediaTimeBase` attributes are instantiated in a video segment that is an ancestor of this instance, then the frame can be addressed as follows:

```
<VideoSegment mediaTimeUnit="PT1N30F" mediaTimeBase="MediaLocator">
   <TemporalDecomposition>
      <VideoSegment id="frame561">
         <MediaTime>
            <MediaRelIncrTimePoint>61</MediaRelIncrTimePoint>
         </MediaTime>
      </VideoSegment>
   </TemporalDecomposition>
</VideoSegment>
```


3.4.5 Media Locators

3.4.5.1 MediaLocator datatype

3.4.5.2 InlineMedia datatype

3.4.5.2.1 InlineMedia datatype examples

The `InlineMedia` datatype enables for instance an embedding of small audio clips and image thumbnails in the description, without having to refer to external data. An example is as follows.

```
<MyInlineMedia type="image/jpeg">
       <MediaData16>98A34F10C5094538AB9387362522DA3</MediaData16>
</MyInlineMedia>
```

3.4.5.3 TemporalSegmentLocator datatype

Information on extraction and use is not provided.

3.4.5.4 ImageLocator datatype

Information on extraction and use is not provided.

3.4.5.5 MediaLocator datatype examples

In the following example the location of a video segment is specified by the URI of a video file and the relative start time with respect to the beginning of the file and the duration of the segment.

```
<MyTemporalSegmentLocator>
    <MediaUri>http://www.mpeg7.org/demo.mpg</MediaUri>
    <MediaTime>
       <MediaRelTimePoint
mediaTimeBase="../../MediaUri">PT3S</MediaRelTimePoint>
       <MediaDuration>PT10S</MediaDuration>
    </MediaTime>
</MyTemporalSegmentLocator>
```

In the second example, the `MediaLocator` refers to a particular stream within an MPEG-4 file.

```
<MyMediaLocator>
    <MediaUri>http://www.mpeg7.org/demo.mp4</MediaUri>
    <StreamID>1</StreamID>
</MyMediaLocator>
```

In the third example, the media data is simply located using a byte-offset from the start of a known file.

```
<MyImageLocator>
    <MediaUri>http://www.mpeg7.org/demo.ppm</MediaUri>
    <BytePosition offset="1024"/>
</MyImageLocator>
```

3.5 Basic description tools

3.5.1 Introduction

This clause defines the basic tools, which are used as components for building other description tools. The basic tools are used in the Multimedia Description Schemes part of the standard (ISO/IEC 15938-5) and also in audio part (see ISO/IEC 15938-4) and visual (see ISO/IEC 15938-3) part. The tools defined in this clause are as follows.

Table 6 - Overview of Basic Description Tools.

Tool	*Functionality*
Language Identification	Tools for identifying the language of a textual description or of the multimedia content itself. This standard uses the XML defined `xml:lang` attribute to identify the language used to write a textual description.
Text Annotation	Tools for representing unstructured and structured textual annotations. Unstructured annotations (i.e. with free text) are represented using the `FreeTextAnnotation` datatype. Annotations that are structured in terms of answering the questions "Who? What? Where? How? Why?" are represented using the `StructuredAnnotation` datatype. Annotations structured as a set of keywords are representations using the `KeywordAnnotation`

	datatype. Finally, annotations structured by syntactic dependency relations—for example, the relation between a verb phrase and its subject—are represented using the `DependencyStructure` datatype.
Classification Schemes and Terms	Tools for classifying using language-independent terms and for defining sets of terms as classification schemes. The `ClassificationScheme` DS describes a vocabulary for classifying a subject area as a set of terms organized into a hierarchy. A term defined in a classification scheme is used in a description with the `TermUse` or `ControlledTermUse` datatypes. Graphical classification schemes are schemes for classifying where the terms in the scheme are themselves graphs. Such schemes can be used as structural templates, for validating of graph-based descriptions, and for graph productions.
Agents	Tools for describing "agents", including persons, groups of persons, and organizations. The `Person` DS represents a person, the `PersonGroup` DS a group of persons, and the `Organization` DS an organization of people.
Places	Tools for describing geographical locations. The `Place` DS is used to describe real and fictional places.
Graphs and Relations	Tools for representing relations and graph structures. The `Relation` DS is a tool for representing named relations between instances of description tools. The `Graph` DS organizes relations into a graph structure.
Ordering	The `OrderingKey` DS describes hints for ordering descriptions
Affective Description	The `Affective` DS describes an audience's affective response to multimedia content.
Phonetic Description	The `PhoneticTranscriptionLexicon` DS describes the pronunciations of a set of words.

3.5.2 Language identification

3.5.2.1 xml:lang attribute

3.5.2.1.1 xml:lang attribute examples

Consider the following example:

```
<TextAnnotation xml:lang="en">
   <KeywordAnnotation>
      <Keyword xml:lang="fr"> chien </Keyword>
      <Keyword> dog </Keyword>
   </KeywordAnnotation>
</TextAnnotation>
```

In this example, the outer level `TextAnnotation` specifies that the language of the description is English ("en"). This automatically applies to all elements contained and thus the value of the `xml:lang` for the contained `Keyword` "dog", defaults to be English. However, because the keyword "chien" specifies that the language is French ("fr") using xml:lang, this value overrides the language specified in the containing `TextAnnotation`.

3.5.2.2 language datatype

3.5.2.2.1 language datatype examples

The `xsd:language` datatype is used for identifying the language properties of the multimedia content. For example, to indicate the language used in the audio, the written language of subtitles, or a user's preferred language for viewing content.

The example below states that the preferred language is English.

```
<PreferredLanguage>en</PreferredLanguage>
```

3.5.3 Textual annotation

3.5.3.1 Textual datatypes

3.5.3.1.1 Textual datatypes example

For examples of the use of these datatypes, see the subclause specifying the `TextAnnotation` datatype.

3.5.3.2 TextAnnotation datatype

3.5.3.2.1 TextAnnotation datatype examples

The following example shows an annotation of a video depicting the scene "Tanaka throws a small ball to Yamada. Yamada catches the ball with his left hand."

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="VideoType">
         <Video>
            <MediaLocator>
               <MediaUri>video.mpg</MediaUri>
            </MediaLocator>
            <TextAnnotation>
               <FreeTextAnnotation xml:lang="en">
                  Tanaka throws a small ball to Yamada.
                  Yamada catches the ball with his left hand.
               </FreeTextAnnotation>
               <StructuredAnnotation>
                  <Who href="urn:people:TANAKA100">
                     <Name xml:lang="en">Tanaka</Name>
                  </Who>
                  <Who>
                     <Name xml:lang="en"> Yamada </Name>
                  </Who>
                  <WhatObject>
                     <Name xml:lang="en"> A small ball </Name>
                  </WhatObject>
                  <WhatAction>
                     <Name xml:lang="en"> Tanaka throws a small ball to
Yamada.
                     </Name>
                  </WhatAction>
                  <WhatAction>
                     <Name xml:lang="en"> Yamada catches the ball with his
left
                        hand. </Name>
                  </WhatAction>
               </StructuredAnnotation>
            </TextAnnotation>
         </Video>
      </MultimediaContent>
   </Description>
</Mpeg7>
```


In this example, there are two different forms of the annotation for the same event:

- **Free text annotation**. This is simply an English description of what happened in the scene without any structuring.
- **Structured text annotation**. In this case the annotation is more structured; "Yamada" is identified as the "Who" and the ball he is throwing as the "What" in the annotation. Also, notice

that Yamada is identified using a term "urn:people:TANAKA100" from a classification scheme for identifying people (identified as "urn:people"). .

3.5.3.3 StructuredAnnotation datatype

Information on extraction and use is not provided.

3.5.3.4 KeywordAnnotation datatype

3.5.3.4.1 KeywordAnnotation datatype examples

The following example shows an annotation describing a video about the U.S. presidential election using keywords:

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="VideoType">
         <Video>
            <TextAnnotation>
               <KeywordAnnotation xml:lang="en">
                  <Keyword>election</Keyword>
                  <Keyword>United States of America</Keyword>
                  <Keyword>President</Keyword>
               </KeywordAnnotation>
            </TextAnnotation>
         </Video>
      </MultimediaContent>
   </Description>
</Mpeg7>
```

3.5.3.5 DependencyStructure datatype

3.5.3.5.1 DependencyStructure datatype examples

The following rules specify the dependency relations in English:

Governor	Dependent	Operator/FunctionWord (of DependencyStructure datatype)	Example (G: Governor, D: Dependent)
Verb	Noun	`subject`	John (D) drank (G)
Verb	Noun	`object`	drink (G) water (D)
Verb	Noun	`indirectObject`	tell (G) you (D) the fact
Verb	Preposition	`functionWord=`(Preposition)	respect (G) for (D) John sit (G) on (D) a chair
Verb	Noun Adjective Preposition	`predicate`	make (G) it possible (D) are (G) friends (D) is (G) without (D) a hat John returned (G) rich (D)
Verb	Adverb		walk (G) fast (D)
Verb	Conjunction	`functionWord=`(Conjunction)	started (G) before (D) I finished breakfast
Noun	Adjective		good (D) friends (G)
Noun	Genitive		John's (D) friends (G)
Noun	Determiner		the (D) cake (G)
Noun	Noun		London (D) hospital (G)

Governor	Dependent	Operator/FunctionWord (of DependencyStructure datatype)	Example (G: Governor, D: Dependent)
Noun	Preposition	`functionWord`=(Preposition)	years (G) of (D) war
Noun	Verb	`functionWord`=(Relative-pronoun)	people (G) who think (D) that
Adjective	Adverb		very (D) good (G)
Preposition	Noun		in (G) water (D)
Conjunction	Verb		before (G) I finished (D) breakfast
Auxiliary verb	Verb		can (G) read (D) a book
"to“	Verb		to (G) go (D) to bed

Rules for other languages can be specified in a similar fashion but are not specified by this standard.

Consider the dependency structure of the following sentence: "John talks to Mary whom he loves." According the rule above, the following tree structure (syntactic tree) represents the dependency structure of the sentence.

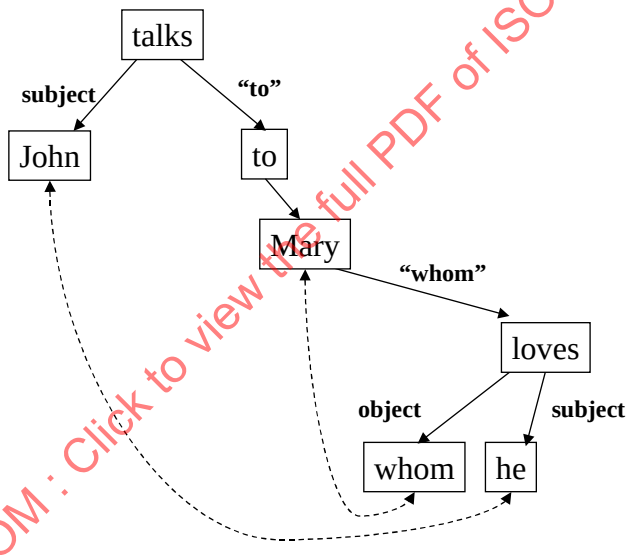


Figure 1 - Example of dependency structure of the sentence: "John talks to Mary whom he loves.“

The solid arrows in Figure 1 show dependency relations and the dashed arrows indicate coreference relations. The labels attached to the arrows indicate the type of dependency relation. Specifically, the verb "talks" governs "John" and "to (Mary)", while "Mary" governs a verb "loves“ in a relative clause. In the relative clause, the verb "loves" governs "whom", which refers "Mary“ in a main clause, and "he", which refers to "John“.

The following shows the example represented using the `DependencyStructure` datatype:

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="VideoType">
         <Video>
            <TextAnnotation>
               <DependencyStructure xml:lang="en">
                  <Sentence>
                     <Phrase operator="subject">
                        <Head type="noun" id="JOHN">John</Head>
                     </Phrase>
                     <Head type="verb" baseForm="talk">talks</Head>
```

```
                        <Phrase functionWord="to">
                           <Head type="preposition">to</Head>
                           <Phrase>
                              <Head type="noun" id="MARY">Mary</Head>
                              <Phrase functionWord="whom">
                                 <Phrase operator="object">
                                    <Head type="pronoun"
equal="MARY">whom</Head>
                                 </Phrase>
                                 <Phrase operator="subject">
                                    <Head type="pronoun" equal="JOHN">he</Head>
                                 </Phrase>
                                 <Head type="verb" baseForm="love">loves</Head>
                              </Phrase>
                           </Phrase>
                        </Phrase>
                     </Sentence>
                  </DependencyStructure>
               </TextAnnotation>
            </Video>
         </MultimediaContent>
      </Description>
</Mpeg7>
```

Notice that the preposition "to" is represented as a `functionWord` attribute attached to the Phrase element representing "to Mary who he loves".

3.5.3.5.2 DependencyStructure datatype extraction

Using a natural language parser (NL parser), it is possible to generate the dependency structure for manually generated free text annotations. For example, one can automatically extract the following information:

Dependency structures

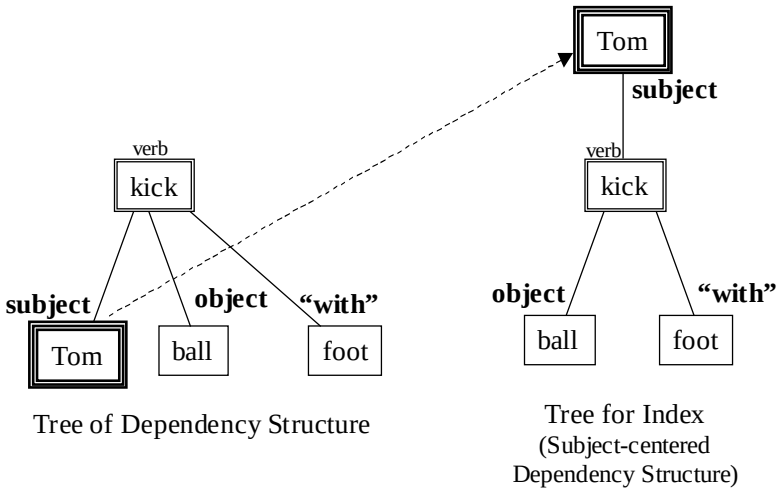
Syntactic role of phrases in the annotation-sentences (relationship with governor is represented by the particle attribute and the operator attribute).

In general, natural language syntactic analysis involves some ambiguity, i.e., a unique solution cannot always be given. The constrained annotations generated by professionals have a relatively simple structure and high accuracy can generally be obtained. On the other hand, amateur annotations, which tend to include many modifiers that make sentences long, results in relatively low analysis accuracy.

Human correction for erroneous results of the syntactic analysis is usually needed. Most of the errors come from the syntactic ambiguity about which phrase modifies which term. Correcting this type of error needs semantic analysis of the sentences. But the error can be fixed by simply changing a governor term (i.e., head) of a modifier phrase (i.e., dependent), which is not very complicated for humans. The syntactic analysis by the NL parser is helpful for instantiation of the Dependency Structure not only from the professional style annotations but also from the amateur style ones that include syntactic ambiguity.

One can retrieve audio or video segments using natural language as an interface by describing video segment with the DependencyStructure datatype. To do this a video segment index is prepared according to the following procedure.

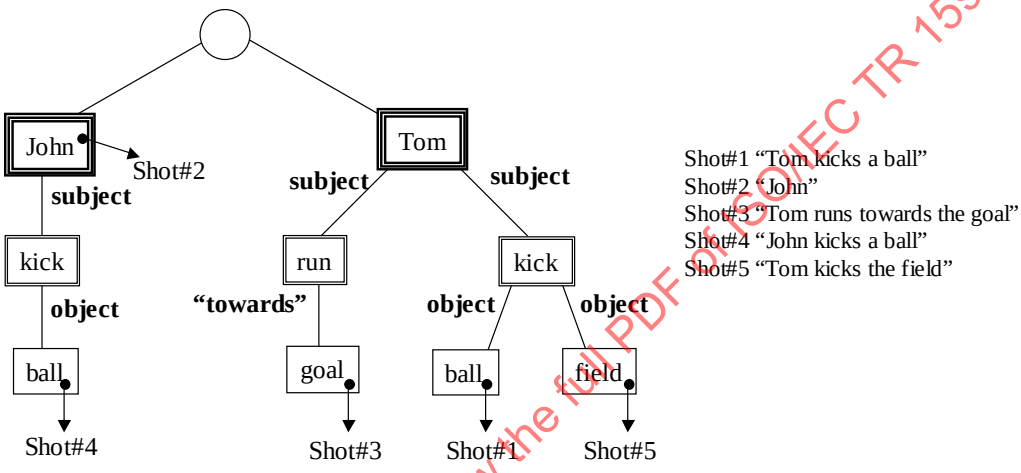
For each segment, the syntactic tree representing an instance of the Dependency Structure is converted to a tree structure for index use. In the tree structure, a noun that is a head of a "sentence" or a head of a phrase that depends on a predicate of a "sentence" as a subject is taken to be the root node. If no such term exists, a dummy node is added.



Tree of Dependency Structure

Tree for Index
(Subject-centered
Dependency Structure)

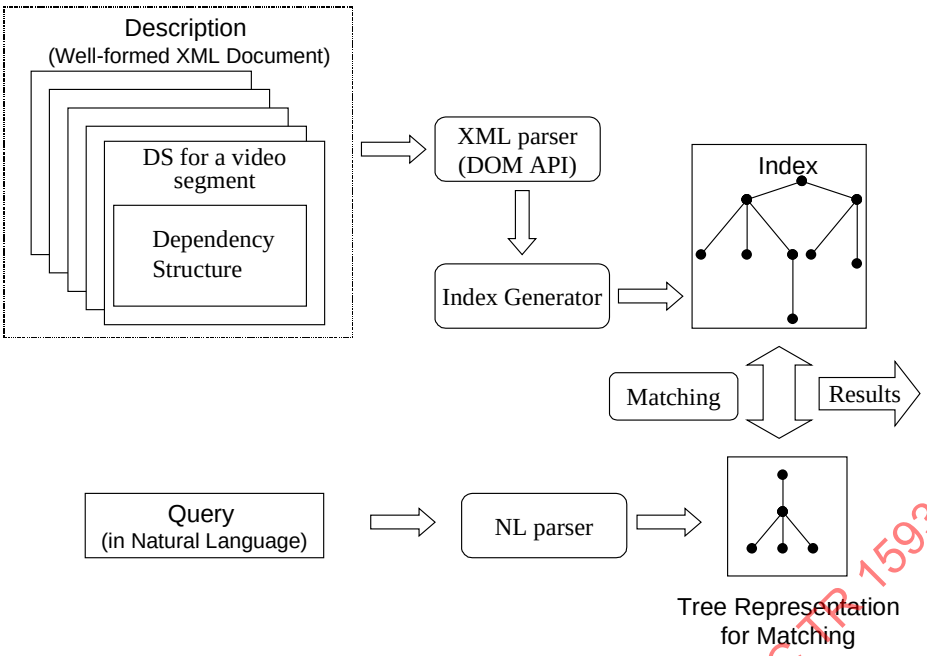
All tree structures for the segment index included in the database are merged to form a database index tree.



Each node in the index tree stores a pointer to the segment in question. Therefore, to perform a search using this index tree, a natural language search query is first converted to a tree structure. This tree is then matched with the index trees to find the desired segment.

Matching may be achieved by partial tree matching and, in the case of inter-node matching, similarity-based retrieval can be performed by using a thesaurus or the like. The reason for configuring an index tree centered about the subject/theme is that candidate can be narrowed down from the start through the use of subjects/themes, which provide the most information in keyword-centered annotations.

An example system is configured as follows.



Traditionally, keywords are used when retrieving based on language. However, using the Dependency Structure has the following advantages.

It supports retrieval that specify inter-element relationships such as "A gives B to C" which cannot be expressed solely by Boolean operators (AND/OR) as employed in ordinary keyword retrieval.

It supports flexible retrieval by allowing the use of "wild cards" such as in the expression "C eats something."

It requires no special query language (retrieval can be performed with natural language sentences).

3.5.4 Classification Schemes and Terms

3.5.4.1 ClassificationScheme DS

3.5.4.1.1 ClassificationScheme format and importing

Information on extraction and use is not provided.

3.5.4.1.2 ClassificationScheme DS examples

The following subclauses show several different examples of defining classification schemes.

Classification Scheme Example One: Audio Domain

The following example shows a classification scheme for audio domain. Note that while this example is based on the the AudioDomainCS classification specified in Annex A, it has been modified and simplified here for explanatory purposes. The instance of the ClassificationScheme DS defining the scheme looks as follows:

```
<Mpeg7>
   <Description xsi:type="ClassificationSchemeDescriptionType">
      <ClassificationScheme uri="urn:mpeg:mpeg7:cs:AudioDomainCS"

   domain="//MediaInformation/MediaProfile/MediaIdentification/AudioDomain">
         <Header xsi:type="DescriptionMetadataType">
            <Version>1.0</Version>
            <Rights>
               <RightsID>urn:rights:x0d01d</RightsID>
            </Rights>
         </Header>
         <Term termID="1">
            <Name xml:lang="en">Source</Name>
            <Definition xml:lang="en">Type of audio source</Definition>
            <Term termID="1.1">
               <Name xml:lang="en">Synthetic</Name>
            </Term>
            <Term termID="1.2">
```

```
                <Name xml:lang="en">Natural</Name>
            </Term>
        </Term>
        <Term termID="2">
            <Name xml:lang="en">Acquisition</Name>
            <Definition xml:lang="en">Type of Content</Definition>
            <Term termID="2.1">
                <Name xml:lang="en">Music</Name>
            </Term>
            <Term termID="2.2">
                <Name xml:lang="en">Speech</Name>
                <Name xml:lang="jp">Onsei</Name>
            </Term>
            <Term termID="2.3">
                <Name xml:lang="en">Mixed</Name>
            </Term>
            <Term termID="2.4">
                <Name xml:lang="en">Multi-track</Name>
            </Term>
        </Term>
        <Term termID="3">
            <Name xml:lang="en">Use</Name>
            <Definition xml:lang="en">Original usage domain</Definition>
            <Term termID="3.1">
                <Name xml:lang="en">Scientific</Name>
            </Term>
            <Term termID="3.2">
                <Name xml:lang="en">Medical</Name>
            </Term>
            <Term termID="3.3">
                <Name xml:lang="en">Security</Name>
            </Term>
            <Term termID="3.4">
                <Name xml:lang="en">Broadcast</Name>
            </Term>
            <Term termID="3.4">
                <Name xml:lang="en">CD-A distribution</Name>
            </Term>
        </Term>
    </ClassificationScheme>
  </Description>
</Mpeg7>
```


The first part of the `ClassificationScheme` instance contains "header" information including:

- **URI**. The unique identifier for this `ClassificationScheme` is a URN: "`urn:mpeg:mpeg7:cs:AudioDomainCS`". The first part of the URI "`urn:`" indicates that this URI is a URN. In fact, all classification schemes defined in this document use URNs as their unique identifier. The second part of the URN, "mpeg", is the namespace identifier. In this case the namespace identifier ("`mpeg`") is one that is registered as belonging to MPEG. Following the "mpeg" namespace identifier is the namespace specific string "`mpeg7`", which identifies the classification schemes as being defined in this standard and a "`cs`" string, which indicates that name, is for a classification scheme. Finally, the "`AudioDomainCS`" is the name assigned to the classification scheme within the "`mpeg`" URN namespace.
- **Domain**. The suggested domain for this `ClassificationScheme` is "`MediaInformation/MediaProfile/MediaIdentification/AudioDomain`". The domain is expressed as an XPath value. In this case, the XPath matches the `AudioDomain` element defined inside of the `MediaIdentification` DS (contained within the `MediaProfile` DS in the `MediaInformation` DS).
- **Description Metadata**. This element contains metadata about the `ClassificationScheme` itself. In the example, the description metadata indicates that this is version "1.0" of the

classification scheme and that the intellectual property rights for the classification scheme are identified by "`urn:rights:x0d01d`".

The next part of this `ClassificationScheme` contains a list of term definitions. This list includes:

- **Term Identifiers**. In this classification scheme, the term identifiers are numerals that encode the term hierarchy. However, this use is simply a convention adopted in this classification scheme. In fact, term identifiers are simply opaque values whose only requirement is that they be unique within the classification scheme. For example, instead of the term identifier "1" for the term "Source", the term identiifer might equally well have been "0d3d" or "source".
- **Term Names**. Each term in this classification scheme has an English name (the language is indicated by the `xml:lang` attribute having a value of "en"). The term names are human readable labels for the terms. Note that terms may have names in multiple languages. For example, term "2.2" has a name in both English ("Speech") and Japanese ("Onsei").
- **Term Definitions**. Only terms "1" and "2" have prose definitions in this classification scheme. The other terms do not have written definitions, which is allowed because the `Definition` element in a term is optional.
- **Term Relations**. This classification scheme contains a hierarchy of terms. In others words, it defines broader term/narrower term relations between pairs of terms. For example, term "1" is a broader term than term "1.1" and term "1.1" is a narrower term than term "1" – these are inverse relations. Note that the definition of term "1.1" is syntactically contained within the definition of term "1". This is how term relations are written in a ClassificationScheme. In fact, other kinds of relations can be specified by using the "relation" attribute to relate the parent and contained terms. Because the default value of a term relation is "NT", indicating that the contained term is narrower than the containing term.

Classification Scheme Example Two: Genre

The following figure shows an example of a simple classification for genre identified by the URI "`urn:example:Genre`". In the figure below, round boxes represent classification schemes and square boxes represent terms.

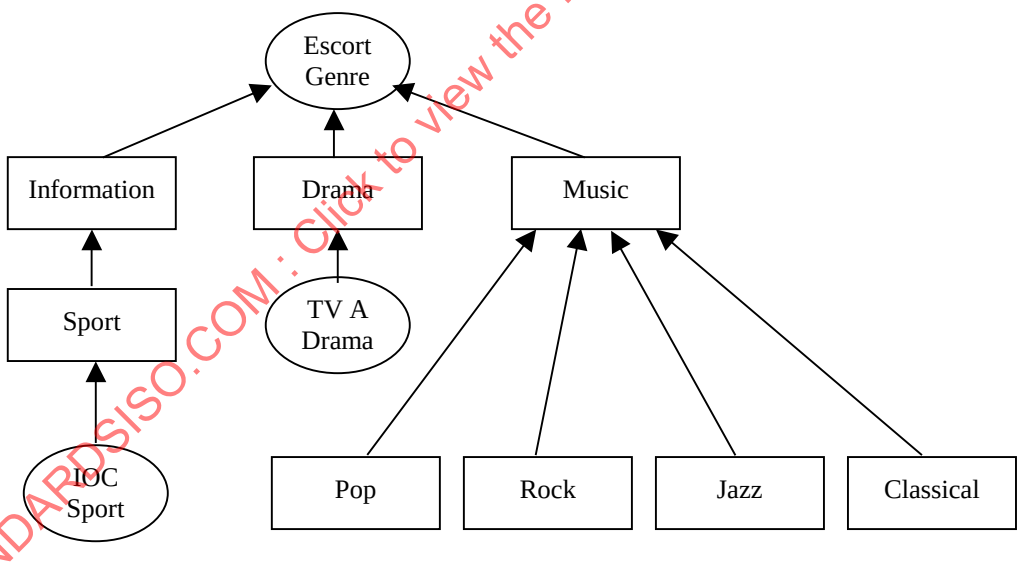


Figure 2 - Illustration of the "Escort2_4: Genre" Genre Classification Scheme.

In this example, there are three terms at the highest level: information, drama, and music. Below the category "information", there is a more detailed term: "Sport". Rather than defining a complete classification for sports, this example shows how an existing classification scheme can be imported. The existing "IOC Sport" classification scheme is added below the "Sport" item. Similarly, the drama category imports the "TVE Drama" classification scheme. For music, the sub-terms (narrower in meaning than their containing term) are "Pop", "Rock", "Jazz", and "Classical".

```
<Mpeg7>
   <Description xsi:type="ClassificationSchemeDescriptionType">
      <ClassificationScheme uri="urn:example:Genre"
         domain="//CreationInformation/Classification/Genre">
         <Import href="http://www.tvid.org/TVE/Drama/"/>
```

```
          <Import href="http://www.ioc.org/IOC/Sports/"/>
          <Term termID="information">
             <Name xml:lang="en">Information</Name>
             <Definition xml:lang="en">Generic news</Definition>
             <!-- This narrower term comes from the imported IOC Sports scheme
-->
             <Term termID="sports"/>
          </Term>
          <Term termID="drama">
             <!-- This narrower term comes from the imported drama scheme-->
          </Term>
          <Term termID="music">
             <Term termID="rock">
                <Name xml:lang="en">Rock</Name>
             </Term>
             <Term termID="pop">
                <Name xml:lang="en">Pop</Name>
             </Term>
             <Term termID="jazz">
                <Name xml:lang="en">Jazz</Name>
             </Term>
             <Term termID="classical">
                <Name xml:lang="en">Classical</Name>
             </Term>
          </Term>
       </ClassificationScheme>
    </Description>
</Mpeg7>
```

3.5.4.2 TermDefinition DS

Information on extraction and use is not provided.

3.5.4.3 TermUse datatype

3.5.4.3.1 TermUse datatype examples

3.5.4.3.1.1 Term reference use

The following example shows some examples of *term reference* using several different means to refer to terms:

```
<!-- Referring to a term using a URN -->
<TermUse href="urn:mpeg:mpeg7:cs:GenreCS:alternativeJazz"/>

<!-- Referring to a term using a HTTP URI -->
<TermUse href="http:://www.mpeg.org/GenreCS.xml#alternativeJazz"/>

<!-- Referring to a term using a classification scheme alias -->
<!-- Define schema aliases                                   -->
<ClassificationSchemeAlias alias="s1" href="urn:mpeg:mpeg7:cs:GenreCS"/>
<ClassificationSchemeAlias alias="s2" href="http:://www.mpeg.org/GenreCS.xml"/>

<!-- Refer to the term using the two schema aliases          -->
<TermUse href=":s1:alternativeJazz"/>
<TermUse href=":s2:alternativeJazz"/>
```

The reference to the term is included in the href attribute. In the first example, this is the URN "`urn:mpeg:mpeg7:cs:GenreCS:alternativeJazz`". Using URN's to reference terms defined in classification schemes is preferred in general and shall be used for referring to terms defined in this document. However, terms defined in existing classification managed by other organizations can be referred to using any valid URI. For example, the reference "`http:://www.mpeg.org/GenreCS.xml#alternativeJazz`" uses a HTTP format for referring to a term. The final two example of `TermUse` show the use of classification schemes aliases, which provide an

abbreviated syntax for referring to terms. In this case, aliases "s1“ is assigned to the classification scheme identified by "urn:mpeg:mpeg7:cs:GenreCS“ and the alias "s2“ is assigned to the classification at "http://www.mpeg.org/GenreCS.xml“. For further details on term references, see the specification of the termReference datatype.

3.5.4.3.1.2 Inline term use

This next example shows an *inline* term use.

```
<TermUse href="urn:AISF:Sports:1.4.9">
   <Name xml:lang="en">Basketball</Name>
   <Definition xml:lang="en">Basket Description</Definition>
   <Term relation="BT" termID="1.4">
      <Name xml:lang="en">Sport</Name>
      <Definition xml:lang="en">Sports news</Definition>
      <Term relation="BT" termID="1">
         <Name xml:lang="en">Information</Name>
         <Definition xml:lang="en">Generic news</Definition>
      </Term>
   </Term>
</TermUse>
```

In this example, the term "1.4.9" (i.e. basketball) is taken from the "urn:AISF:Sports" classification scheme. In addition to the term identifier in the href attribute, the TermUse also includes inline information about the term: its name, definition, and some related terms. In this example, the term "1.4.9“ is related to the broader term "1.4", which is in turn related to the broader term "1". In other words, this indicates that the hierarchy of terms for the genre is: 1.4.9 (Basketball) --> Sports (1.4) --> 1 (Information) .

3.5.4.3.1.3 Free term use

The last example shows the use of TermUse datatype as a *free term use.*

```
<TermUse>
   <Name>My genre</Name>
</TermUse>
```

What distinguishes a free term from a reference TermUse or an inline TermUse is that there is no reference to a term in a classification scheme. Instead of referencing the term, a free term use includes an arbitrary textual name or definition. This use is supported to allow the option of either writing free text or using a term inside of a description. It provides the greatest freedom of expression as no restrictions are imposed. On the other hand, this means that an application may find it difficult to interpret the content of a free TermUse.

3.5.4.4 ControlledTermUse datatype

3.5.4.4.1 ControlledTermUse datatype examples

The following example shows how a ControlledTermUse can refer to a term in an existing classification scheme, which has not been defined as an instance of the ClassificationScheme DS. The first example is taken from The Art and Architecture Thesaurus (AAT) compiled by the Getty Research Institutes. The AAT is a thesaurus widely used for cataloguing in the museum community. This case shows how the term for "High Baroque" in the AAT can be referenced as a controlled term:

```
<ControlledTermUse href="http://www.getty.edu/aat/21150">
   <Name xml:lang="en">High Baroque</Name>
   <Definition>The fully Baroque style that emerged in ...</Definition>
</ControlledTermUse>
```

Note several things about this example:

- **Term Reference**. In this example, the resource for the term is identified by a URI. In the example, the URI identifies the source (the Getty Research Institute) and the term's identifier ("21150") within the AAT. In the AAT, term identifiers are opaque numeric values.
- **Name and Definition**. Names and definitions can be given for terms in a classification schemes by including them inline inside of the ControlledTermUse. In this case the name indicates that

the term means "High Baroque" in English and gives a definition of that term in English (abbreviated in the example).

The second example of referencing a term in an existing classification scheme uses a term in the Dewey Decimal classification scheme (used in many libraries for cataloguing books).

```
<ControlledTermUse href="urn:dewey:630">
   <Name xml:lang="en">Agriculture</Name>
</ControlledTermUse>
```

The term is referenced using a URN (made up for the purpose of this example), which indicates that the term comes from the "dewey" URN identifier space. The "630" following the colon further qualifies the in the "dewey" URN space. In this case it indicates that it refers to the "630"; that is, pertaining to agriculture.

3.5.4.5 termReference datatype

3.5.4.5.1 Format of URN for terms

The following defines the normative form of URN for referring to terms defined in classification schemes specified in this or other parts of the ISO/IEC 15938 standard.

If the `termReferenceType` is a URI, and the term being referenced is defined in ISO/IEC 15938, whether normative or informative, then the URI shall be a URN of the following form:

`urn:mpeg:mpeg7:cs:`*`SchemeName`*`:`*`termID`*"

The "`urn:mpeg:mpeg7:cs:`*`SchemeName`*" is the URN identifying the classification scheme for this term, as specified in 3.5.4. The *`termID`* part of the URN shall match the `termID` attribute value specified for the term in the term's definition. Note however that URN's defined in the MPEG URN namespace are case insensitive and therefore the use of upper and lowercase letters are not distinguished in both *`termID`* and *`schemeName`*

For classification schemes that are not defined in ISO/IEC 15938, the form of the URI used to reference terms is not specified by this standard. However, using a URN for term reference URIs is strongly recommended.

3.5.4.6 ClassificationSchemeAlias datatype

Information on extraction and use is not provided.

3.5.4.7 GraphicalClassificationScheme DS

Information on extraction and use is not provided.

3.5.4.8 GraphicalTermDefinition DS

Information on extraction and use is not provided.

3.5.4.9 GraphicalRuleDefinition DS

Information on extraction and use is not provided.

3.5.4.10 PullbackDefinition DS

Information on extraction and use is not provided.

3.5.4.11 DoublePullbackDefinition DS

Information on extraction and use is not provided.

3.5.4.12 PushoutDefinition DS

Information on extraction and use is not provided.

3.5.4.13 DoublePushoutDefinition DS

Information on extraction and use is not provided.

3.5.4.14 GraphicalTermDefinition DS examples

The complete example description follows:

```
<Mpeg7>
   <Description xsi:type="ClassificationSchemeDescriptionType">
      <ClassificationSchemeBase xsi:type="GraphicalClassificationSchemeType"
         uri="urn:example:cs:Graph1">
```

```
            <GraphicalTerm termID="1">
               <AlphabetGraph id="ag">
                  <Node id="unknown">
                     <Name href="urn:example:any"/>
                  </Node>
                  <Node id="boundary">
                     <Name href="urn:example:Object"/>
                  </Node>
                  <Node id="context">
                     <Name href="urn:example:any"/>
                  </Node>
                  <Relation id="ag1" source="#unknown" target="#unknown"
                     type="urn:example:any"/>
                  <Relation id="ag2" source="#boundary" target="#unknown"
                     type="urn:example:any"/>
                  <Relation id="ag3" source="#unknown" target="#boundary"
                     type="urn:example:any"/>
                  <Relation id="ag4" source="#boundary" target="#context"
                     type="urn:example:any"/>
                  <Relation id="ag5" source="#context" target="#boundary"
                     type="urn:example:any"/>
                  <Relation id="ag6" source="#context" target="#context"
                     type="urn:example:any"/>
               </AlphabetGraph>
            </GraphicalTerm>
            <GraphicalTerm termID="2">
               <ProductionRule xsi:type="PullbackDefinitionType">
                  <RuleGraph id="rg">
                     <Node id="rghand">
                        <Name href="urn:example:HandObject"/>
                     </Node>
                     <Node id="rgboundary">
                        <Name href="urn:example:Object"/>
                     </Node>
                     <Node id="rgcontext">
                        <Name href="urn:example:any"/>
                     </Node>
                     <Relation id="rg1" source="#rgboundary" target="#rghand"
                        type="urn:example:contains"/>
                     <Relation id="rg2" source="#rgboundary" target="#rgcontext"
                        type="urn:example:any"/>
                     <Relation id="rg3" source="#rgcontext" target="#rgboundary"

                        type="urn:example:any"/>
                     <Relation id="rg4" source="#rgcontext" target="#rgcontext"
                        type="urn:example:any"/>
                  </RuleGraph>
                  <AlphabetGraphRef href="urn:example:cs:Graph1:1"/>
                  <MorphismGraph>
                     <Relation source="#rghand" target="#unknown"
                        type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
                     <Relation source="#rgboundary" target="#boundary"
                        type="urn:example:any"/>
                     <Relation source="#rgcontext" target="#context"
                        type="urn:example:any"/>
                     <Relation source="#rg1" target="#ag2"
type="urn:example:any"/>
                     <Relation source="#rg2" target="#ag4"
type="urn:example:any"/>
                     <Relation source="#rg3" target="#ag5"
type="urn:example:any"/>
                     <Relation source="#rg4" target="#ag6"
type="urn:example:any"/>
                     <SourceGraphRef href="#rg"/>
```

```
                    <TargetGraphTermRef href="urn:example:cs:Graph1:1"/>
                </MorphismGraph>
            </ProductionRule>
        </GraphicalTerm>
    </ClassificationSchemeBase>
</Description>
<Description xsi:type="SemanticDescriptionType">
    <Semantics>
        <Label>
            <Name>Semantic description of "person" with "leftarm" and
"rightarm".
            </Name>
        </Label>
        <SemanticBase xsi:type="ObjectType" id="person">
            <Label>
                <Name>Person</Name>
            </Label>
        </SemanticBase>
        <SemanticBase xsi:type="ObjectType" id="leftarm">
            <Label>
                <Name>left arm</Name>
            </Label>
        </SemanticBase>
        <SemanticBase xsi:type="ObjectType" id="rightarm">
            <Label>
                <Name>right arm</Name>
            </Label>
        </SemanticBase>
        <Graph id="persongraph">
            <Relation id="person1" type="urn:example:has" source="#person"
                target="#leftarm"/>
            <Relation id="person2" type="urn:example:has" source="#person"
                target="#rightarm"/>
        </Graph>
    </Semantics>
</Description>
<Description xsi:type="SemanticDescriptionType">
    <Semantics>
        <Label>
            <Name> Morphisms graph of relations </Name>
        </Label>
        <Graph xsi:type="MorphismGraphType">
            <Relation source="#object3" target="#tom1"
                type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
            <Relation source="#object4" target="#mary1"
                type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
            <Relation source="#lhs1" target="#ew1"
                type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
            <SourceGraphTermRef href="urn:example:cs:Graph2:1"/>
            <TargetGraphRef href="#eastwestgraph"/>
        </Graph>
    </Semantics>
</Description>
</Mpeg7>
```

```
<Mpeg7>
    <Description xsi:type="ClassificationSchemeDescriptionType">
        <ClassificationSchemeBase xsi:type="GraphicalClassificationSchemeType"
            uri="urn:example:cs:Graph2">
            <GraphicalTerm termID="1">
                <AlphabetGraph id="ag">
                    <Node id="unknown">
                        <Name href="urn:example:any"/>
```

```
            </Node>
            <Node id="context">
               <Name href="urn:example:any"/>
            </Node>
            <Relation id="ag1" source="#unknown" target="#unknown"
               type="urn:example:any"/>
            <Relation id="ag2" source="#unknown" target="#context"
               type="urn:example:any"/>
            <Relation id="ag3" source="#context" target="#unknown"
               type="urn:example:any"/>
            <Relation id="ag4" source="#context" target="#context"
               type="urn:example:any"/>
         </AlphabetGraph>
      </GraphicalTerm>
      <GraphicalTerm termID="2">
         <ProductionRule xsi:type="DoublePullbackDefinitionType">
            <RuleGraph id="rule1">
               <Node id="rg1context">
                  <Name href="urn:example:any"/>
               </Node>
               <Node id="sun">
                  <Name href="urn:example:Sun"/>
               </Node>
               <Node id="waves">
                  <Name href="urn:example:waves"/>
               </Node>
               <Node id="fish">
                  <Name href="urn:example:fish"/>
               </Node>
               <Relation id="rg11" source="#rg1context" target="#context"
                  type="urn:example:any"/>
               <Relation id="rg12" source="#rg1context" target="#sun"
                  type="urn:example:contains"/>
               <Relation id="rg13" source="#rg1context" target="#waves"
                  type="urn:example:contains"/>
               <Relation id="rg14" source="#rg1context" target="#fish"
                  type="urn:example:contains"/>
            </RuleGraph>
            <RuleGraph id="rule2">
               <Node id="rg2context">
                  <Name href="urn:example:any"/>
               </Node>
               <Node id="clouds">
                  <Name href="urn:example:clouds"/>
               </Node>
               <Node id="icebergs">
                  <Name href="urn:example:icebergs"/>
               </Node>
               <Node id="seals">
                  <Name href="urn:example:seals"/>
               </Node>
               <Relation id="rg21" source="#rg2context" target="#context"
                  type="urn:example:any"/>
               <Relation id="rg22" source="#rg2context" target="#clouds"
                  type="urn:example:contains"/>
               <Relation id="rg23" source="#rg2context" target="#icebergs"
                  type="urn:example:contains"/>
               <Relation id="rg24" source="#rg2context" target="#seals"
                  type="urn:example:contains"/>
            </RuleGraph>
            <AlphabetGraphRef href="urn:example:cs:Graph2:1"/>
            <MorphismGraph>
               <Relation source="#rg1context" target="#context"
                  type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
```

```
                    <Relation source="#waves" target="#unknown"
                        type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
                    <Relation source="#sun" target="#unknown"
                        type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
                    <Relation source="#fish" target="#unknown"
                        type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
                    <Relation source="#rg11" target="#ag4"
                        type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
                    <Relation source="#rg12" target="#ag3"
                        type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
                    <Relation source="#rg13" target="#ag3"
                        type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
                    <Relation source="#rg14" target="#ag3"
                        type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
                    <SourceGraphRef href="#rule1"/>
                    <TargetGraphRef href="#ag"/>
                </MorphismGraph>
                <MorphismGraph>
                    <Relation source="#rg2context" target="#context"
                        type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
                    <Relation source="#clouds" target="#unknown"
                        type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
                    <Relation source="#icebergs" target="#unknown"
                        type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
                    <Relation source="#waves" target="#unknown"
                        type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
                    <Relation source="#rg21" target="#ag4"
                        type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
                    <Relation source="#rg22" target="#ag3"
                        type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
                    <Relation source="#rg23" target="#ag3"
                        type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
                    <Relation source="#rg24" target="#ag3"
                        type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
                    <SourceGraphRef href="#rule2"/>
                    <TargetGraphRef href="#ag"/>
                </MorphismGraph>
            </ProductionRule>
        </GraphicalTerm>
    </ClassificationSchemeBase>
  </Description>
</Mpeg7>
```

The following example takes a semantic description of a beach, described as having just beach and sky, and applies a rule that describes a beach as having both a beach and waves. The result (the output of the rule) is a beach with both sky and waves.

```
<Mpeg7>
   <Description xsi:type="ClassificationSchemeDescriptionType">
      <ClassificationSchemeBase xsi:type="GraphicalClassificationSchemeType"
         uri="urn:example:cs:Graph3">
         <GraphicalTerm termID="1">
            <ProductionRule xsi:type="PushoutDefinitionType">
               <LHSGraph id="lhs">
                  <Node id="agbeach">
                     <Name href="urn:example:beach"/>
                  </Node>
               </LHSGraph>
               <RHSGraph id="rhs">
                  <Node id="rgbeach">
                     <Name href="urn:example:beach"/>
                  </Node>
                  <Node id="rgwaves">
```

```
                        <Name href="urn:example:waves"/>
                    </Node>
                </RHSGraph>
                <MorphismGraph>
                    <Relation source="#agbeach" target="#rgbeach"
                        type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
                    <SourceGraphRef href="#lhs"/>
                    <TargetGraphRef href="#rhs"/>
                </MorphismGraph>
            </ProductionRule>
        </GraphicalTerm>
    </ClassificationSchemeBase>
</Description>
<Description xsi:type="SemanticDescriptionType">
    <Semantics>
        <Label>
            <Name>Beach scene</Name>
        </Label>
        <SemanticBase xsi:type="ObjectType" id="beach1">
            <Label>
                <Name>Beach</Name>
            </Label>
        </SemanticBase>
        <SemanticBase xsi:type="ObjectType" id="sky1">
            <Label>
                <Name>Sky</Name>
            </Label>
        </SemanticBase>
        <Graph id="beachgraph">
            <Node id="beach" href="#beach1"/>
            <Node id="sky" href="#sky1"/>
        </Graph>
    </Semantics>
</Description>
<Description xsi:type="SemanticDescriptionType">
    <Semantics>
        <Label>
            <Name> Morphisms graph of relations </Name>
        </Label>
        <Graph xsi:type="MorphismGraphType">
            <Relation source="#agbeach" target="#beach"
                type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
            <SourceGraphTermRef href="urn:example:cs:Graph3:1"/>
            <TargetGraphRef href="#beachgraph"/>
        </Graph>
    </Semantics>
</Description>
</Mpeg7>
```

```
<Mpeg7>
    <Description xsi:type="ClassificationSchemeDescriptionType">
        <ClassificationSchemeBase xsi:type="GraphicalClassificationSchemeType"
            uri="urn:example:cs:Graph4">
            <GraphicalTerm termID="1">
                <ProductionRule xsi:type="DoublePushoutDefinitionType">
                    <LHSGraph id="LHS">
                        <Node id="object3">
                            <Name href="urn:example:object"/>
                        </Node>
                        <Node id="object4">
                            <Name href="urn:example:object"/>
                        </Node>
```

```
                    <Relation id="lhs1" type="urn:example:west"
source="#object4"
                        target="#object3"/>
                </LHSGraph>
                <ContextGraph id="context">
                    <Node id="object1">
                        <Name href="urn:example:object"/>
                    </Node>
                    <Node id="object2">
                        <Name href="urn:example:object"/>
                    </Node>
                </ContextGraph>
                <RHSGraph id="RHS">
                    <Node id="object5">
                        <Name href="urn:example:object"/>
                    </Node>
                    <Node id="object6">
                        <Name href="urn:example:object"/>
                    </Node>
                    <Relation id="rhs1" type="urn:example:east"
source="#object5"
                        target="#object6"/>
                </RHSGraph>
                <MorphismGraph>
                    <Relation id="left1"
                        type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"
                        source="#object1" target="#object3"/>
                    <Relation id="left2"
                        type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"
                        source="#object2" target="#object4"/>
                    <SourceGraphRef href="#context"/>
                    <TargetGraphRef href="#LHS"/>
                </MorphismGraph>
                <MorphismGraph>
                    <Relation id="rgt1"
                        type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"
                        source="#object1" target="#object3"/>
                    <Relation id="rgt2"
                        type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"
                        source="#object2" target="#object4"/>
                    <SourceGraphRef href="#context"/>
                    <TargetGraphRef href="#LHS"/>
                </MorphismGraph>
            </ProductionRule>
        </GraphicalTerm>
    </ClassificationSchemeBase>
</Description>
<Description xsi:type="SemanticDescriptionType">
    <Semantics>
        <Label>
            <Name>East West</Name>
        </Label>
        <SemanticBase xsi:type="ObjectType" id="tom">
            <Label>
                <Name>Tom</Name>
            </Label>
        </SemanticBase>
        <SemanticBase xsi:type="ObjectType" id="mary">
            <Label>
                <Name>Mary</Name>
            </Label>
        </SemanticBase>
        <Graph id="eastwestgraph">
            <Node id="tom1" href="#tom"/>
```

```
            <Node id="mary1" href="#mary"/>
            <Relation id="ew1" type="urn:example:west" source="#Tom"
               target="#Mary"/>
         </Graph>
      </Semantics>
   </Description>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics>
         <Label>
            <Name> Morphisms graph of relations </Name>
         </Label>
         <Graph xsi:type="MorphismGraphType">
            <Relation source="#object3" target="#tom1"
               type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
            <Relation source="#object4" target="#mary1"
               type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
            <Relation source="#lhs1" target="#ew1"
               type="urn:mpeg:mpeg7:cs:GraphRelationCS:2001:identity"/>
            <SourceGraphTermRef href="urn:example:cs:Graph2:1"/>
            <TargetGraphRef href="#eastwestgraph"/>
         </Graph>
      </Semantics>
   </Description>
</Mpeg7>
```

3.5.5 Description of agents

3.5.5.1 Agent DS

Information on extraction and use is not provided.

3.5.5.2 Person DS

3.5.5.2.1 Person DS examples

The following example shows the use of Person DS for describing a production assistant who is an individual called "John Smith" in English and "Jean Smith" in French who is affiliated with ISO and whose e-mail address is "john.smith@iso.ch".

```
<Mpeg7>
   <Description xsi:type="CreationDescriptionType">
      <CreationInformation>
         <Creation>
            <Title/>
            <Creator>
               <Role href="urn:mpeg:mpeg7:cs:RoleCS:2001:PRODUCTION-
ASSISTANT"/>
               <Agent xsi:type="PersonType">
                  <Name xml:lang="en">
                     <GivenName>John</GivenName>
                     <FamilyName>Smith</FamilyName>
                  </Name>
                  <Name xml:lang="fr">
                     <GivenName>Jean</GivenName>
                     <FamilyName>Smith</FamilyName>
                  </Name>
                  <Affiliation>
                     <Organization>
                        <Name>International Standards Organization</Name>
                     </Organization>
                  </Affiliation>
                  <ElectronicAddress>
                     <Email>john.smith@iso.ch</Email>
                  </ElectronicAddress>
               </Agent>
```

```
            </Creator>
         </Creation>
      </CreationInformation>
   </Description>
</Mpeg7>
```

3.5.5.3 PersonGroup DS

3.5.5.3.1 PersonGroup DS examples

The following example describes the person group artist of musical content. The example shows how the `PersonGroup` describes a musical group, the Rolling Stones. Each member of the group (Mick Jagger, Keith Richard, Ron Wood, and Charlie Watts) is represented as a `Member` of the group. Each `Member` is represented by an instance of the Person DS.

```
<Mpeg7>
   <Description xsi:type="CreationDescriptionType">
      <CreationInformation>
         <Creation>
            <Title>Beggars Banquet</Title>
            <Creator>
               <Role href="urn:mpeg:mpeg7:cs:RoleCS:2001:ARTIST"/>
               <Agent xsi:type="PersonGroupType">
                  <Name>The Rolling Stones</Name>
                  <Kind>
                     <Name>Rock band</Name>
                  </Kind>
                  <Member>
                     <Name>
                        <GivenName initial="M">Mick</GivenName>
                        <FamilyName>Jagger</FamilyName>
                     </Name>
                  </Member>
                  <Member>
                     <Name>
                        <GivenName>Keith</GivenName>
                        <FamilyName>Richard</FamilyName>
                     </Name>
                  </Member>
                  <Member>
                     <Name>
                        <GivenName>Ron</GivenName>
                        <FamilyName>Wood</FamilyName>
                     </Name>
                  </Member>
                  <Member>
                     <Name>
                        <GivenName>Charly</GivenName>
                        <FamilyName>Watts</FamilyName>
                     </Name>
                  </Member>
               </Agent>
            </Creator>
         </Creation>
      </CreationInformation>
   </Description>
</Mpeg7>
```

3.5.5.4 Organization DS

3.5.5.4.1 Organization DS examples

The following example shows an example description of a disseminator organization named "Acme Inc."In this example, the kind of organization is a company. The contact for the company is a person named "John

Smith" who can be reached via his e-mail address of "jsmith@acme.org". Furthermore, the jurisdiction is the United States and the address for this organization is the `Place` DS instance whose id is "acme-address" (not shown in the example).

```
<Mpeg7>
    <Description xsi:type="CreationDescriptionType">
        <CreationInformation>
            <Creation>
                <Title/>
                <Creator>
                    <Role href="urn:mpeg:mpeg7:cs:RoleCS:2001:DISSEMINATOR"/>
                    <Agent xsi:type="OrganizationType" id="ORG1">
                        <Name type="main" xml:lang="en">Acme Inc.</Name>
                        <Name type="variant" xml:lang="en">ACME</Name>
                        <Kind>
                            <Name>company</Name>
                        </Kind>
                        <Contact xsi:type="PersonType">
                            <Name>
                                <GivenName>John</GivenName>
                                <FamilyName>Smith</FamilyName>
                            </Name>
                            <ElectronicAddress>
                                <Email>jsmith@acme.org</Email>
                            </ElectronicAddress>
                        </Contact>
                        <Jurisdiction>
                            <Region>us</Region>
                        </Jurisdiction>
                        <ElectronicAddress>
                            <Url>www.acme.com</Url>
                        </ElectronicAddress>
                    </Agent>
                </Creator>
            </Creation>
        </CreationInformation>
    </Description>
</Mpeg7>
```

3.5.5.5 PersonName datatype

3.5.5.5.1 PersonName datatype examples

The following series of examples show several different variations for describing the name for "Edward Hoover".

In the first example, the name is represented in the simplest fashion, with no decomposition into its various components:

```
<Name>
    <GivenName>Edward J. Hoover</GivenName>
</Name>
```

In the next example, the name is represented in a more structured fashion with additional information.

```
<Name>
    <GivenName>Edward</GivenName>
    <GivenName initial="J"/>
    <FamilyName>Hoover</FamilyName>
</Name>
```

Finally, the name is represented in a great deal of detail with decomposition into name components.

```
<Name>
    <Title>Professor</Title>
    <GivenName>Edward</GivenName>
    <GivenName initial="J">Jermina</GivenName>
    <FamilyName>Hoover</FamilyName>
    <FamilyName>van Blumen</FamilyName>
    <FamilyName initial="Jr.">Junior</FamilyName>
    <Title>F.R.S.</Title>
</Name>
```

Another example shows a name for which only a given name exists:

```
<Name>
    <GivenName>Dinesh</GivenName>
</Name>
```

In the following Spanish name, the given name for the person cannot be broken down further. Notice also the use of the language attribute `xml:lang` to specify the language of the name.

```
<Name xml:lang="es">
    <GivenName initial="J.M">José María</GivenName>
    <FamilyName>Garcia</FamilyName>
    <FamilyName>Sánchez</FamilyName>
</Name>
```

3.5.5.5.2 PersonName datatype usage guidelines

The following guidelines should be followed for describing names:

- Select the name by which the individual is most commonly known. Use sources of information in the language of the individual. This may be a real name, pseudonym, title of nobility, nickname, initials or another name. If more than one name is used, use the name most commonly known.
- In library practice, "authority files" such as the Library of Congress Name Authority Files would be consulted prior to establishing the name in local files. In the absence of access to national data, local decisions about the predominant form of name based on resources available locally, and associated name references for variant names are "linked" to the official name. Variations in spelling, different transliteration systems from non-roman alphabets, names in different languages, fuller versus abbreviated forms of name, or changes in the name used provide opportunities for linking to the official form of name.
- Separate entities: When a person actively uses two or more names for different types of creative works, separate entries can be created. Example: Dodgson, Charles Ludwidge (for mathematical works) and Carroll, Lewis (literary works). Entries would be created under both names with reference to the other name.
- Change of name: When names have changed due to marriage, choose the latest form of name unless it is determined that an earlier name will persist as the name by which a person is better known.
- Qualification elements, i.e. dates, titles of address, fuller form of name, etc. are added to distinguish between persons with the same name.
- Persons using more than one language: Choose the form corresponding to the language of most of the works. The other language forms become linking references. Defer to the name most commonly found in reference sources of the person's country of residence or activity. The country of birth need not be the country of the person's residence or predominant creative activity. Names utilized in professional contribution would be used, with references from the additional names.

3.5.5.6 Electronic Address datatype

3.5.6 Description of places

3.5.6.1 Place DS

3.5.6.1.1 Place DS examples

The following example shows the use of `Place DS` for describing a shooting location. In this case, the place is a university in Madrid, Spain.

```
<Mpeg7>
    <DescriptionUnit xsi:type="PlaceType">
        <Name xml:lang="en">Madrid</Name>
        <Role>
            <Name>shooting location</Name>
        </Role>
        <GeographicPosition datum="itrf">
            <Point longitude="135.75" latitude="35.5" altitude="100"/>
        </GeographicPosition>
        <Region>es-cam</Region>
        <AdministrativeUnit type="city">Madrid</AdministrativeUnit>
        <PostalAddress>
            <AddressLine>E.T.S.Ing. Telecomunicación</AddressLine>
            <AddressLine>Universidad Politécnica de Madrid</AddressLine>
            <AddressLine>Ciudad Universitaria s/n</AddressLine>
            <PostingIdentifier>E-28040</PostingIdentifier>
        </PostalAddress>
        <InternalCoordinates>C-306</InternalCoordinates>
    </DescriptionUnit>
</Mpeg7>
```

3.5.6.2 GeographicPoint datatype

Information on extraction and use is not provided.

3.5.7 Graphs and relations

3.5.7.1 Graph DS examples

Nodes are optional. Any item referenced by a relation in a graph is automatically defined as a node (this is called an anonymous node). For example, the following two representations are equivalent up to isomorphism.

```
<Graph>
    <Node id="n1" idref="a">
        <Name href="urn:example:bicycle"/>
    </Node>
    <Node id="n2" idref="b">
        <Name href="urn:example:object"/>
    </Node>
    <Relation xsi:type="RelationType" source="#n2" target="#n1"
        type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:specializationOf"/>
</Graph>

<Graph>
    <Relation xsi:type="RelationType" source="#b" target="#a"
    type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:specializationOf"/>
</Graph>
```

The following example illustrates the use of `Graph DS` for describing the graph of relations between two `objects`. The following relations are desribed: `left` and `goalOf`, which means that `object` A is to the left of `object` B, and `object` A is the goal of `object` B. Additional examples of the use of the `Graph DS` are given in 3.9.10.3 and 3.10.5.1.1.

```
<Mpeg7>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics>
         <Label>
            <Name> Graph of relations between object A and object B </Name>
         </Label>
         <SemanticBase xsi:type="ObjectType" id="objectA">
            <Label>
               <Name> Object A </Name>
            </Label>
         </SemanticBase>
         <SemanticBase xsi:type="ObjectType" id="objectB">
            <Label>
               <Name> Object B </Name>
            </Label>
         </SemanticBase>
         <Graph>
            <Node id="nodeA" href="#objectA"/>
            <Node id="nodeB" href="#objectB"/>
            <Relation type="urn:mpeg:mpeg7:cs:SpatialRelationCS:2001:left"
               source="#nodeA" target="#nodeB"/>
            <Relation type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:goalOf"
               source="#nodeA" target="#nodeB"/>
         </Graph>
      </Semantics>
   </Description>
</Mpeg7>
```

3.5.7.2 Relation DS

3.5.7.2.1 Relation DS examples

Consider expressing the relation that segment A is to the left of segment B. This can be expressed as the following graph, made up of two nodes and one labeled edge "leftOf". One can write this using the external form of the `Relation DS` as follows:

```
<Graph>
   <Node id="nodeA1" idref="segmentA"/>
   <Node id="nodeB1" idref="segmentB"/>
   <!-- Edge from a->b -->
   <Relation type="urn:relation:leftOf" source="#nodeA2" target="#nodeB2"/>
</Graph>
```

However, the internal form of the `Relation DS` may be used to write the relation within the source argument (i.e. "segmentA") as follows:

```
<VideoSegment id="segmentA">
   <Relation type="urn:relation:leftOf" target="#segmentB"/>
</VideoSegment>
<VideoSegment id="segmentB"/>
```

Both these examples are equivalent to each other and differ only in the syntax used to express the relation.

3.5.7.3 MorphismGraph DS

Information on extraction and use is not provided.

3.5.7.4 Graph relations classification scheme

Information on extraction and use is not provided.

3.5.7.5 Set and topology relations classification scheme

3.5.7.5.1 BaseRelation CS examples

The following example illustrates the use of the `BaseRelation CS` for describing the following relationship between collections: `disjoint` and `refines`, which means that the collections are disjoint and that one collection refines the other collection.

```
<Mpeg7>
    <Description xsi:type="ContentEntityType">
        <MultimediaContent xsi:type="MultimediaCollectionType">
            <StructuredCollection>
                <Collection id="collection1" xsi:type="ContentCollectionType">
                    <!-- more elements here -->
                </Collection>
                <Collection id="collection2" xsi:type="ContentCollectionType">
                    <!-- more elements here -->
                </Collection>
                <Relationships>
                    <Node id="source" href="#collection1"/>
                    <Node id="target1" href="#collection2"/>
                    <Relation
                        type="urn:mpeg:mpeg7:cs:BaseRelationCS:2001:disjoint"
                        source="#source" target="#target1"/>
                    <Relation
                        type="urn:mpeg:mpeg7:cs:BaseRelationCS:2001:refines"
                        source="#source" target="#target1"/>
                </Relationships>
            </StructuredCollection>
        </MultimediaContent>
    </Description>
</Mpeg7>
```

3.5.8 Ordering Tools

3.5.8.1 OrderingKey DS

3.5.8.1.1 Ordering Key DS examples

The following example illustrates the use of the `OrderingKey D` for describing the ordering of VideoSegment DS description based on two elements of the CameraMotion D, the TRACK_LEFT_F element and the ZOOM_IN_F element. In the first `OrderingKey` DS description, the ordering is based on the TRACK_LEFT_F element of the `CameraMotion` D so the shots containing the most amount of "action" would appear first in the ordered list. In the second `OrderingKey` D description, the ordering is based on the ZOOM_IN_F element of the `CameraMotion` D so the shots containing close-ups would appear first in the ordered list.

```
<Mpeg7>
    <Description xsi:type="ContentEntityType">
        <OrderingKey name="ActionOrdering" semantics="The shots containing more
            action">
            <Selector
                xpath="/Mpeg7/Description/MultimediaContent/TemporalDecomposition/
                       VideoSegment"/>
            <Field

    xpath="CameraMotion/CameraMotionSegment/FractionalPresence@TRACK_LEFT_F"/>
        </OrderingKey>
        <OrderingKey name="Close-up Ordering" semantics="The shots containing
close-up
            of a player">
            <Selector
                xpath="/Mpeg7/Description/MultimediaContent/TemporalDecomposition/
                   VideoSegment"/>
            <Field
```

```
   xpath="CameraMotion/CameraMotionSegment/FractionalPresence@ZOOM_IN_F"/>
      </OrderingKey>
      <MultimediaContent xsi:type="VideoType">
         <Video id="id1">
            <MediaTime>
               <MediaTimePoint>T00:00:00</MediaTimePoint>
               <MediaDuration>PT0M15S</MediaDuration>
            </MediaTime>
            <TemporalDecomposition>
               <VideoSegment id="id2">
                  <MediaTime>
                     <MediaTimePoint>T00:00:00</MediaTimePoint>
                     <MediaDuration>PT0M15S</MediaDuration>
                  </MediaTime>
                  <!-- CameraMotion descriptor value omitted -->
               </VideoSegment>
               <VideoSegment id="id3">
                  <MediaTime>
                     <MediaTimePoint>T00:00:10</MediaTimePoint>
                     <MediaDuration>PT0M10S</MediaDuration>
                  </MediaTime>
                  <!-- CameraMotion descriptor value omitted -->
               </VideoSegment>
               <VideoSegment id="id4">
                  <MediaTime>
                     <MediaTimePoint>T00:00:20</MediaTimePoint>
                     <MediaDuration>PT0M10S</MediaDuration>
                  </MediaTime>
                  <!-- CameraMotion descriptor value omitted -->
               </VideoSegment>
            </TemporalDecomposition>
         </Video>
      </MultimediaContent>
   </Description>
</Mpeg7>
```


3.5.9 Affective description

3.5.9.1 Affective DS

3.5.9.1.1 Affective DS examples

The following example demonstrates the use of the Affective DS to describe the story shape of a movie. The story shape represents the development of a story along time by assigning a score to each scene, which measures the degree of "story complication" in that scene. The peaks in the score usually correspond to climaxes in the story. Figure 3 shows an example of the story shape characterized for a certain action movie.

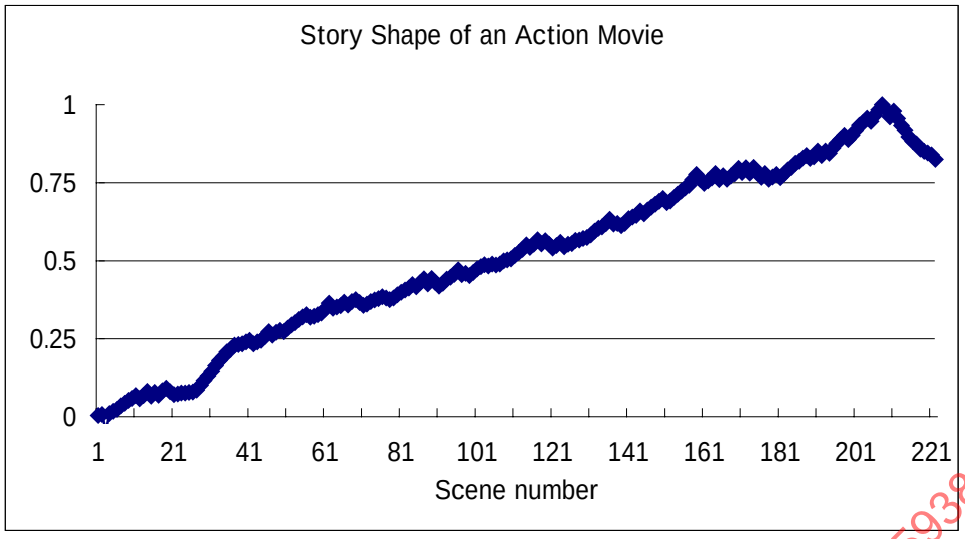


Figure 3 - Illustration of the story shape of an action movie.

The description of the story shape shown in Figure 3 is given as follows:

```
<Mpeg7>
    <Description xsi:type="ContentEntityType">
        <!--
            Story Shape description by Affective DS.
            Note: Story shape is defined in the informative classification scheme
            identified by "AffectTypeCS".
        -->
        <Affective id="affective1">
            <Header xsi:type="DescriptionMetadataType">
                <Confidence>0.85</Confidence>
                <Version>1.0</Version>
                <Comment>
                    <FreeTextAnnotation>
                        Confidence is measured using a certain statistical
technique.
                        Noticeable experimental conditions are used to describe
                        the creation information.
                    </FreeTextAnnotation>
                </Comment>
                <PrivateIdentifier>example1</PrivateIdentifier>
                <Creator>
                    <Role href="urn:mpeg:cs:AffectBasedContentAnalysisCS:2001">
                        <Name>experimentalSubject</Name>
                    </Role>
                    <Agent xsi:type="OrganizationType">
                        <Name>N.Univ.</Name>
                    </Agent>
                </Creator>
                <Creator>
                    <Role href="urn:mpeg:cs:AffectBasedContentAnalysisCS:2001">
                        <Name>organizer</Name>
                    </Role>
                    <Agent xsi:type="PersonType">
                        <Name>
                            <GivenName>Yoshiaki</GivenName>
                            <FamilyName>Shibata</FamilyName>
                        </Name>
                    </Agent>
                </Creator>
                <CreationLocation>
                    <Region>jp</Region>
```

```
                <AdministrativeUnit>Tokyo</AdministrativeUnit>
            </CreationLocation>
            <CreationTime>1999-09-12T13:45:00+09:00</CreationTime>
            <Instrument>
                <Tool>
                    <Name>SemanticScoreMethod</Name>
                </Tool>
            </Instrument>
        </Header>
        <Type href="urn:mpeg:cs:AffectTypeCS:2001">
            <Name>storyShape</Name>
        </Type>
        <Score idref="scene1">0.00360117</Score>
        <Score idref="scene2">0.00720234</Score>
        <!-- : -->
        <Score idref="scene222">0.825006</Score>
    </Affective>
    <!--
        Description of AudioVisualSegment Decomposition
    -->
    <MultimediaContent xsi:type="AudioVisualType">
        <AudioVisual id="program" mediaTimeBase="./MediaLocator"
            mediaTimeUnit="PT1N30F">
            <MediaLocator>

<MediaUri>http://www.mpeg.org/contents/TheMaskOfZorro.mpg</MediaUri>
            </MediaLocator>
            <!-- 0.0 .. 7669.5 sec for "program" -->
            <MediaTime>
                <MediaRelTimePoint>PT0S</MediaRelTimePoint>
                <!--   <MediaRelTimePoint>PT0S</MediaRelTimePoint> -->
                <MediaDuration>PT2H7M49S5N10F</MediaDuration>
            </MediaTime>
            <!-- Decomposition into scenes -->
            <TemporalDecomposition>
                <AudioVisualSegment id="scene1">
                    <!-- 0.0 .. 48.9 sec for "scene1" -->
                    <MediaTime>
                        <MediaRelTimePoint>PT0S</MediaRelTimePoint>
                        <MediaDuration>PT48S9N10F</MediaDuration>
                    </MediaTime>
                </AudioVisualSegment>
                <AudioVisualSegment id="scene2">
                    <!-- 48.9 .. 81.0 sec for "scene2" -->
                    <MediaTime>
                        <MediaRelTimePoint>PT48S9N10F</MediaRelTimePoint>
                        <MediaDuration>PT32S1N10F</MediaDuration>
                    </MediaTime>
                </AudioVisualSegment>
                <!-- : -->
                <AudioVisualSegment id="scene222">
                    <!-- 7639.8 .. 7669.5 sec for "scene222" -->
                    <MediaTime>
                        <MediaRelTimePoint>PT2H7M19S8N10F</MediaRelTimePoint>
                        <MediaDuration>PT29S3501N5000F</MediaDuration>
                    </MediaTime>
                </AudioVisualSegment>
            </TemporalDecomposition>
        </AudioVisual>
    </MultimediaContent>
</Description>
</Mpeg7>
```

This description consists of two parts:

1. The instance of `Affective` DS with the `DescriptionMetadata` DS as a header, where each affective value is associated with a sub-segment (scene) by referencing its identifier ("`id`") using the `idref` attribute.
2. The hierarchical decomposition of the movie. The AV segment representing the entire movie ("program") is decomposed into 222 sub-segments called "scenes".

The "storyShape" is specified in the `Type` element by referencing a term defined in the informative Affective Type Classification Scheme (See Annex A). The information included in the `DescriptionMetadata` header indicates that the scores were obtained from students in N Univ. based on the Semantic Score Method. Note that the value of the `Confidence` element in the Header is 0.85, indicating that the score was obtained using a method that can provide a reliability for the score. In this case, the score is actually a composite score synthesized from the individual score of many individual students using statistical techniques.

Another example of using the `Affective` DS is to describe the affective response to the events and objects depicted in a soccer game video. Suppose that the video contains a goal event, where a goalkeeper "A" fails to capture a slow ball kicked by a forward "B", resulting in losing a point for "A's" team. The objects, the goalkeeper "A" and the forward "B", may be described using the `SemanticPerson` DS. Because a fan of "B's" team may feel angrier towards the goalkeeper, who fails to catch such an easy ball, than towards the forward who kicks the ball, his/her affective response to the object descriptions can be represented as:

```
<Affective>
   <Type href="AffectTypeCS:2001">
      <Name> anger </Name>
   </Type>
   <Score idref="Goalkeeper-id">0.8</Score>
   <Score idref="Forward-id">0.2</Score>
</Affective>
```

In this description, "`Goalkeeper-id`" and "`Forward-id`" reference the goalkeeper and the forward descriptions respectively, which are assumed to have been described elsewhere.

3.5.9.1.2 Affective DS extraction

The `Affective` DS does not impose any extraction method of the score. In other words, the `Affective` DS can be used to describe any kind of audience's affective information on multimedia content as long as it is represented as a set of scores of relative intensity. For readers' convenience, however, a couple of extraction methods are introduced in this subclause.

3.5.9.1.2.1 Semantic Score Method

The Semantic Score Method [Takahashi00-1] is a well-defined subjective evaluation of video based on Freytag's theory [Freitag98, Laurel93]. This method can be used to extract the story shape of video content.

3.5.9.1.2.1.1 Freytag's Triangle

Gustav Freytag, a German critic and playwright, suggested in 1863 that the action of a play could be represented graphically when the pattern of emotional tension created in its audience was evaluated. Since tension typically rises during the course of a play until the climax of the action and falls thereafter, he modeled this pattern in a triangle form, referred to as "Freytag's Triangle" shown in Figure 4. In this figure, the left side of the triangle indicates the rising action that leads up to a climax or turning point while the right side of the triangle is the falling action that happens from the climax to the conclusion. The horizontal axis of the graph is time; the vertical axis is *complication*. According to Brenda Laurel [Laurel93], the complication axis of the Freytag's triangle represents the *informational attributes* of each dramatic incident. An incident that raises questions is part of the rising action, which increases *complication*, while one that answers questions is part of falling action, resulting in decreasing the complication, i.e., *resolution*.

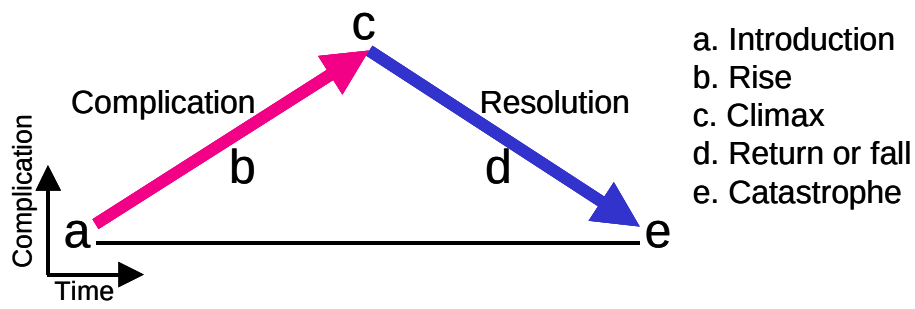


Figure 4 - Freytag's triangle [Laurel93].

In reality, however, things are more complicated than in Freytag's idealized model. One dramatic incident may raise some questions and answer others simultaneously. Hence, the *degree of complication* is introduced to specify the net increase of complication caused by an incident. The degree of complication is represented by a positive value when complication caused by an incident's raising questions overwhelms resolution by answering questions and a negative value vice versa. The *cumulative complication* for an incident is defined as the cumulative sum of the degree of complication for all incidents preceding this incident, representing the net intensity of complication for this incident. Note that because of a fractal-like property of a play where whole story is composed of several sub-stories that can be further divided into various dramatic incidents, the shape of a practical play is characterized in more irregular and jagged form than shown in Figure 4.

In order to help readers' understanding, an example from [Laurel93] is reproduced. Assume the following background situation: a group of strangers have been invited by an anonymous person to spend the weekend in a remote mansion. During the night, one member of the group (Brown) has disappeared. Some of the remaining characters are gathered in the drawing room expressing concern and alarm. The butler (James) enters and announces that Brown has been found. The following are conversations made among those people.

James: I'm afraid I have some rather shocking news.

Smith: Spit it out, man.

Nancy: Yes, can't you see my nerves are absolutely shot? If you have any information at all, you must give it to us at once.

James: It's about Mr. Brown.

Smith: Well?

James: We've just found him on the beach.

Smith: Thank heavens. Then he's all right.

James: I'm afraid not, sir.

Smith: What's that?

James: Actually, he's quite dead, sir.

Nancy: Good God! What happened?

James: He appears to have drowned.

Smith: That's absurd, man. Brown was a first-class swimmer.

The informational components raised in the above dialog are summarized as:

James has shocking news.

The news concerns Brown.

Brown has been found.

Brown is dead.

Brown has drowned.

Brown was a good swimmer.

Then, each component is evaluated based on the degree of complication (between 0 and +/-1). Possible scoring result is shown in Table 7.

Table 7 - Complication/Resolution based evaluation

Informational Component	Degree of Complication	Cumulative Complication
a. James has shocking news.	+0.4	0.4
b. The news concerns Brown.	+0.5	0.9
c. Brown has been found.	-0.7	0.2
d. Brown is dead.	+0.9	1.1
e. Brown has drowned.	-0.4	0.7
f. Brown was a good swimmer.	+0.8	1.5

In this table, the component **c** and **e** are evaluated as *negative* complication (resolution). The former provides an answer to the puzzle that "Brown had disappeared", while the latter gives an answer to the question that "how Brown died" raised in the component **d**. The third column in the table denotes the cumulative sum of the degree of complication from the component **a**. Assume that each component in the table is a dramatic incident occurring sequentially. Then, since the degree of complication evaluated at each incident indicates the increase of complication at each incident, the cumulative complication in the table reflects the net complication at each moment resulting from preceding incidents since the initial one. The cumulative complication is then used to visualize the story shape for the dialog as shown in Figure 5.

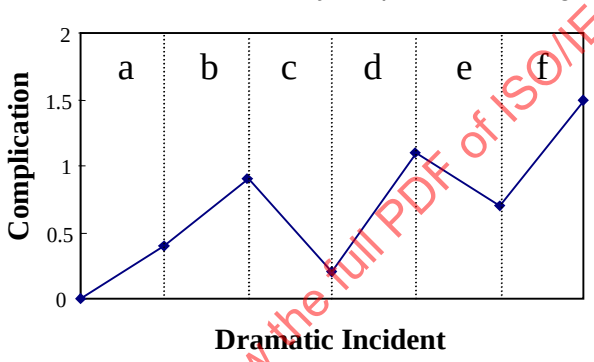


Figure 5 - The story shape for the dialog example.

3.5.9.1.2.1.2 Semantic Score Method

Based on the Freytag's play analysis, a subjective evaluation method for storied video, called "Semantic Score Method", is proposed [Takahashi00-1]. According to Brenda Laurel [Laurel93], an implicit assumption was made in the Freytag analysis that there is a direct relationship between what we *know* about the dramatic incident and how we *feel* about it. The method, however, mainly focuses on the former aspect, i.e., the method is developed as an analytical tool for a subjective video evaluation. In short, the evaluators are asked to give a positive (negative) value to each pre-determined scene according to the degree of complication (resolution) they perceived. The evaluators are expected to *interpret* what happens in the scene and *analyze* dramatic incidents involved in the scene in order to characterize the scene with a single value (called Semantic Score) from the complication/resolution viewpoint.

In order to obtain reliable data from general audiences, it is useful to provide the following items as supporting tools of the method [Takahashi01]:

- Instruction video and booklet
- Test material (target movie)
- Specially designed score sheet

The instruction video and booklet are used to explain the purpose of the evaluation, the evaluation procedure and the evaluation criterion (the complication and the resolution). The instruction video can also include a concrete evaluation example: A demonstration of the scene scoring using a short storied video provides evaluators with a common yardstick with which how a certain scene is to be scored. The score is typically assigned within a range between –5 and 5 by steps of one. If necessary, however, it should be allowed to score a scene with a fractional value or beyond the range as well.

The test material is a movie whose story shape is to be characterized. Since evaluators are asked to score scenes one by one, the video should be modified from its original form. For example, by marking the end of

each scene with the final frame as a still (the scene number superimposed) for a few seconds, evaluators can recognize each scene easily, resulting in smooth evaluation of the scenes.

One of the issues in the method is the scene definition. A scene is typically defined as a video segment that has minimum semantics as a story component with monotonic complication or resolution. The boundary between scenes is identified when a situation is drastically changed. Here, the situation includes time, place, character, context (e.g. in dialog), particular dramatic incident, and so on. This implies that one scene may be composed of several shots or that a long shot may be divided into several scenes. For example, when a long video shot has both the question raising and answering sequentially, the shot should be divided into two concatenated scenes. Based on the scene definition, one movie is typically divided into 100 - 250 scenes, resulting in each scene lasting 30 – 60 seconds. The scene length depends on its genre: an action type movie tends to have shorter scenes while the one regarded as a love story tends to have longer scenes than other genres.

In addition, a specially designed score sheet is useful to record the scores the evaluators assigns. Figure 6 shows a part of an example of the score sheet. In this sheet, each row corresponds to a scene, which is composed of the scene number, a short scene description, duration of the scene, and a cell to be filled with the complication value. Supplemental information is provided for the sake of evaluators' convenience, i.e., evaluators can easily recognize where they are evaluating at any moment. In addition, several consecutive scenes are grouped to form an episode, the second level story component that can be identified without ambiguity. In this score sheet, the boundary of the episode is represented with a thick solid line. Although the yardstick evaluators keep in mind may vary during the evaluation, a request to keep the consistency of scoring within whole video is often hard to achieve. It is therefore practical to ask evaluators to at least keep the consistency within the episode.

Movie title - **The Mask of Zorro**

Name( ) Age( ) Sex(M / F) Ever watched this title? (Y / N)

Comment Examples

Cannot judge Complication/Resolution : ?

Should be divided into sub scenes : /

Should be merged into one scene : +

Episode	Scene	Description	Duration	Score	Comment
	1	Historical Background	63		
	2	Somebody is watching through holes	12		
	3	They are two boys	10		
	4	People are gathering	22		
	5	Boys are waiting for Zorro	30		
	6	Boys are running out	17		
	7	A man looking down to people	19		
	8	Men riding horses are coming	29		
	9	Rafael and Lewis are discussing political issues	55		
1	10	Rafael orders to drive boys away	11		
	11	Black man takes boys	7		
	12	The man is Zorro	19		
	13	Execution begins	43		
	14	Zorro appears and stops the execution	4		
	15	Zorro scatters enemies	48		
	16	Hidden soldiers are aiming at Zorro	12		
	17	Boys defeats the soldiers	32		
	18	Zorro thanks boys and gives them a pendant	21		
	19	Zorro goes to Rafael's place	34		
	20	Zorro carves a "Z" at Rafael's neck	23		
	21	Zorro leaves with Tornado	35		
	22	Boys are watching the pendant	25		
	23	Zorro reaches his home	49		
	24	Old woman and a baby there	55		
	25	A woman notice Zorro's coming back	13		
	26	Zorro tells a story to his daughter	17		
	27	Embarrassed to find his wife behind him	77		
	28	Esperanza is concerned about Diego's injury	36		
	29	Rafael arrives at his home with his soldiers	39		
2	30	Rafael discovers that Zorro is Diego	24		

Figure 6 - Score Sheet for the Semantic Score Method.

3.5.9.1.2.1.3 Evaluation Procedure on Semantic Score Method

Using the supporting tools introduced above, typical evaluation procedure based on the Semantic Score Method can be described as follows:

- Instruct evaluators using the instruction video and booklet
- Ask evaluators to watch the designated title in a normal fashion.
- Ask evaluators to re-watch the test material and to evaluate it using the score sheet.
- Ask evaluators to answer some questionnaires and interview.

It should be noted that it is useful to ask evaluators to watch the assigned title before actual evaluation (Step 2). The reason for this is to let evaluators know the content in advance so that evaluators can evaluate the title calmly. What the method aimed at is not an identification of exciting part of a video where evaluators might lose themselves but to characterize how a story develops. Thus, excitation caused by unexpected development of a story and/or audiovisual effects should be carefully controlled. In other words, if evaluators were really excited with watching the title, they might even forget the evaluation itself.

Figure 7 shows a typical example of the story shape for four evaluators based on the Semantic Score Method. The story shape, called “Semantic Graph” in this method, can be obtained by integrating the complication/resolution value (given by evaluators) with respect to the story timeline.

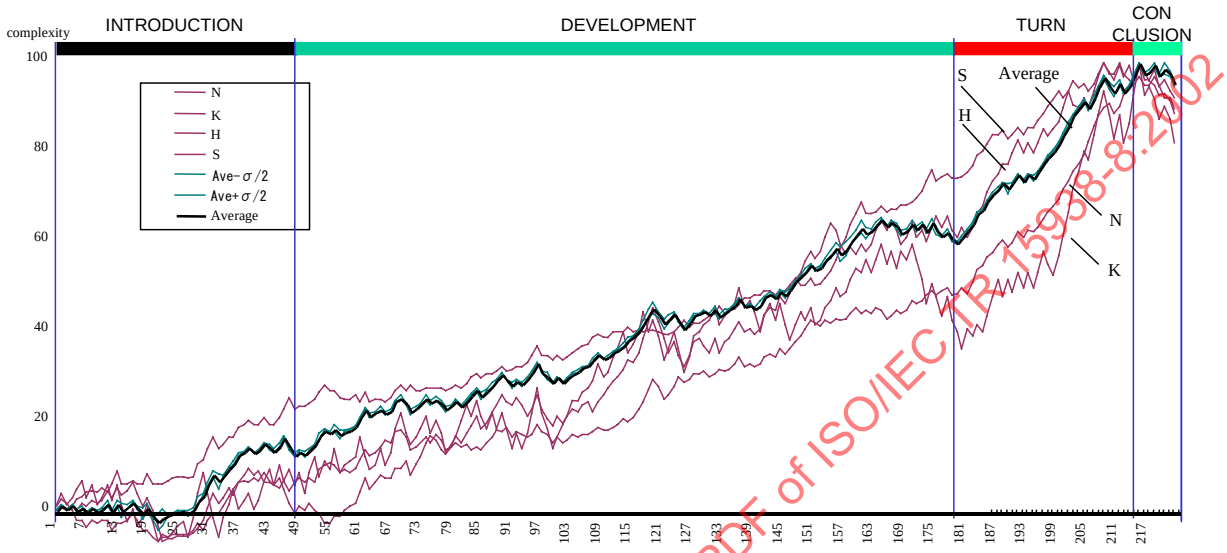


Figure 7 - Semantic Graph of “THE MASK OF ZORRO.”

In Figure 7, the vertical axis denotes the accumulated complication while the horizontal axis is the scene number (instead of time stamp of the whole movie). All data are normalized with respect to their maximum peak value so that direct comparison among them is available. It is also noted that a whole story is divided into four regions based on a conventional Japanese story model known as Ki-Sho-Ten-Ketsu, where Ki, Sho, Ten and Ketsu correspond to Introduction, Development, Turn, and Conclusion, respectively.

The thick line in the graph of Figure 7 is obtained by combining the four Semantic Graphs. Note that a simple averaging operation does not work well in this analysis because there are cases where a scene is scored with both high positive and negative values. Although the case clearly suggests that evaluators recognize something in the scene, a simple averaging operation may diminish the information. For the thick line in Figure 7, a special averaging is used [Takahashi01], where the magnitude and the sign of the combined score are determined by averaging the absolute value of the original scores and by taking the majority decision of them, respectively. With this averaging technique, the dulling of the graph shape can be successfully avoided.

3.5.9.1.2.2 Physiological Measurements and Analysis

Other possible methods to extract the score for the Affective DS instantiation include the physiological measurements and analysis.

Recent developments of sensor technology and brain science have shown the potential to reveal human emotional and/or mental states through physiological measurement and analysis. This suggests that the physiological approach can be a promising tool for multimedia content evaluation, which provides valuable information that is hard to detect through other approaches. Specifically, the measurement and analysis of physiological responses from audience watching multimedia content will characterize the content from the viewpoint on how audience feels interested and/or excited. Furthermore, since some response may reflect specific emotions such as happiness, anger, sadness, and so on, it can also describe how the audience’s emotion changes during his/her watching the content.

Comparing the evaluation method described in the last subclause, the physiological approach has the following advantages:

Can evaluate a content in real-time,

Can evaluate a content in automatic way with an appropriate apparatus,

Can obtain information of high-resolution in time for a content such as video and audio.

Furthermore, it is possible to obtain a response that is not consciously influenced by the audience.

In the following, a couple of trials on the movie evaluation using the physiological measurements and analysis are introduced.

Figure 8 shows time dependent Electromyogram (EMG) signals obtained from three audiences for a certain scene in “THE MASK OF ZORRO”. The EMG signal is the electrical signal of muscles recorded by an electromyograph. In this measurement, electrodes are placed on the forehead of audiences, and the voltage difference between the electrodes is continuously recorded. Hence, when a muscle gives a particular movement, then the movement is indirectly detected as a change of the electric signal.

As is seen in Figure 8, there is a spike in the EMG signals and, more notably the spikes in the EMG activities from three audiences coincide. In fact, this is the moment when all audiences smile at the bang sound in the movie. In order to explain what happens in the scene, two images are extracted before and after the bang sound and shown under the graph. At the image before the bang sound, Zorro attempted to jump off a wall onto his waiting horse (see left image). But just before he lands, the horse moves forward and Zorro ends up on the ground. The bang sound occurs at this moment. Since he was supposed to mount the horse successfully, he is embarrassed after the bang sound (see right image). Audiences also expected that Zorro could mount the horse smoothly, the unexpected happening leads them to smile.

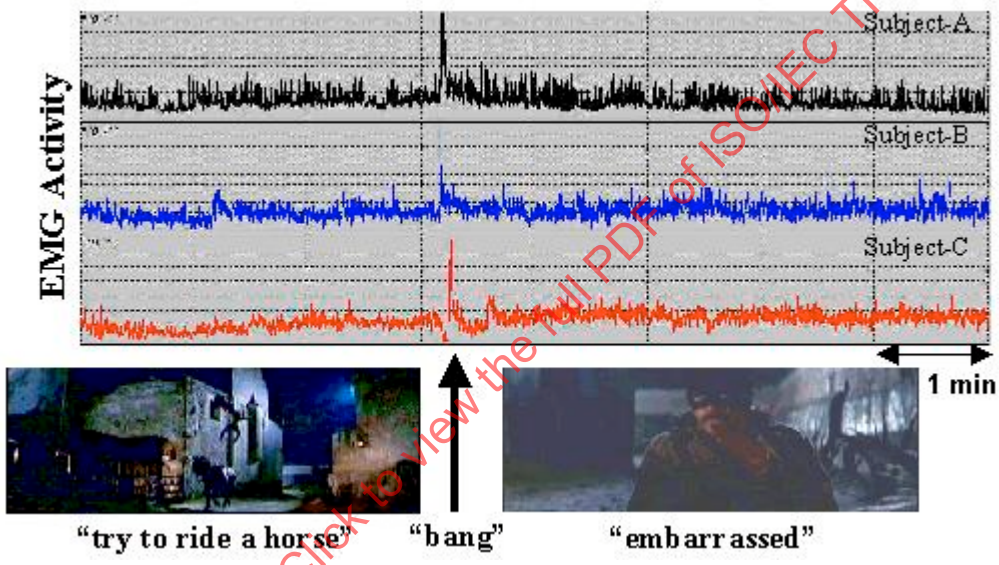


Figure 8 - Spikes in Electromyogram (EMG) caused by smiling in “THE MASK OF ZORRO.”[1]

As is demonstrated, the EMG measurement can be used to detect smiles of audiences. Strictly speaking, what is detected is a particular muscle movement at the forehead, and it could happen not only for smile but also for other emotions. Therefore, electromyography is a promising tool to capture some emotions of human being through his/her muscle activity.

Another example shown in Figure 9 concerns the highlight scene detection through the analysis of non-blinking periods. Video image of audience’s eye is captured and analyzed using image-processing technology to extract the eye-blinking points in time. Then non-blinking periods are measured as a time difference between two eye-blinking points. Figure 9 shows non-blinking periods along the entire movie. In the graph of Figure 9, the horizontal axis denotes time over whole the movie while the vertical axis is non-blinking period in second. This graph is created as follows: when a non-blinking period is given, then a regular square whose height (the vertical coordinate) is the same as the period is aligned on the horizontal period. Hence, the length of non-blinking periods can be easily seen from the graph.

According to the graph, it is observed that there are several long periods of non-blinking. The notable point again is that these long non-blinking periods correspond well to the highlight scenes in the movie. Here, the highlight scene is defined as the one audience pays special attention to. In order to show what happened at each highlight scene, an image is extracted from each highlight scene and shown around the graph with an

[1] "The Mask of Zorro".

arrow pointing to the corresponding non-blinking period. Simple text annotation was also attached to each frame to describe the scene.

Figure 9 - Highlight scenes detected by non-blinking periods in "THE MASK OF ZORRO."[1]

Figure 9 clearly indicates that the detection of non-blinking period can be a tool to identify the highlight scene in a movie. This is qualitatively explained by the fact that, as a natural property of human being, we tend to open our eyes wide without blinking when we watch something that attracts our attention.

3.5.9.1.3 Affective DS use

The description using the `Affective` DS provides high-level information on audience's interpretation as well as perception on multimedia content and therefore can be used in various ways. One of the examples is given as a preprocessing for video summary: In the case of story shape for example, one can obtain a video summary that reflects the story development. Furthermore, the highlight video summary can be obtained by selectively concatenating high score video segment notably when the Type element takes a value of, e.g., "excited". The description can also be used as fundamental data in high-level multimedia content analysis. For example, since the patterns of the story shape strongly depends on the genre of audiovisual content, it may be used to classify the content into its genre [Takahashi00-2].

In the following, the use of the story shape to analyze a trailer creation [Takahashi00-3] is demonstrated.

A trailer is a short movie clip consisting of small pieces of video segment mainly taken from an original movie. It is used to advertise a new movie and therefore a trailer often includes a video segment, telop, narration, and so on, that does not appear in the original move in order to enhance its effectiveness. Strictly speaking, a trailer is not a so-called video summary: it is rare that we can grasp the outline of a movie by just watching its trailer, but should be attractive enough to make many people feel like to watch the movie. Although the trailer creation itself is a highly refined artistic work, it is interesting to investigate how a skilled and talented creator creates an attractive trailer from the viewpoint of video segment selection.

Using the story shape description based on the Semantic Score Method obtained from various movies together with their originally created trailers, the analysis reveals a strategy on which scenes are to be chosen for an attractive trailer. Borrowing the conventional Japanese story model, the scene selection strategy is summarized as follows:

- **Introduction (Ki):**

  Choose both complication and resolution scenes whose absolute Semantic Score are higher than a given threshold,

  Choose scenes at local peaks in the Semantic Graph (story shape) and the following scene,

- **Development (Sho):**

  Choose complication scenes whose Semantic Score are higher than a given threshold,

  Choose scenes at local peaks in the Semantic Graph,

- **Turn (Ten):**

  Same as those in the Development,

- **Conclusion (Ketsu):**

  No scene should be chosen.

In order to simulate a practical trailer creation, further strategy is needed because the scenes used in the Semantic Score Method typically last for thirty to sixty seconds and thus simply concatenating selected scenes gives a long video clip which is too long to be a trailer. A study [Takahashi00-3] reveals the strategy on how to identify a shot within the selected scene. According to the strategy, the following criteria should be taken into consideration:

- Upper body image of main actor/actress
- Whole body image of main actor/actress
- Visual effect (CG, telop, dissolve, etc.)
- Sound effect (climax of BGM, explosion, scream, etc.)
- Speech
- High activity (of visual object and/or camera work)
- Shot length (slow motion more than several seconds)
- Camera zoom-in/out

By assigning an appropriate weighting value to each shot within a scene according to the criteria listed above, a shot candidate for a trailer can be determined at each scene.

According to the evaluation of the *simulated* trailer created based on the strategy introduced above, the resulting trailer can gain more than 60 points compared with an original trailer having 100 points as a basis. Note that the simulated trailer is created only using video segments in the original movie, i.e., none of extra technique such as taking special video segments and/or advertising narration that is not included in the original movie is taken into account. Hence, this result clearly indicates that the strategy introduced above actually reflects a certain essence of an attractive trailer creation. Although it is obvious that a trailer created in such way cannot overwhelm the one created by a skilled and talented creator, it is expected that this sort of approach will bring some reference materials that stimulate his/her creativity.

3.5.10 Phonetic description.

3.5.10.1 PhoneticTranscriptionLexicon header

Information on extraction and use is not provided.

3.6 Media description tools

3.6.1 Introduction

This clause specifies tools for describing the media features of the coded multimedia data. The coded multimedia data may be available in multiple modalities, formats, coding versions, or as multiple instances. The tools defined in this clause allow the description of an original instance of coded multimedia data and the multiple variations of the original instance. The following tools are specified in this clause:

Table 8 - Overview of Media Information Tools.

Tool	*Functionality*
Media Information Tools	Tools for describing the media-specific information of the multimedia data. The `MediaInformation DS` is centered around an identifier for the content entity and a set of coding parameters grouped into profiles. The `MediaIdentification DS` allows the description of the content entity. The different `MediaProfile DS` instances allow the description of the different sets of coding parameters values available for different coding profiles.

3.6.2 Media information tools

3.6.2.1 MediaInformation DS

Information on extraction and use is not provided.

3.6.2.2 MediaIdentification D

Information on extraction and use is not provided.

3.6.2.3 MediaProfile DS

Information on extraction and use is not provided.

3.6.2.4 MediaFormat D

Information on extraction and use is not provided.

3.6.2.5 MediaTranscodingHints D

Information on extraction and use is not provided.

3.6.2.6 Media Quality D

Information on extraction and use is not provided.

3.6.2.7 MediaInstance DS

Information on extraction and use is not provided.

3.6.2.8 Media information examples

3.6.2.8.1 MediaInformation DS examples

The following example shows the use of `MediaInformation` DS for describing the media information for a video. The content is identified as corresponding to "natural" content from the video domain. A single media profile is described, which identifies the medium as "CD", the visual coding format as "MPEG-1 Video", the audio coding format as "MPEG-1 Audio." Furthermore, two instances of the content are described, one belonging to a CD collection, and another provided on-line.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="VideoType">
         <Video>
            <MediaInformation id="news1_media">
               <MediaIdentification>
                  <EntityIdentifier organization="MPEG"
type="MPEG7ContentSetId">
                     mpeg7_content:news1
                  </EntityIdentifier>
                  <VideoDomain
href="urn:mpeg:mpeg7:cs:VideoDomainCS:2001:1.2">
                     <Name xml:lang="en">Natural</Name>
                  </VideoDomain>
               </MediaIdentification>
               <MediaProfile>
                  <MediaFormat>
                     <Content href="urn:mpeg:mpeg7:cs:ContentCS:2001:2">
                        <Name xml:lang="en">audiovisual</Name>
                     </Content>
                     <Medium href="urn:mpeg:mpeg7:cs:MediumCS:2001:1.1">
                        <Name xml:lang="en">CD</Name>
                     </Medium>
                     <FileFormat
href="urn:mpeg:mpeg7:cs:FileFormatCS:2001:3">
                        <Name xml:lang="en">mpeg</Name>
                     </FileFormat>
                     <FileSize>666478608</FileSize>
                     <VisualCoding>
```

```
                        <Format

   href="urn:mpeg:mpeg7:cs:VisualCodingFormatCS:2001:1"
                            colorDomain="color">
                            <Name xml:lang="en">MPEG-1 Video</Name>
                        </Format>
                        <Pixel aspectRatio="0.75" bitsPer="8"/>
                        <Frame height="288" width="352" rate="25"/>
                    </VisualCoding>
                    <AudioCoding>
                        <Format

   href="urn:mpeg:mpeg7:cs:AudioCodingFormatCS:2001:3">
                            <Name xml:lang="en">MPEG-1 Audio</Name>
                        </Format>
                        <AudioChannels front="3" rear="2" lfe="1">6
                        </AudioChannels>
                    </AudioCoding>
                </MediaFormat>
                <MediaTranscodingHints difficulty="0.562789">
                    <MotionHint>
                        <MotionRange xLeft="15" xRight="15" yDown="15"
yUp="15"/>
                    </MotionHint>
                </MediaTranscodingHints>
                <MediaQuality>
                    <QualityRating type="objective">
                        <RatingValue>40.05</RatingValue>
                        <RatingScheme style="higherBetter"

   href="urn:mpeg:mpeg7:cs:QualityRatingSchemeCS:2001:2.3">
                            <Name xml:lang="en">PSNR_Y</Name>
                        </RatingScheme>
                    </QualityRating>
                    <RatingInformationLocator
                        href="Measurement/PicQuality/quality.html"/>
                    <PerceptibleDefects>
                        <VisualDefects
                            href="urn:mpeg:mpeg7:cs:VisualDefectsCS:2001:3">
                            <Name xml:lang="en">Edge noise</Name>
                        </VisualDefects>
                    </PerceptibleDefects>
                </MediaQuality>
                <MediaInstance id="mp7cs17news1">
                    <InstanceIdentifier organization="MPEG"
                        type="MPEG7ContentSetId"> mpeg7_17/news1
                    </InstanceIdentifier>
                    <LocationDescription> news1.mpg in Content Set CD 17
                    </LocationDescription>
                </MediaInstance>
                <MediaInstance id="onlinemp7cs17news1">
                    <InstanceIdentifier organization="MPEG"
                        type="MPEG7ContentSetOnLineId"> mpeg7/content17/news1
                    </InstanceIdentifier>
                    <MediaLocator>
                        <MediaUri>
                            http://www.mpeg.org/mpeg7/contentset/17/news1.mpg
                        </MediaUri>
                    </MediaLocator>
                </MediaInstance>
            </MediaProfile>
        </MediaInformation>
    </Video>
</MultimediaContent>
```

```
    </Description>
</Mpeg7>
```

3.6.2.8.2 ColorSampling D examples

The following example shows the use of the `ColorSampling D` for describing the following progressive sampling: YCbCr 4:4:4, where all samples co-sited.

```
<Mpeg7>
    <Description xsi:type="ContentEntityType">
        <MultimediaContent xsi:type="VideoType">
            <Video>
                <MediaInformation>
                    <MediaIdentification>
                        <EntityIdentifier organization="MPEG"
type="MPEG7ContentSetId">
                            mpeg7_content:news1
                        </EntityIdentifier>
                    </MediaIdentification>
                    <MediaProfile>
                        <MediaFormat>
                            <Content href="MPEG7ContentCS">
                                <Name>audiovisual</Name>
                            </Content>
                            <VisualCoding>
                                <ColorSampling>
                                    <Lattice width="720" height="486"/>
                                    <Field temporalOrder="0" positionalOrder="0">
                                        <Component>
                                            <Name>Luminance</Name>
                                            <Offset horizontal="0.0" vertical="0.0"/>
                                            <Period horizontal="1.0" vertical="1.0"/>
                                        </Component>
                                        <Component>
                                            <Name>ChrominanceBlueDifference</Name>
                                            <Offset horizontal="0.0" vertical="0.0"/>
                                            <Period horizontal="1.0" vertical="1.0"/>
                                        </Component>
                                        <Component>
                                            <Name>ChrominanceRedDifference</Name>
                                            <Offset horizontal="0.0" vertical="0.0"/>
                                            <Period horizontal="1.0" vertical="1.0"/>
                                        </Component>
                                    </Field>
                                </ColorSampling>
                            </VisualCoding>
                        </MediaFormat>
                    </MediaProfile>
                </MediaInformation>
            </Video>
        </MultimediaContent>
    </Description>
</Mpeg7>
```

The following example shows the use of the `ColorSampling D` for describing the following MPEG-2 interlaced sampling: YCbCr 4:2:2, which is illustrated in Figure 10.

```
<Mpeg7>
    <Description xsi:type="ContentEntityType">
        <MultimediaContent xsi:type="VideoType">
            <Video>
                <MediaInformation>
                    <MediaIdentification>
```

```
                    <EntityIdentifier organization="MPEG"
type="MPEG7ContentSetId">
                        mpeg7_content:news1
                    </EntityIdentifier>
                </MediaIdentification>
                <MediaProfile>
                    <MediaFormat>
                        <Content href="MPEG7ContentCS:2001">
                            <Name>audiovisual</Name>
                        </Content>
                        <VisualCoding>
                            <ColorSampling>
                                <Lattice width="720" height="486"/>
                                <Field temporalOrder="0" positionalOrder="0">
                                    <Component>
                                        <Name>Luminance</Name>
                                        <Offset horizontal="0.0" vertical="0.0"/>
                                        <Period horizontal="1.0" vertical="2.0"/>
                                    </Component>
                                    <Component>
                                        <Name>ChrominanceBlueDifference</Name>
                                        <Offset horizontal="0.0" vertical="0.0"/>
                                        <Period horizontal="2.0" vertical="2.0"/>
                                    </Component>
                                    <Component>
                                        <Name>ChrominanceRedDifference</Name>
                                        <Offset horizontal="0.0" vertical="0.0"/>
                                        <Period horizontal="2.0" vertical="2.0"/>
                                    </Component>
                                </Field>
                                <Field temporalOrder="1" positionalOrder="1">
                                    <Component>
                                        <Name>Luminance</Name>
                                        <Offset horizontal="0.0" vertical="1.0"/>
                                        <Period horizontal="1.0" vertical="2.0"/>
                                    </Component>
                                    <Component>
                                        <Name>ChrominanceBlueDifference</Name>
                                        <Offset horizontal="0.0" vertical="1.0"/>
                                        <Period horizontal="2.0" vertical="2.0"/>
                                    </Component>
                                    <Component>
                                        <Name>ChrominanceRedDifference</Name>
                                        <Offset horizontal="0.0" vertical="1.0"/>
                                        <Period horizontal="2.0" vertical="2.0"/>
                                    </Component>
                                </Field>
                            </ColorSampling>
                        </VisualCoding>
                    </MediaFormat>
                </MediaProfile>
            </MediaInformation>
        </Video>
    </MultimediaContent>
</Description>
</Mpeg7>
```

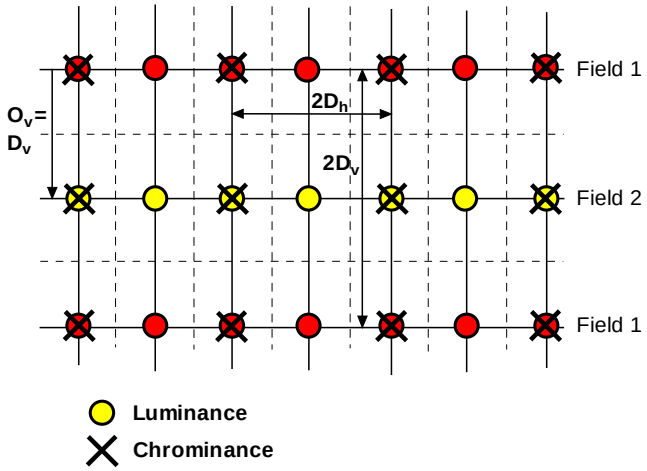


Figure 10 - Illustration of the siting of luminance and chrominance samples for 4:2:2 data (i.e., MPEG-2 interlaced color sampling YCbCr 4:2:2).

The following example shows the use of the `ColorSampling D` for describing the following MPEG-2 interlaced sampling: YCbCr 4:2:0, which is illustrated in Figure 11.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="VideoType">
         <Video>
            <MediaInformation>
               <MediaIdentification>
                  <EntityIdentifier organization="MPEG"
type="MPEG7ContentSetId">
                     mpeg7_content:news1
                  </EntityIdentifier>
               </MediaIdentification>
               <MediaProfile>
                  <MediaFormat>
                     <Content href="MPEG7ContentCS:2001">
                        <Name>audiovisual</Name>
                     </Content>
                     <VisualCoding>
                        <ColorSampling>
                           <Lattice height="720" width="486"/>
                           <Field temporalOrder="0" positionalOrder="0">
                              <Component>
                                 <Name>Luminance</Name>
                                 <Offset horizontal="0.0" vertical="0.0"/>
                                 <Period horizontal="1.0" vertical="2.0"/>
                              </Component>
                              <Component>
                                 <Name>ChrominanceBlueDifference</Name>
                                 <Offset horizontal="0.0" vertical="0.5"/>
                                 <Period horizontal="2.0" vertical="4.0"/>
                              </Component>
                              <Component>
                                 <Name>ChrominanceRedDifference</Name>
                                 <Offset horizontal="0.0" vertical="0.5"/>
                                 <Period horizontal="2.0" vertical="4.0"/>
                              </Component>
                           </Field>
                           <Field temporalOrder="1" positionalOrder="1">
                              <Component>
                                 <Name>Luminance</Name>
                                 <Offset horizontal="0.0" vertical="1.0"/>
                                 <Period horizontal="1.0" vertical="2.0"/>
                              </Component>
```

```
                                    <Component>
                                       <Name>ChrominanceBlueDifference</Name>
                                       <Offset horizontal="0.0" vertical="2.5"/>
                                       <Period horizontal="2.0" vertical="4.0"/>
                                    </Component>
                                    <Component>
                                       <Name>ChrominanceRedDifference</Name>
                                       <Offset horizontal="0.0" vertical="2.5"/>
                                       <Period horizontal="4.0" vertical="2.0"/>
                                    </Component>
                                 </Field>
                              </ColorSampling>
                           </VisualCoding>
                        </MediaFormat>
                     </MediaProfile>
                  </MediaInformation>
               </Video>
            </MultimediaContent>
         </Description>
      </Mpeg7>
```

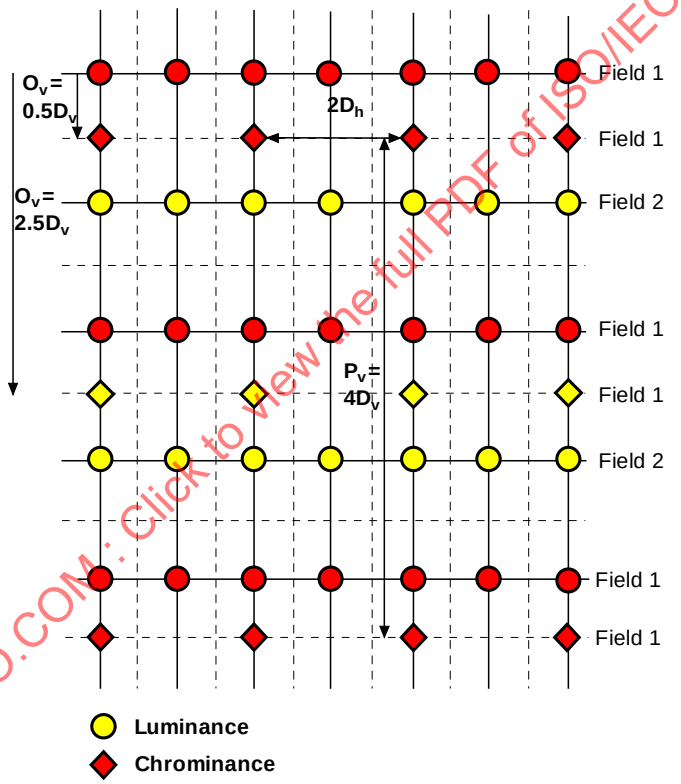


Figure 11 - Illustration of the siting of luminance and chrominance samples for 4:2:0 data (i.e., MPEG-2 interlaced color sampling YCbCr 4:2:0).

3.7 Creation and production description tools

3.7.1 Introduction

This clause specifies tools for describing information about the creation and production of multimedia content. The creation information is related to the multimedia content and is typically not depicted in the multimedia content. As a result, the creation information is typically not extracted from the multimedia content itself. The following tools are specified in this clause:

Table 9 - Overview of Creation and Production Tools

Tool	*Function*
Creation and Production	Tools for describing the creation and production of the multimedia content.

Tools	The CreationInformation DS is composed of one Creation DS, zero or one Classification DS, and zero or more RelatedMaterial DSs. The Creation DS contains description tools for author generated information about the creation process. The Classification DS contains the description tools for classifying the multimedia content using classification schemes and also subjective reviews. The RelatedMaterial DS contains the description tools that allow the description of additional material that is related to the multimedia content.

3.7.2 Creation information tools

3.7.2.1 CreationInformation DS

Information on extraction and use is not provided.

3.7.2.2 Creation DS

Information on extraction and use is not provided.

3.7.2.3 Classification DS

Information on extraction and use is not provided.

3.7.2.4 RelatedMaterial DS

Information on extraction and use is not provided.

3.7.2.5 CreationInformation examples

3.7.2.5.1 CreationInformation DS examples

The following example shows the use of CreationInformation DS for describing the creation information for a video.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="VideoType">
         <Video>
            <CreationInformation id="news1_creation">
               <Creation>
                  <Title xml:lang="es">Telediario (segunda edición)</Title>
                  <Title xml:lang="en" type="popular">Afternoon news</Title>
                  <Title xml:lang="es" type="popular">Noticias de la
tarde</Title>
                  <Abstract>
                     <FreeTextAnnotation>
            The trial about the kidnapping of Segundo Marey started this
            morning. Short interview with Segundo Marey after the end of the
            first session.
                     </FreeTextAnnotation>
                     <StructuredAnnotation>
                        <Who>
                           <Name>Segundo Marey</Name>
                        </Who>
                     </StructuredAnnotation>
                  </Abstract>
                  <Creator>
                     <Role href="urn:mpeg:mpeg7:cs:RoleCS:2001:ANCHOR">
                        <Name xml:lang="en">Anchorman</Name>
                     </Role>
                     <Agent xsi:type="PersonType">
                        <Name>
                           <GivenName>Ana</GivenName>
                           <FamilyName>Blanco</FamilyName>
                        </Name>
                     </Agent>
                  </Creator>
```

```
                    <CreationCoordinates>
                        <Location>
                            <Name xml:lang="es">Piruli</Name>
                            <Region>es</Region>
                            <AdministrativeUnit>Madrid</AdministrativeUnit>
                        </Location>
                        <Date>
                            <TimePoint>1998-10-03T14:13+01:00</TimePoint>
                        </Date>
                    </CreationCoordinates>
                    <CreationTool>
                        <Tool>
                            <Name>Video Camera</Name>
                        </Tool>
                        <Setting name="zoom" value="1.5"/>
                        <Setting name="aperture" value="35"/>
                    </CreationTool>
                </Creation>
                <Classification>
                    <Form href="urn:mpeg:mpeg7:cs:FormatCS:2001:1.1">
                        <Name xml:lang="en">Bulletin</Name>
                    </Form>
                    <Genre href="urn:mpeg:mpeg7:cs:ContentCS:2001:1.3.1">
                        <Name xml:lang="en">Daily news</Name>
                    </Genre>
                    <Purpose href="urn:mpeg:mpeg7:cs:IntentionCS:2001:2.1">
                        <Name xml:lang="en">Pure information</Name>
                    </Purpose>
                    <Language type="original">es</Language>
                    <Release date="1998-06-16T21:30+01:00">
                        <Region>es</Region>
                    </Release>
                    <ParentalGuidance>
                        <ParentalRating

   href="urn:mpeg:mpeg7:cs:MPAAParentalRatingCS:2001:G"/>
                        <Region>es</Region>
                    </ParentalGuidance>
                    <MediaReview>
                        <Rating>
                            <RatingValue>10</RatingValue>
                            <RatingScheme best="10" worst="1"
style="higherBetter">
                                <Name>Overall</Name>
                            </RatingScheme>
                        </Rating>
                    </MediaReview>
                    <MediaReview>
                        <FreeTextReview xml:lang="en">Interesting News today.
                        </FreeTextReview>
                        <FreeTextReview xml:lang="es">Interesantes noticias hoy.
                        </FreeTextReview>
                        <ReviewReference>
                            <DisseminationFormat

   href="urn:mpeg:mpeg7:cs:DisseminationFormatCS:2001:4">
                                <Name xml:lang="en">Internet</Name>
                            </DisseminationFormat>
                            <MediaLocator>
                                <MediaUri>http://tvmagazine.com</MediaUri>
                            </MediaLocator>
                        </ReviewReference>
                    </MediaReview>
                </Classification>
```

```
                <RelatedMaterial>
                    <DisseminationFormat
                        href="urn:mpeg:mpeg7:cs:DisseminationFormatCS:2001:4"/>
                    <MaterialType>
                        <Name xml:lang="en">Broadcaster Web Page</Name>
                    </MaterialType>
                    <MediaLocator>
                        <MediaUri>http://www.rtve.es</MediaUri>
                    </MediaLocator>
                </RelatedMaterial>
            </CreationInformation>
        </Video>
    </MultimediaContent>
</Description>
</Mpeg7>
```

3.7.2.5.2 Additional language description examples

In the following example, the original spoken audio of the multimedia content is in English; however, the content includes dubbed audio tracks in French and Spanish.

```
<CreationInformation>
<!-- more elements here -->
    <Classification>
        <Language type="original">en</Language>
        <Language type="dubbed">es</Language>
        <Language type="dubbed">fr</Language>
    </Classification>
</CreationInformation>
```

The following example is a description of a program broadcasted by a French TV station. The interview was originally done in Spanish and dubbed to English for a program produced and broadcasted in England. After dubbing, the Spanish can still be heard in the background. The interview was bought by the French TV station, which added subtitles in French for its broadcast.

```
<CreationInformation>
<!-- more elements here -->
    <Classification>
        <Language type="dubbed">en</Language>
        <Language type="background">es</Language>
        <CaptionLangauge closed="false">fr</CaptionLanguage>
    </Classification>
</CreationInformation>
```

3.8 Usage description tools

3.8.1 Introduction

This clause specifies tools describing information about the usage of the multimedia content. The following tools are specified in this clause:

Table 10 - Overview of Usage Information Tools.

Tool	*Functionality*
Usage Tools	Tools for describing the usage of the multimedia content. The `UsageInformation DS` include a `Rights D`, zero or one `FinancialResults D`, and several `Availability DS`s and associated `UsageRecord DS`s. The `Rights D` contains references to rights holders in order to obtain rights information. The `FinancialResults D` contains the description of costs and incomes generated by the multimedia content. The `Availability DS` describes the details about the availability of the multimedia content for usage. The `UsageRecord DS` describes the details pertaining to the usage of the multimedia

	content. It is important to note that the UsageInformation DS description will incorporated new descriptions each time the multimedia content is used (e.g, UsageRecord DS, Income in FinancialResults D), or when there are new ways to access to the multimedia content (Availability DS).

3.8.2 Usage information tools

3.8.2.1 UsageInformation DS

Information on extraction and use is not provided.

3.8.2.2 Rights datatype

Information on extraction and use is not provided.

3.8.2.3 Financial datatype

Information on extraction and use is not provided.

3.8.2.4 Availability DS

Information on extraction and use is not provided.

3.8.2.5 UsageRecord DS

Information on extraction and use is not provided.

3.8.2.6 Usage information examples

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="VideoType">
         <Video>
            <UsageInformation id="news1_usage">
               <Rights>
                  <RightsID organization="TVE" type="TVECopyRightsID">
                     tve:19980618:td2
                  </RightsID>
               </Rights>
               <FinancialResults>
                  <AccountItem currency="EUR" value="423.46">
                     <CostType>
                        <Name>Total for production</Name>
                     </CostType>
                  </AccountItem>
                  <AccountItem currency="EUR" value="200">
                     <CostType>
                        <Name>Broadcast</Name>
                     </CostType>
                  </AccountItem>
                  <AccountItem currency="EUR" value="600">
                     <IncomeType>
                        <Name>Advertisment</Name>
                     </IncomeType>
                  </AccountItem>
               </FinancialResults>
               <Availability id="live_news1">
                  <InstanceRef idref="onlinemp7cs17news1"/>
                  <Dissemination>
                     <Format

   href="urn:mpeg:mpeg7:cs:DisseminationFormatCS:2001:4">
                        <Name xml:lang="en">Internet</Name>
                     </Format>
                     <Location>
```

```
                        <Region>es</Region>
                    </Location>
                </Dissemination>
                <Financial>
                    <AccountItem currency="EUR" value="1">
                        <CostType>
                            <Name>Pay-per-view price</Name>
                        </CostType>
                    </AccountItem>
                </Financial>
                <AvailabilityPeriod type="payPerUse">
                    <TimePoint>1998-06-16T21:00+01:00</TimePoint>
                    <Duration>PT30M</Duration>
                </AvailabilityPeriod>
            </Availability>
            <Availability id="repeated_news1">
                <InstanceRef href="http://www.rtve.es/19980616/td2.mpeg"/>
                <Dissemination>
                    <Format

   href="urn:mpeg:mpeg7:cs:DisseminationFormatCS:2001:1">
                        <Name>Terrestrial</Name>
                    </Format>
                    <Disseminator>
                        <Role
href="urn:mpeg:mpeg7:cs:RoleCS:2001:PUBLISHER"/>
                        <Agent xsi:type="OrganizationType">
                            <Name>Discovery Channel</Name>
                        </Agent>
                    </Disseminator>
                    <Location>
                        <Region>es</Region>
                    </Location>
                </Dissemination>
                <AvailabilityPeriod type="repeat">
                    <TimePoint>1998-06-16T21:30+01:00</TimePoint>
                </AvailabilityPeriod>
            </Availability>
            <UsageRecord>
                <AvailabilityRef idref="live_news1"/>
                <Audience>245747</Audience>
                <Financial>
                    <AccountItem currency="EUR" value="1">
                        <EffectiveDate>1998-06-16</EffectiveDate>
                        <IncomeType>
                            <Name>Income for pay-per-view live access</Name>
                        </IncomeType>
                    </AccountItem>
                </Financial>
            </UsageRecord>
        </UsageInformation>
    </Video>
  </MultimediaContent>
 </Description>
</Mpeg7>
```


3.9 Structure description tools

3.9.1 Introduction

This clause specifies tools for describing the structure of multimedia content. These tools describe the following:

- Images and spatial regions of images and video frames;

- Video, temporal segments, and spatio-temporal segments of video;
- Audio and temporal segments of audio;
- Audio-visual content and spatio-temporal segments of AV content;
- Multimedia content and segments of multimedia content;
- Visual text in images or video;
- Video mosaics;
- Edited video and segments of edited video;

3.9.1.1 Structure description example

Figure 12 shows an example of the use of the structure description tools for describing a video. In this example, the video is described using the `VideoSegment DS` (top). The temporal decomposition of the video into two video segments is described using the `VideoSegmentTemporalDecomposition DS`. The specific attributes of the different video segments are described using the segment attribute description tools. The following tools are used to describe the attributes of the whole video (top): `CreationInformation DS`, `MediaInformation DS`, `UsageInformation DS`, and `Semantic DS`. The following tools are used to describe the attributes of the video segment on the left: `TextAnnotation datatype`, `MediaTime datatype`, `MotionActivity D`, and other visual Ds. The following tools are used to describe the video segment on the right: `TextAnnotation datatype`, `SpatioTemporalMask D`, and other visual Ds.

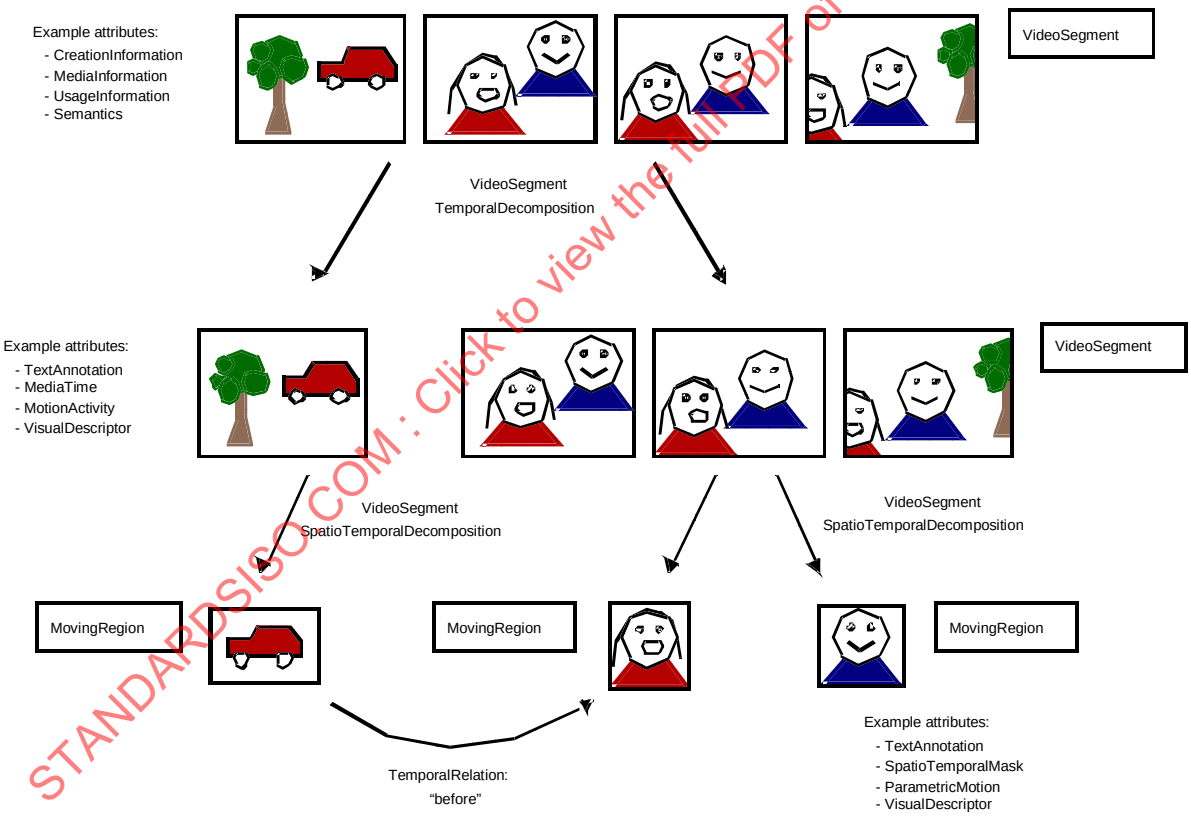


Figure 12 - Illustration of the description of a video segment using tools for describing the structure of multimedia content.

3.9.2 Base segment description tools

3.9.2.1 Segment DS

Information on extraction and use is not provided.

3.9.2.2 Base segment decomposition tools

Information on extraction and use is not provided.

3.9.3 Segment attribute description tools

3.9.3.1.1 Mask D

Information on extraction and use is not provided.

3.9.3.1.2 SpatialMask D

3.9.3.1.2.1 SpatialMask D examples

The following example illustrates the use of the `SpatialMask D` for describing the spatial mask that consists of three spatially connected sub-regions. Each sub-region is described using a polygon that denotes its boundary.

```
<SpatialMask>
   <SubRegion>
      <Polygon>
         <Coords mpeg7:dim="2 5"> 5 25 10 20 15 15 10 10 5 15 </Coords>
      </Polygon>
   </SubRegion>
   <SubRegion>
      <Polygon>
         <Coords mpeg7:dim="2 6"> 7 24 15 24 20 27 18 25 15 22 7 22 </Coords>
      </Polygon>
   </SubRegion>
   <SubRegion>
      <Polygon>
         <Coords mpeg7:dim="2 4"> 7 30 15 30 15 25 7 25</Coords>
      </Polygon>
   </SubRegion>
</SpatialMask>
```

3.9.3.1.3 TemporalMask D

3.9.3.1.3.1 TemporalMask D examples

The following example illustrates the use of the `TemporalMask D` for describing the temporal mask that consists of two temporally connected sub-intervals. Each sub-interval is described using a media time description (time point and duration) that denotes its boundaries in time.

```
<TemporalMask>
   <SubInterval>
      <MediaTimePoint>T00:00:00</MediaTimePoint>
      <MediaDuration>PT6M</MediaDuration>
   </SubInterval>
   <SubInterval>
      <MediaTimePoint>T00:07:00</MediaTimePoint>
      <MediaDuration>PT3M</MediaDuration>
   </SubInterval>
</TemporalMask>
```

3.9.3.1.4 SpatioTemporalMask D

3.9.3.1.4.1 SpatioTemporalMask D examples

The following example illustrates the use of the `SpatioTemporalMask D` for describing a spatio-temporal mask comprised of two spatio-temporal sub-regions. Each sub-region is described by trajectories of the representative points of a reference region using a spatio-temporal locator description.

```
<SpatioTemporalMask>
   <SubRegion>
      <FigureTrajectory type="rectangle">
         <MediaTime>
```

```
            <MediaTimePoint>T00:00:15</MediaTimePoint>
            <MediaDuration>PT1M15S</MediaDuration>
         </MediaTime>
         <Vertex><!-- more elements here --></Vertex>
         <Vertex><!-- more elements here --></Vertex>
         <Vertex><!-- more elements here --></Vertex>
         <!-- more elements here -->
      </FigureTrajectory>
   </SubRegion>
   <SubRegion>
      <FigureTrajectory type="ellipse">
         <MediaTime>
            <MediaTimePoint>T00:14:00</MediaTimePoint>
            <MediaDuration>PT1M7S</MediaDuration>
         </MediaTime>
         <Vertex><!-- more elements here --></Vertex>
         <Vertex><!-- more elements here --></Vertex>
         <Vertex><!-- more elements here --></Vertex>
         <!-- more elements here -->
      </FigureTrajectory>
   </SubRegion>
</SpatioTemporalMask>
```

3.9.3.1.5 MediaSpaceMask D

3.9.3.1.5.1 MediaSpaceMask D examples

The following example illustrates the use of the `MediaSpaceMask D` for describing a media space mask consisting of two sub-intervals from the media stream shown in Figure 13.

```
<MediaSpaceMask>
   <SubInterval offset="105" length="34"/>
   <SubInterval offset="167" length="50"/>
</MediaSpaceMask>
```

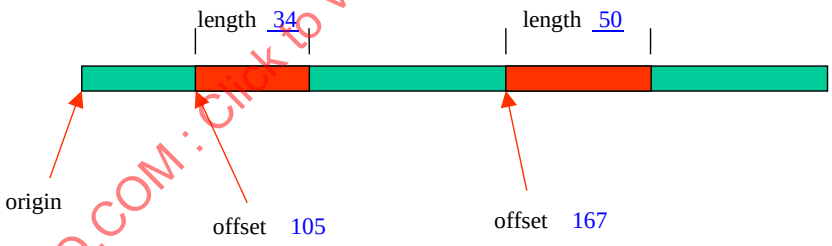


Figure 13 - Example of a media space mask.

3.9.3.1.6 SceneGraphMask D

3.9.3.1.6.1 SceneGraphMask D examples

The following example illustrates the use of the `SceneGraphMask D` for describing a scene graph mask comprised of two sub-graphs (#1 and #21) from the scene graph shown in Figure 14.

```
<SceneGraphMask>
   <SubGraphNum>1</SubGraphNum>
   <SubGraphNum>21</SubGraphNum>
</SceneGraphMask>
```

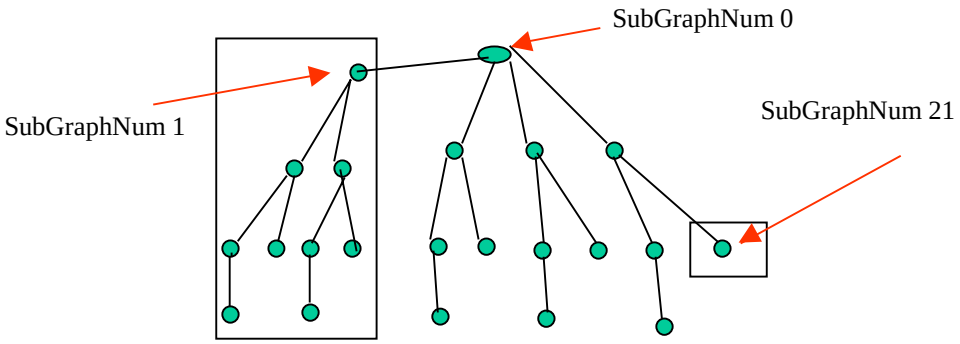


Figure 14 - Example of a scene graph mask.

3.9.3.1.7 OrderedGroupDataSetMask D

3.9.3.1.7.1 OrderedGroupDataSetMask D example

The following example illustrates the use of the `OrderedGroupDataSetMask D` for describing an ordered group data set mask consisting of two sub-intervals as shown in Figure 15. This example organizes ink content by grouping ink strokes into ordered group data sets. Each ordered group data set consists of ink strokes to form the component layer, and each stroke consists of ink data points to form the unit layer.

```
<OrderedGroupDataSetMask>
   <SubInterval setRef="http://www…/demo.stk#1" startComponent="0"
startUnit="0"
                endComponent="0" endUnit="U"/>
   <SubInterval setRef="http://www…/demo.stk#Set_N" startComponent="1"
startUnit="0"
                endComponent="1" endUnit="V"/>
</OrderedGroupDataSetMask>
```

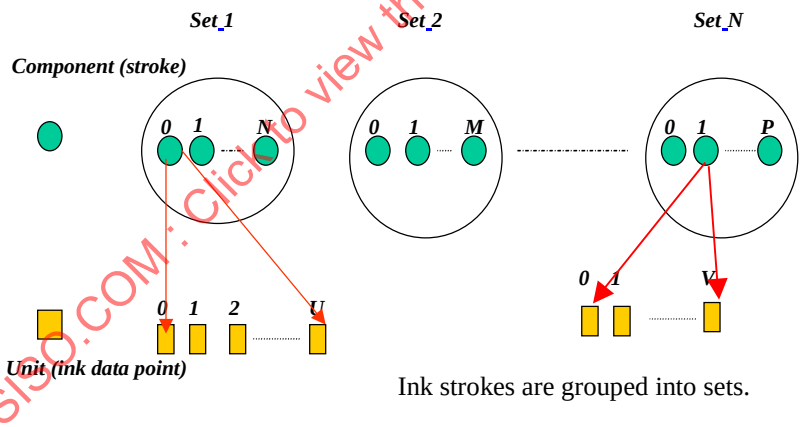


Figure 15 - Example of an ordered group mask.

3.9.3.2 MatchingHint D

3.9.3.2.1 MatchingHint D examples

The following example illustrates the use of the `MatchingHint D` for describing relative importance values to the several instances of visual description tools in a `StillRegion DS` description.

```
<StillRegion id="IMG0001">
   <MatchingHint reliability="0.900000">
      <Hint value="0.455" xpath="../../../ColorStructure"/>
      <Hint value="0.265" xpath="../../../DominantColor"/>
      <Hint value="0.280" xpath="../../../HomogeneousTexture"/>
   </MatchingHint>

   <VisualDescriptor xsi:type="DominantColorType">
```

```
      <!-- more elements here -->
   </VisualDescriptor>
   <VisualDescriptor xsi:type="ColorStructureType">
      <!-- more elements here -->
   </VisualDescriptor>
   <VisualDescriptor xsi:type="HomegeneousTextureType">
      <!-- more elements here -->
   </VisualDescriptor>
   <!-- more elements here -->
</StillRegion>
```

MatchingHint D descriptions can be generated and updated continuously by user's feedback. The reliability of the importance values may vary depending on how the values have been updated. For example, matching hint values learned from a large number of feedback sessions from reliable experts will have higher reliability.

3.9.3.2.2 MatchingHint D extraction

There is no limitation in the extraction methods for the MatchingHint D. But the automatic extraction method by relevance feedback can work well on extracting the values of the DS. Relevance feedback is a feedback from a user regarding what is relevant and/or irrelevant results from a given retrieval output. In this subclause, the automatic extraction method for MatchingHints is described.

The MatchingHints can be automatically extracted using the learning algorithm based on the clustering information where similar data are grouped together. This clustering information can be given by a service provider or can be built-up by user's relevance feedback. By using the extracted MatchingHints, the retrieval system can retrieve similar data even which is not used in the MatchignHint training. The descriptor that classifies the data in the same cluster better has the higher hint value and the descriptor which misclassifies the data in different clusters into the same cluster has the lower hint value. The hint value can be learned continuously if there are more feedbacks. To prevent wrong learning from the wrong feedback, the reliability factor describing how reliable the hint values are is used. In other words, the reliability describes how stable the current hint values are. The reliability becomes high when there are frequent feedbacks from the known experts. The higher the reliability is, the less a feedback affects the current hint value.

The equation of the learning MatchingHint D value follows as:

$$W_{new} = \frac{R_t}{R_t + e_c} W_t + \frac{e_c}{R_t + e_c} W_c$$

$$0 <= e_c <= 1$$

W_t : the matchng hints currently stored in an image (or a part of a video).

W_c : the matching hints caculated from feedback

W_{new} : updated matching hints of an image (or a part of a video).

R_t : current Reliability of the matching hints.

e_c : effect value of a user giving relevance feedback

The system calculates matching hints with the feedback, and updates and stores matching hints of an image (or a part of a video). Updating matching hints (W_{new}) are based on the matching hints (W_t) currently stored in the image (or the part of a video) and the matching hints (W_c) derived from feedback, as shown in the above equation. In the equation, updated matching hint (W_{new}) is affected by W_t and W_c in proportion to the current reliability and the effect value. In other words, the updated matching hint (W_{new}) is more affected by W_t when the reliability is higher, and more affected by W_c when the effect value is higher. The effect value, e_c is high when the user giving feedback is the expert authorized, but generally, it is fixed as a constant.

The matching hints W_c can be calculated by the following equation from the feedback. If feedback is a relevant image, then a matching hint of a descriptor becomes higher when the similarity calculated using this descriptor is high. On the contrary, in the case of an irrelevant image, a matching hint of a descriptor becomes higher when the distance calculated using this descriptor is high.

if (FI is relevant image) then

$W_k = \alpha$ Sim$_k(RI, FI)$

else if (FI is irrelevant image) then

$W_k = \alpha$ Dist$_k(RI, FI)$

W_k : the matching hint for the descriptor k

α : normalization coefficient

Sim(RI, FI) : similarity between RI, FI using the descriptor k

Dist(RI, FI) : distance between RI, FI using the descriptor k

RI : reference image

FI : feedback image

Reliability is updated by the following equation. The reliability becomes high when there is frequent feedback and continuous increase of performance by learning

$R_{new}=f(R_{old}+e \bullet (IncreaseTerm+a))$

$IncreaseTerm=(Precision(t)-Precision(t-1))$

R_{new} : new updated reliability

R_{old} : current reliability

e :effect coefficient

a : constant value

Precision(t) : the precision calculated from feedback at the time t

Precision(t-1) : the precision calculated from feedback at the time t-1

f(): normalizing function

3.9.3.3 PointOfView D

3.9.3.3.1 PointOfView D examples

The following examples illustrate the use of the `PointOfView D` for describing the relative importance of AV segments given a specific viewpoint. In these examples, the AV segments belong to the video of a football game between Team A and Team *B*. The `PointOfView D` describes the viewpoints of "Team A" and "Team B". In this example, it is assumed that the content creator assigned the relative importance values to the AV segments manually using an authoring tool. The examples show the description of the `PointOfView D` in the nested form and in the separated form, respectively.

In the first example, the description contains several `PointOfView D` descriptions with the same viewpoint "Team A". The importance values of the `PointOfView D` descriptions with viewpoint "Team A" included within the `AudioVisualSegment DS` descriptions with ids "seg1", "seg2", ..., "seg20", ... can be compared; the same is true within the `AudioVisualSegment DS` descriptions with ids of "seg1_2", "seg2_2", ..., "seg20_2", ... However, the importance values of `PointOfView D` descriptions across the two sets of `AudioVisualSegment DS` descriptions cannot be compared because they are of different scope.

```
<!-- Description of PointOfView D: nested form -->
<Mpeg7>
    <Description xsi:type="ContentEntityType">
        <MultimediaContent xsi:type="AudioVisualType">
            <AudioVisual>
                <TemporalDecomposition>
                    <AudioVisualSegment id="FootBallGame">
                        <TemporalDecomposition>
                            <AudioVisualSegment id="seg1">
                                <PointOfView viewpoint="Team A">
                                    <Importance>
                                        <Value>0.3</Value>
                                    </Importance>
                                </PointOfView>
                                <PointOfView viewpoint="Team B">
```

```
                        <Importance>
                            <Value>0.7</Value>
                        </Importance>
                    </PointOfView>
                </AudioVisualSegment>
                <AudioVisualSegment id="seg2">
                    <PointOfView viewpoint="Team A">
                        <Importance>
                            <Value>0.5</Value>
                        </Importance>
                    </PointOfView>
                </AudioVisualSegment>
                <!-- more elements here -->
                <AudioVisualSegment id="seg20">
                    <PointOfView viewpoint="Team A">
                        <Importance>
                            <Value>0.8</Value>
                        </Importance>
                    </PointOfView>
                    <PointOfView viewpoint="Team B">
                        <Importance>
                            <Value>0.2</Value>
                        </Importance>
                    </PointOfView>
                </AudioVisualSegment>
                <!-- more elements here -->
            </TemporalDecomposition>
            <TemporalDecomposition>
                <AudioVisualSegment id="seg1_2">
                    <PointOfView viewpoint="Team A">
                        <Importance>
                            <Value>0.3</Value>
                        </Importance>
                    </PointOfView>
                </AudioVisualSegment>
                <AudioVisualSegment id="seg2_2">
                    <PointOfView viewpoint="Team A">
                        <Importance>
                            <Value>0.5</Value>
                        </Importance>
                    </PointOfView>
                </AudioVisualSegment>
                <!-- more elements here -->
                <AudioVisualSegment id="seg20_2">
                    <PointOfView viewpoint="Team A">
                        <Importance>
                            <Value>0.8</Value>
                        </Importance>
                    </PointOfView>
                </AudioVisualSegment>
                <!-- more elements here -->
            </TemporalDecomposition>
        </AudioVisualSegment>
    </TemporalDecomposition>
  </AudioVisual>
 </MultimediaContent>
</Description>
</Mpeg7>
```

In the second example, the scope of each `PointOfView D` description is each description itself.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
```

```
      <MultimediaContent xsi:type="AudioVisualType">
         <AudioVisual>
            <TemporalDecomposition>
               <AudioVisualSegment id="FootBallGame">
                  <!-- Description of PointOfView D: separated form -->
                  <PointOfView viewpoint="Team A">
                     <Importance>
                        <Value>0.3</Value>
                        <SegmentRef href="#seg1"/>
                     </Importance>
                     <Importance>
                        <Value>0.5</Value>
                        <SegmentRef href="#seg2"/>
                     </Importance>
                     <!-- more elements here -->
                     <Importance>
                        <Value>0.8</Value>
                        <SegmentRef href="#seg20"/>
                     </Importance>
                     <!-- more elements here -->
                  </PointOfView>
                  <PointOfView viewpoint="Team B">
                     <Importance>
                        <Value>0.7</Value>
                        <SegmentRef href="#seg1"/>
                     </Importance>
                     <!-- more elements here -->
                     <Importance>
                        <Value>0.2</Value>
                        <SegmentRef href="#seg20"/>
                     </Importance>
                     <!-- more elements here -->
                  </PointOfView>
                  <!-- Description of AV segment tree -->
                  <TemporalDecomposition>
                     <AudioVisualSegment id="seg1">
                        <!-- more elements here -->
                     </AudioVisualSegment>
                     <AudioVisualSegment id="seg2">
                        <!-- more elements here -->
                     </AudioVisualSegment>
                     <!-- more elements here -->
                     <AudioVisualSegment id="seg20">
                        <!-- more elements here -->
                     </AudioVisualSegment>
                     <!-- more elements here -->
                  </TemporalDecomposition>
               </AudioVisualSegment>
            </TemporalDecomposition>
         </AudioVisual>
      </MultimediaContent>
   </Description>
</Mpeg7>
```


3.9.3.3.2 PointOfView D use

The PointOfView D is a tool that allows generating a scalable summary dynamically. A scalable summary consists of the segments that have user's preferred viewpoints. To achieve scalability of summary, the relative importance value and corresponding viewpoint is attached to each segment, and the segment filtering engine of the PointOfView D descriptions selects segments in order of high importance value for each viewpoint until the total time of summary becomes user's demanding time period. The PointOfView D consists of the relative importance of segments and a specific viewpoint that is the axis of the relative importance.

The PointOfView D can be used to summarize multimedia content dynamically from the combination of the viewpoint(s) and the duration which user or agent or system required. The functionality of segment filtering, which can be enabled by PointOfView D, can be used as a preprocessor for the Summarization DS to make summary descriptions. The PointOfView D can also be used for scalable multimedia distribution by generating different multimedia presentations that consist of the filtered (preferred) segments, which can be adapted to the different capabilities of the client terminals, network conditions or user preferences, and so on.

A generic usage model is depicted in Figure 16 below, where a segment filter takes media description including PointOfView descriptions embedded in (or associated with) Segments as input and user preferences and generates a filtered output containing media or summary description that consists of preferred segments that fit personal preference.

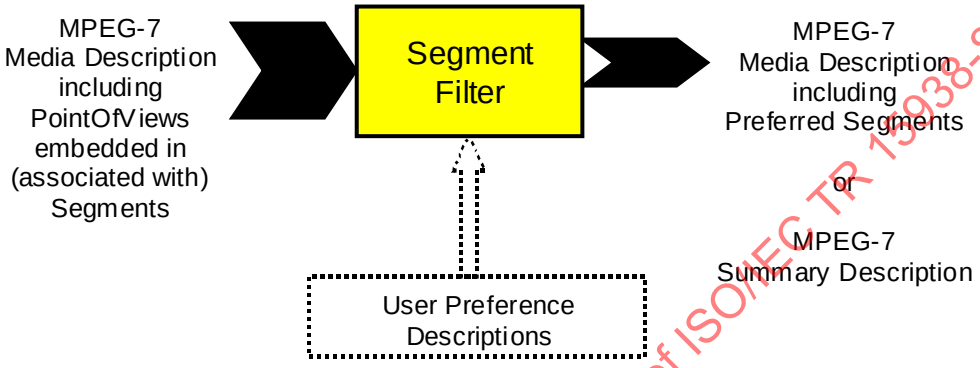


Figure 16 - A generic usage model for PointOfView D descriptions.

3.9.4 Visual segment description tools

3.9.4.1 StillRegion DS

3.9.4.1.1 StillRegion DS examples

The following example illustrates the use of the `StillRegion DS` for describing the image shown in Figure 17. Various attributes of the image such as the location, annotation, and color are described using the following tools, respectively: `MediaLocator datatype`, the `TextAnnotation datatype`, and the `ScalableColor D` (defined in ISO/IEC 15938-3).

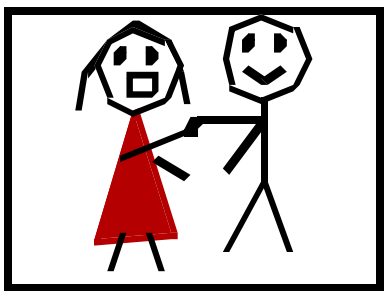


Figure 17 - Example of an image showing two people shaking hands. The image is described using the StillRegion DS.

```
<StillRegion>
    <MediaLocator>
        <MediaUri>image.jpg</MediaUri>
    </MediaLocator>
    <TextAnnotation>
        <FreeTextAnnotation> Alex shakes hands with Ana </FreeTextAnnotation>
    </TextAnnotation>
    <VisualDescriptor xsi:type="ScalableColorType" numOfCoeff="16"
```

```
      numOfBitplanesDiscarded="0">
      <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
   </VisualDescriptor>
</StillRegion>
```

3.9.4.1.2 StillRegion DS extraction

Still regions cab be the result of a spatial segmentation or a spatial decomposition methods. This may be done automatically or by hand, based on semantics criteria or not. Several techniques are reported in Special issue on Object Based Video Coding and Description, 1999, Hermann et al., 1999. Note that this kind of analysis tools have been extensively studied in the framework of the MPEG-4 standard. Some examples are described in Kim et al., 1999, Hermann et al., 1999, Salembier and Marqués, 1999. This subclause describes one example proposed in Salembier and Marqués, 1999.

The extraction of individual spatial or temporal regions and their organization within a tree structure can be viewed as a hierarchical segmentation problem also known as a partition tree creation. The strategy presented here involves three steps illustrated in Figure 18: the first step is a conventional segmentation. Its goal is to produce an initial partition with a rather high level of details. Depending on the nature of the segment tree, this initial segmentation can be a shot detection algorithm (for VideoSegment DS) or a spatial segmentation following a color homogeneity criterion (for StillRegion DS). The second step is the creation of a Binary Partition Tree. Combining the segments (VideoSegment or StillRegion DSs) created in the first step, the Binary Partition Tree defines the set of segments to be indexed and encodes their similarity with the help of a binary tree. Finally, the third step restructures the binary tree into an arbitrary tree. Although the approach can be used for many types of segments, the following description assumes still regions.

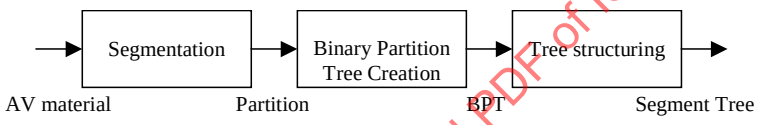


Figure 18 - Outline of segment tree creation.

The first step is rather classical (see Special issue on Object Based Video Coding and Description, 1999, and the reference herein for example). The second step of the Segment tree creation is the computation of a Binary Partition Tree. Each node of the tree represents connected components in space (regions). The leaves of the tree represent the regions defined by the initial segmentation step. The remaining nodes represent segments that are obtained by merging segments represented by the children. This representation should be considered as a compromise between representation accuracy and processing efficiency. Indeed, all possible merging of initial segments are not represented in the tree. Only the most "useful" merging steps are represented. However, the main advantage of the binary tree representation is that efficient techniques are available for its creation and it conveys enough information about segment similarity to construct the final tree. The Binary Partition Tree should be created in such a way that the most "useful" segments are represented. This issue can be application dependent. However, a possible solution, suitable for a large number of cases, is to create the tree by keeping track of the merging steps performed by a segmentation algorithm based on merging. This information is called the merging sequence. The process is illustrated in Figure 19. The original partition involves four regions. The regions are indicated by a letter and the number indicates the mean gray level value. The algorithm merges the four regions in three steps.

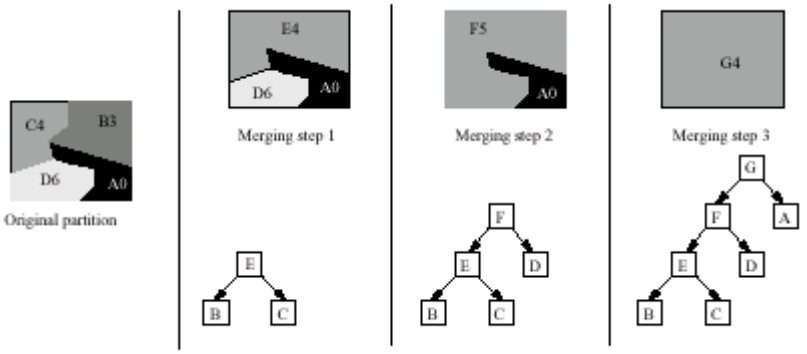


Figure 19 - Example of Binary Partition Tree creation with a region merging algorithm.

To create the Binary Partition Tree, the merging algorithm may use several homogeneity criteria based on low-level features. For example, if the image belongs to a sequence of images, motion information can be used to generate the tree: in a first stage, regions are merged using a color homogeneity criterion, whereas a motion homogeneity criterion is used in the second stage. Figure 20 presents an example of a Binary Partition Tree created with color and motion criteria for the Foreman sequence. The nodes appearing in the lower part of the tree as white circles correspond to the color criterion, whereas the dark squares correspond to the motion criterion. As can be seen, the process starts with a color criterion and then, when a given Peak Signal to Noise Ratio (PSNR) is reached, it changes to the motion criterion. Regions that are homogeneous in motion as the face and helmet are represented by a single node (B) in the tree.

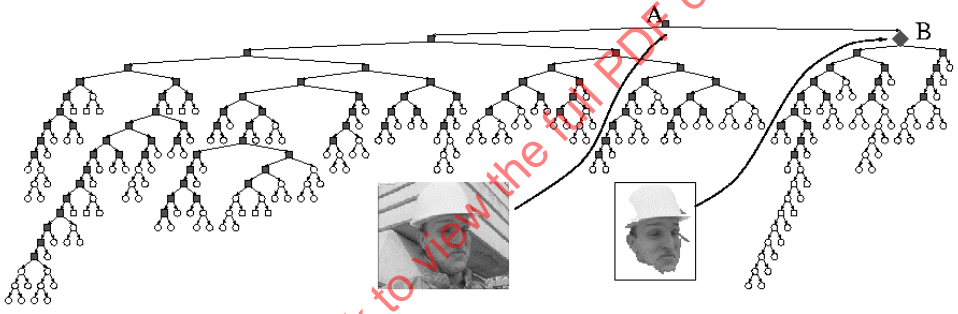


Figure 20 - Examples of creation of the Binary Partition Tree with color and motion homogeneity criteria.

Furthermore, additional information about previous processing or detection algorithms can also be used to generate the tree in a more robust way. For instance, an object mask can be used to impose constraints on the merging algorithm in such a way that the object itself is represented as a single node in the tree. Typical examples of such algorithms are face, skin, character or foreground object detection. An example is illustrated in Figure 21. Assume for example that the original Children sequence has been analyzed so that masks of the two foreground objects are available. If the merging algorithm is constrained to merge regions within each mask before dealing with remaining regions, the region of support of each mask will be represented as a single node in the resulting tree. In Figure 21 the nodes corresponding to the background and the two foreground objects are represented by squares. The three sub-trees further decompose each object into elementary regions.

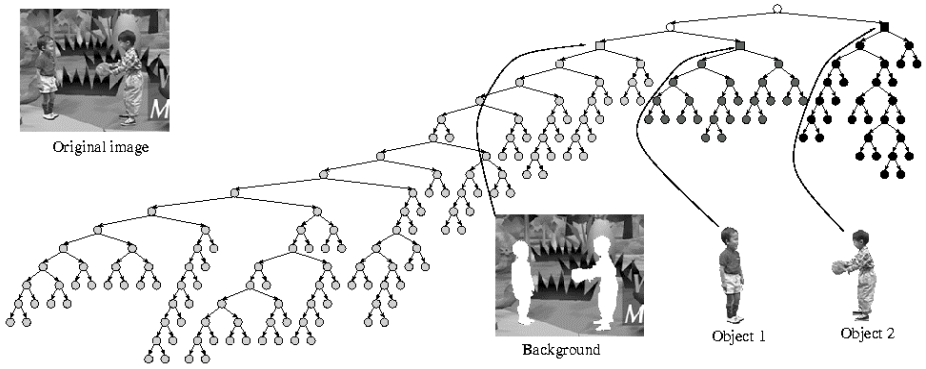


Figure 21 - Example of partition tree creation with restriction imposed with object masks.

The purpose of the third and last step of the algorithm is to restructure the Binary Partition Tree into an arbitrary tree that shall reflect more clearly the image structure. To this end, nodes that have been created by the binary merging process but do not convey any relevant information should be removed. The criterion used to decide if a node must appear in the final tree can be based on the variation of segments homogeneity. A segment is kept in the final tree if the homogeneity variation between itself and its parent is low. Furthermore, techniques pruning the tree can be used since not all regions may have to be described. Finally, a specific GUI can also be designed to manually modify the tree to keep the useful sets of segments. An example of simplified and restructured tree is shown in Figure 22.

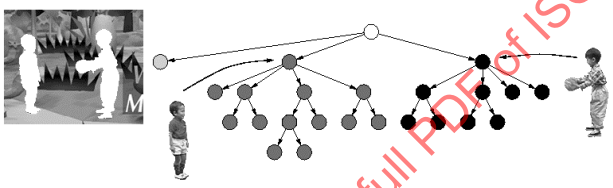


Figure 22 - Example of restructured tree.

3.9.4.2 Still region decomposition tools

3.9.4.2.1 Still region decomposition tools examples

The following example illustrates the use of the `StillRegionSpatialDecomposition DS` in the `StillRegion DS` for describing the spatial decomposition of the image in Figure 17 into two still regions shown in Figure 23. In this example, the still region with `id` = "AlexAnaSR" corresponds to the full image from which two still regions, `id` = "AlexSR" and `id` = "AnaSR" are generated by spatial segmentation. In this example, each still region segment, `id` = "AlexSR", and `id` = "AnaSR", correspond to a person in the image. In this example, the segment decomposition has gaps (`gaps` = true) but no overlaps (`overlap` = false). The two still regions are spatially connected. The `TextAnnnotation` describes an annotation of each still region. The `ScalableColor D` (defined in ISO/IEC 15938-3) describes the contour shape of each still region.

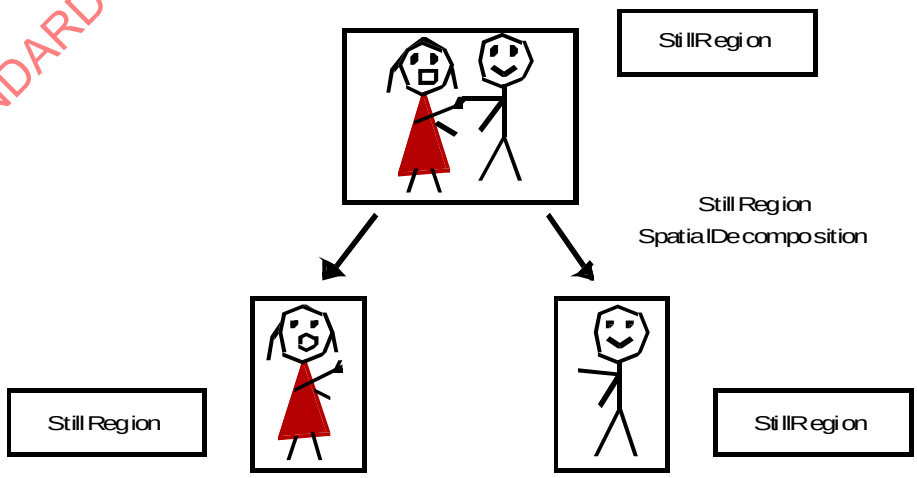


Figure 23 - Example of the spatial decomposition of an image into two still regions.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="ImageType">
         <Image>
            <SpatialDecomposition gap="true" overlap="false">
               <StillRegion id="AlexSR">
                  <TextAnnotation>
                     <FreeTextAnnotation> Alex </FreeTextAnnotation>
                  </TextAnnotation>
                  <VisualDescriptor xsi:type="ScalableColorType"
numOfCoeff="16"
                     numOfBitplanesDiscarded="0">
                     <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                  </VisualDescriptor>
               </StillRegion>
               <StillRegion id="AnaSR">
                  <TextAnnotation>
                     <FreeTextAnnotation> Ana </FreeTextAnnotation>
                  </TextAnnotation>
                  <VisualDescriptor xsi:type="ScalableColorType"
numOfCoeff="16"
                     numOfBitplanesDiscarded="0">
                     <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                  </VisualDescriptor>
               </StillRegion>
            </SpatialDecomposition>
         </Image>
      </MultimediaContent>
   </Description>
</Mpeg7>
```


3.9.4.3 ImageText DS

3.9.4.3.1 ImageText DS examples

The following example illustrates the use of the `ImageText` DS for describing the image text of the image shown in Figure 24. The image contains one instance of scene image text ("Cherie, je suis la") and two instances of superimposed image text ("En direct du stade DE-KUIP Rotterdam Jean-Francois DEVELEY" and "Nous allons assister a un match fantastique").

Figure 24 - Example of an image that contains image text.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="ImageType">
         <Image>
            <SpatialDecomposition gap="true" overlap="false">
               <StillRegion xsi:type="ImageTextType" textType="scene">
                  <SpatialLocator>
                     <!-- more elements here -->
                  </SpatialLocator>
                  <Text xml:lang="fr"> Cherie, je suis la </Text>
               </StillRegion>
               <StillRegion xsi:type="ImageTextType" textType="superimposed"
                  fontSize="40" fontType="Arial">
                  <SpatialLocator>
                     <!-- more elements here -->
                  </SpatialLocator>
                  <Text xml:lang="fr">
               En direct du state DE-KUIP Rotterdam Jean-Francois DEVELEY
</Text>
               </StillRegion>
               <StillRegion xsi:type="ImageTextType" textType="superimposed"
                  fontSize="30" fontType="Times New Roman">
                  <SpatialLocator>
                     <!-- more elements here -->
                  </SpatialLocator>
                  <Text xml:lang="fr">
                     Nous allons assister a un match fantastique </Text>
               </StillRegion>
            </SpatialDecomposition>
         </Image>
      </MultimediaContent>
   </Description>
</Mpeg7>
```

3.9.4.4 Mosaic DS

3.9.4.4.1 Mosaic DS examples

The following example illustrates the use of the `Mosaic DS` for describing the mosaic of a video segment.

```
<Mosaic>
   <!-- Affine model, Center of Source -->
   <WarpingParam modelType="6"
                     sourceSequenceWidth="352"
                     sourceSequenceHeight="288"
                     xOffset="2" yOffset="7"
                     xOrigin="176" yOrigin="144">
      <MediaTimePoint> <!-- more elements here --> </MediaTimePoint>
      <MotionParam> 0.0 0.0 0.0 0.0 0.0 0.0 </MotionParam>
      <MediaTimePoint> <!-- more elements here --> </MediaTimePoint>
      <MotionParam> -3.60 0.73 0.03 0.01 0.01 0.51 </MotionParam>
      <!—- more elements here -->
   </WarpingParam>
</Mosaic>
```

A mosaic allows the representation and visualization of a video segment using a single image. This functionality can also be provided by key frames. However, a mosaic contains more visual information than a key frame (e.g., motion warping parameters), but is not suitable for all kinds of shots (e.g., shots with rapidly changing background). Thus, mosaics and key frames serve complementary functions. Mosaics can also be useful for performing searching of video segments. Image features can be extracted from the mosaic image to describe the features of the video segment. Moreover, since the `Mosaic DS` extends the `StillRegion DS`, the `StillRegionSpatialDecomposition DS` can be used to describe the decomposition of a

mosaic into still regions, each of which can be described individually. The warping information an also be used for summarizing the video segment since it describes the global motion in the segment. The mosaics may also be useful for video editing since the mosaics can be easily manipulated, using common image processing tools, and then resconstructing the video segment from the manipulated mosaic image.

3.9.4.4.2 Mosaic DS extraction

It is very important to be able to construct good mosaics even from video shots that are not pre-segmented, videos with lots of free moving objects and videos where motion is large and subsequent frames therefore are largely disaligned. Thus a very stable and robust algorithm is important for handling these situations. The algorithm described below is described in detail in Wallin et al., 2000. Below a brief description is given.

As input to a mosaic algorithm is a set of video frames and as the final output there is the resulting mosaic image of these frames. Generally, the mosaicing procedure can be divided into two main parts. First the set of frames have to be aligned with each other, and then follows the construction of the mosaic where the data is merged into one single image.

The merging can be done with several criteria, for instance averaging of the frame data or pasting with the latest frame. But before the merging can be done, alignment of the frames has to be performed, and the method of alignment is critical for the quality and robustness of the algorithm.

The aim when developing a mosaic construction method has been to make an algorithm that is robust and reliable, well prepared to deal with unsegmented video containing free-moving objects and large frame disalignment. In order to achieve this, the algorithm is based on minimization of an error measure for the alignment of the frames.

This alignment process between frames is described in detail in 4.5.3 in the context of the Parametric Motion Descriptor. When all frames have been aligned, the mosaic can be constructed by merging the data from all frames into the same reference system. Generally in the entire algorithm, if masks are present, only data that are not masked out is used in the calculations.

3.9.4.5 StillRegion3D DS

Information on extraction and use is not provided.

3.9.4.6 3D still region decomposition tools

Information on extraction and use is not provided.

3.9.4.7 VideoSegment DS

3.9.4.7.1 VideoSegment DS examples

The following examples illustrate the use of the `VideoSegment DS` for describing the video shown in

Figure 12. In this example, the video segment `id` ="RootVS" represents the full video. The `MediaTime` describes the time information for the segment. The `GoFGoPColor D` (defined in ISO/IEC 15938-3) describes the color information of the video segment.

```
<VideoSegment id="RootVS">
   <MediaTime>
      <MediaTimePoint>T00:00:00</MediaTimePoint>
      <MediaDuration>PT1M30S</MediaDuration>
   </MediaTime>
   <VisualDescriptor xsi:type="GoFGoPColorType" aggregation="Average">
      <ScalableColor numOfCoeff="16" numOfBitplanesDiscarded="0">
         <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
      </ScalableColor>
   </VisualDescriptor>
</VideoSegment>
```

3.9.4.7.2 VideoSegment DS extraction

Video segments can be the result of a temporal segmentation methods. This may be done automatically or by hand, based on semantics or other criteria. An overview of temporal segmentation can be found in Special issue on Object Based Video Coding and Description, 1999, Hanjalic and Zhang, 1999, and Salembier and Marqués, 1999. This subclause describes an automatic method for detecting scene changes (Meng et al., 1995) in MPEG-2 streams, which results in the temporal segmentation of video sequences into scenes.

This scene change detection algorithm is formed based on the statistical characteristics of the DCT DC coefficient values and motion vectors in the MPEG-2 bitstream. First, the algorithm detects candidate scene change on I, P, and B-frames separately, and dissolved editing effects. Then, a final decision is made to select the true scene changes. The overall scene change detection algorithm has five stages: minimal decoding, parsing, statistical detection, and decision stages; these five stages are described below. Figure 25 shows the block diagram of each stage.

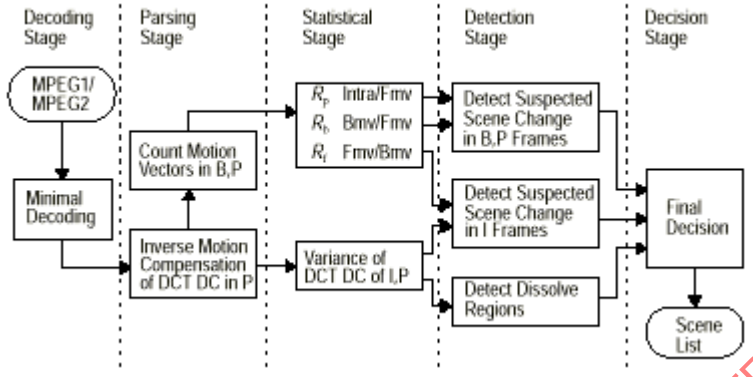


Figure 25 - The Block diagram of the scene change detection algorithm.

- Minimal Decoding Stage: The MPEG bitstream is partially decoded to obtain motion vectors and the DCT DCs.
- Parsing Stage: The motion vectors in B, and P frames are counted; the DCT DC coefficients in P frames are reconstructed.
- Statistical Stage:
  1. Compute R p, the ratio of intra coded blocks and forward motion vectors in P-frames.
  2. Compute R b, the ratio of backward and forward motion vectors in B-frames.
  3. Compute R f, the ratio of forward and backward motion vectors in B-frames.
  4. Compute the variance of DCT DC coefficients of the luminance in I and P frames.
- Detection Stage:
  1. Detect R p peaks in P frames and mark them as candidate scene change frames.
  2. Detect R b peaks in B frames and mark them as candidate scene change frames.
  3. Detect R f peaks in B frames. Detect all $|\Delta\sigma 2|$, absolute value of the frame intensity variance difference, in I, P frames. Mark I-frames as candidate scene change frames if they have $|\Delta\sigma 2|$ peaks and if the immediate B-frames have R f peaks.
  4. Detect the parabolic variance curve for dissolve effects.
- Decision Stage:
  1. All candidate frames that fall in the dissolve region are unmarked.
  2. Search through all marked frames from the lowest frame number

     `if (current marked frame number - last scene change number) > T rejection,`
     `then current marked frame is a true scene change`
     `else unmark current frame`

     (where *T rejection* is the rejection threshold, default one GOP.)

The criterion in step 2 of the Decision Stage is used to eliminate situations when a scene change happens on a B frame, then the immediately subsequent P-frame and/or I-frame (of display order) will likely be marked as candidate scene change as well. But since they don't satisfy the criterion of "the minimum distance between two scene changes has to be greater than *T rejection*", these candidate frames will be unmarked. Situations where multiple scene changes occur on one GOP are very rare.

For P frames, the marked frame decision can be obtained both from step 1 (R_p peaks) and step 3 ($|\Delta\sigma^2|$ peaks) in the Detection Stage. The outcome from step 1 is usually more reliable. The outcome from step 3 can be used as reference if they are conflicting with the outcome of step 1.

The following subclauses describe a technique for detecting the peak ratios R_b, R_p and R_f and a method to detect dissolves.

3.9.4.7.2.1 Adaptive Local Window Threshold Setting Technique for Detecting Peak Ratios

Different scenes have very different motion vector ratios. But within the same scene, they tend to be similar. Setting several levels of global thresholds will not only complicate the process but will also cause false alarms and false dismissals. A local adaptive threshold technique is used to overcome this problem.

The peak ratios R_b, R_p and R_f are detected separately. All ratios are first clipped to a constant upper limit, usually 10 to 20. Then ratio samples are segmented into time windows. Each window is 2 to 4 times the Group of Picture (GOP)'s size. For typical movie sequences, scene change distances are mostly greater than 24 frames, so a window size of 2 GOP is sufficient. If the GOP is 12 frames, and window size is 2 frames, there will be 6 ratio samples for P-frames and 12 samples for B-frame. These samples are enough to detect the peaks.

Within the window, a histogram of the samples with a bin size of 256 is calculated. If the peak-to-average ratio is greater than the threshold, T_d , then the peak frame is declared as a candidate scene change. The peak values are not included in calculating the average. A typical T_d value is 3 for R_b, R_p and R_f. Figure 26b. shows the histogram of a local window corresponding to P-frames (from frames 24 to 47) in Figure 26a. where there is a peak at frame 29. For B-frames, if a scene change happens at a B-frame (frame 10, in Figure 26a.), then the ratio of the immediately subsequent B frame (frame 11) will be also high. Both of them will be considered as peaks and will not be considered into the average, only the first B-frame will be marked as a candidate scene change.

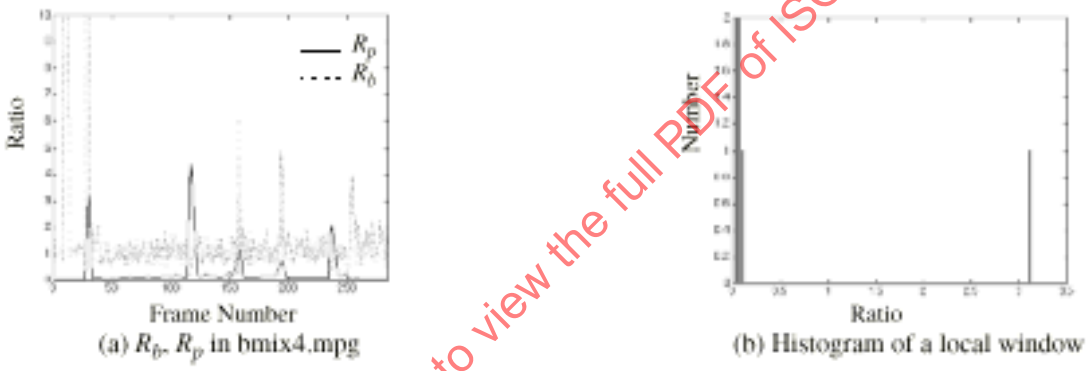


Figure 26 - Motion Vector Ratio In B and P Frames.

3.9.4.7.2.2 Detection of Dissolves

Dissolve is the most frequently used editing effect to connect two scenes together. A dissolve zone is created by linearly mixing two scenes sequences: one gradually decreasing in intensity and another gradually increasing. Dissolves can be detected by taking the pixel domain intensity variance of each frame and then detecting a parabolic curve. Given an MPEG-2 bitstream, the variance of the DCT DC coefficients in I and P frames is calculated instead of the spatial domain variance. Experiments have shown that this approximation is accurate enough to detect dissolves.

3.9.4.7.2.2.1 Calculation of DCT DC Coefficient Values

The I-frames in MPEG are all intra coded, so the DCT DC coefficient values can be obtained directly (without temporal prediction). The P-frames consist of backward motion compensated (MC) macroblocks and the intra coded macroblocks. An MC macroblock has a motion vector and a DCT coded MC prediction error. Each macroblock consists of 4 luminance blocks (8x8 pixels each) and some chrominance blocks (2, 6 or 8 depending on the chrominance subsampling format). To ensure maximum performance, only the DCT DC coefficients of the luminance macroblock are used for dissolve detection. The DCT DC coefficient values of B pictures could also be reconstructed applying the same technique.

To get the DCT DC coefficient values for a P frame, inverse motion compensation is applied on the luminance blocks and the DCT DC coefficient value of the prediction error is added to the DCT DC coefficient prediction. Assume that the variance within each block is small enough, then *b*, the DCT DC coefficient of a MC block in a P frame can be approximated by taking the area-weighted average of the four blocks in the previous frame pointed by the motion vector.

$$b = [b\ 0 *(8-x)*(8-y) + b\ 1 *x*(8-y) + b\ 2 *(8-x)*y + b\ 3 *x*y]/64 + b\ error\_DCT\_DC$$

where *x*, *y* are the horizontal and vertical motion vector modulo block size 8; *b 0* , *b 1* , *b 2* and *b 3* are the DCT DC coefficients of the four neighboring blocks pointed by the motion vector; *b error_DCT_DC* is the DCT DC coefficient of the motion compensation error of the block to be reconstructed (see Figure 27).

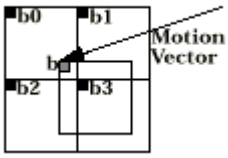


Figure 27 - Inverse Motion Compensation of DCT DC coefficient.

3.9.4.7.2.2.2 Dissolve Detection

Two criteria are used for dissolved detection --first, the depth of the variance valley must be large enough and second, the MediaDuration of the candidate dissolve region must be long enough (otherwise it is more likely an abrupt scene change). A typical dissolve would last from 30 to 60 frames. The specific procedure is as following.

All the positive-peaks, *p* + are detected by using the local window method on $\Delta\sigma^2$, the frame variance difference; all the negative-peaks *p* - are found by detecting the minimum value between two positive-peaks; the peak-to-peak difference *Δp = current peak - previous peak,* is calculated and thresholded using the proposed local window method; finally potential matches with MediaDuration length (positive peak to current negative peak) long enough (> *T f* frames, e.g. 1/3 of the minimum allowed dissolve MediaDuration) are declared as candidate dissolves.

The starting point of the candidate dissolve is the previous positive peak. If the next positive peak is at least *T f* frames from the current negative peak, then a dissolve is declared and the ending point is set to the next positive peak. Frames whose peak-to-peak distance meets the magnitude threshold, but fail to meet the MediaDuration threshold are usually the direct scene changes. Similarly, if the frame MediaDuration from the current negative peak to the next positive peak fails to meet *T f* , the candidate dissolve will be unmarked also.

3.9.4.8 Video segment decomposition tools

3.9.4.8.1 Video segment decomposition tools examples

The following examples illustrate the use of the `VideoSegmentTemporalDecomposition DS` and `VideoSegmentSpatioTemporalDecomposition DS` for describing the temporal and spatio-temporal decomposition of a video segment.

The first example describes the segment decompositon shown in

Figure 12. In this example, the video segment has two scenes, "Chase" and "Capture". The video segment `id` = "RootVS" is decomposed in two video segments, `id` = "ChaseVS" and `id` = "CaptureVS". The video segment `id` = "ChaseVS" corresponds to the scene "Chase", and video segment `id` = "CaptureVS" corresponds to the scene "Capture". The segment decomposition has neither gaps (`gap` = false) nor overlaps (`overlap` = false). The video segments are temporally connected. At the same time, the video segment "CaptureVS" is decomposed into two moving regions: `id` = "ManMR" and `id` = "WomanMR". The moving region `id` = "ManMR" corresponds to the object "Man" and moving region `id` = "WomanMR" corresponds to the object "Woman". This segment decomposition has gaps and overlaps (`gap` = true) nor overlaps (`overlap` = true). Each of the moving regions is connected. The `GoFGoPColor D` (defined in ISO/IEC 15938-3) describes the color information of the video segment.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="VideoType">
         <Video id="RootVS">
            <MediaTime>
               <MediaTimePoint>T00:00:00</MediaTimePoint>
               <MediaDuration>PT1M30S</MediaDuration>
            </MediaTime>
            <VisualDescriptor xsi:type="GoFGoPColorType"
aggregation="Average">
               <ScalableColor numOfCoeff="16" numOfBitplanesDiscarded="0">
                  <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
```

```
                </ScalableColor>
            </VisualDescriptor>
            <TemporalDecomposition gap="false" overlap="false">
                <VideoSegment id="ChaseVS">
                    <TextAnnotation>
                        <FreeTextAnnotation> Chase </FreeTextAnnotation>
                    </TextAnnotation>
                    <MediaTime>
                        <MediaTimePoint>T00:00:00</MediaTimePoint>
                        <MediaDuration>PT0M15S</MediaDuration>
                    </MediaTime>
                    <VisualDescriptor xsi:type="GoFGoPColorType"
                        aggregation="Average">
                        <ScalableColor numOfCoeff="16"
numOfBitplanesDiscarded="0">
                            <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                        </ScalableColor>
                    </VisualDescriptor>
                </VideoSegment>
                <VideoSegment id="CaptureVS">
                    <TextAnnotation>
                        <FreeTextAnnotation> Capture </FreeTextAnnotation>
                    </TextAnnotation>
                    <MediaTime>
                        <MediaTimePoint>T00:00:15</MediaTimePoint>
                        <MediaDuration>PT1M15S</MediaDuration>
                    </MediaTime>
                    <VisualDescriptor xsi:type="GoFGoPColorType"
                        aggregation="Average">
                        <ScalableColor numOfCoeff="16"
numOfBitplanesDiscarded="0">
                            <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                        </ScalableColor>
                    </VisualDescriptor>
                    <SpatioTemporalDecomposition gap="true" overlap="true">
                        <MovingRegion id="ManMR">
                            <TextAnnotation>
                                <FreeTextAnnotation> Man </FreeTextAnnotation>
                            </TextAnnotation>
                        </MovingRegion>
                        <MovingRegion id="WomanMR">
                            <TextAnnotation>
                                <FreeTextAnnotation> Woman </FreeTextAnnotation>
                            </TextAnnotation>
                        </MovingRegion>
                    </SpatioTemporalDecomposition>
                </VideoSegment>
            </TemporalDecomposition>
        </Video>
    </MultimediaContent>
</Description>
</Mpeg7>
```


The second example describes the video segment decomposition. In this example, video segment `id` = "VS1" represents a video consisting of four segments: " `id` = VS2", `id` = "VS3", `id` = "VS4", and `id` = "VS5". The segment decomposition has neither gaps nor overlaps (`gap` = false) nor overlaps (`overlap` = false). The video segment `id` = "VS1" is not connected in time; it is composed of two temporal intervals of duration six and three minutes, respectively. Each video segment `id` = "VS2", `id` = "VS3", `id` = "VS4", and `id` = "VS5" is temporally connected.

```
<Mpeg7>
    <Description xsi:type="ContentEntityType">
        <MultimediaContent xsi:type="VideoType">
```

```
          <Video id="VS1">
             <TemporalMask>
                <SubInterval>
                   <MediaTimePoint>T00:00:00</MediaTimePoint>
                   <MediaDuration>PT6M</MediaDuration>
                </SubInterval>
                <SubInterval>
                   <MediaTimePoint>T00:07:00</MediaTimePoint>
                   <MediaDuration>PT3M</MediaDuration>
                </SubInterval>
             </TemporalMask>
             <TemporalDecomposition gap="false" overlap="false">
                <VideoSegment id="VS2">
                   <MediaTime>
                      <MediaTimePoint>T00:00:00</MediaTimePoint>
                      <MediaDuration>PT5M</MediaDuration>
                   </MediaTime>
                   <VisualDescriptor xsi:type="GoFGoPColorType"
                      aggregation="Average">
                      <ScalableColor numOfCoeff="16"
numOfBitplanesDiscarded="0">
                         <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                      </ScalableColor>
                   </VisualDescriptor>
                </VideoSegment>
                <VideoSegment id="VS3">
                   <MediaTime>
                      <MediaTimePoint>T00:05:00</MediaTimePoint>
                      <MediaDuration>PT1M</MediaDuration>
                   </MediaTime>
                   <VisualDescriptor xsi:type="GoFGoPColorType"
                      aggregation="Average">
                      <ScalableColor numOfCoeff="16"
numOfBitplanesDiscarded="0">
                         <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                      </ScalableColor>
                   </VisualDescriptor>
                </VideoSegment>
                <VideoSegment id="VS4">
                   <MediaTime>
                      <MediaTimePoint>T00:07:00</MediaTimePoint>
                      <MediaDuration>PT2M</MediaDuration>
                   </MediaTime>
                   <VisualDescriptor xsi:type="GoFGoPColorType"
                      aggregation="Average">
                      <ScalableColor numOfCoeff="16"
numOfBitplanesDiscarded="0">
                         <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                      </ScalableColor>
                   </VisualDescriptor>
                </VideoSegment>
                <VideoSegment id="VS5">
                   <MediaTime>
                      <MediaTimePoint>T00:09:00</MediaTimePoint>
                      <MediaDuration>PT1M</MediaDuration>
                   </MediaTime>
                   <VisualDescriptor xsi:type="GoFGoPColorType"
                      aggregation="Average">
                      <ScalableColor numOfCoeff="16"
numOfBitplanesDiscarded="0">
                         <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                      </ScalableColor>
                   </VisualDescriptor>
                </VideoSegment>
```

```
            </TemporalDecomposition>
         </Video>
      </MultimediaContent>
   </Description>
</Mpeg7>
```

3.9.4.9 MovingRegion DS

3.9.4.9.1 MovingRegion DS examples

The following example illustrates the use of the `MovingRegion DS` for describing the spatio-temporal region corresponding to the object "Man" in the video shown in

Figure 12. In this example, the moving region `id` = "ManMR" corresponds to the object "Man".

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="VideoType">
         <Video>
            <SpatioTemporalDecomposition>
               <MovingRegion id="ManMR">
                  <TextAnnotation>
                     <FreeTextAnnotation> Man </FreeTextAnnotation>
                  </TextAnnotation>
                  <SpatioTemporalLocator>
                     <FigureTrajectory type="rectangle">
                        <MediaTime>
                           <MediaTimePoint>T00:00:15</MediaTimePoint>
                           <MediaDuration>PT1M15S</MediaDuration>
                        </MediaTime>
                        <Vertex>
                           <WholeInterval>
                              <MediaDuration>PT0S</MediaDuration>
                           </WholeInterval>
                           <InterpolationFunctions>
                              <KeyValue type="startPoint">
                                 <!-- more elements here -->
                              </KeyValue>
                              <KeyValue type="startPoint">
                                 <!-- more elements here -->
                              </KeyValue>
                           </InterpolationFunctions>
                        </Vertex>
                        <Vertex>
                           <WholeInterval>
                              <MediaDuration>PT1S</MediaDuration>
                           </WholeInterval>
                           <InterpolationFunctions>
                              <KeyValue type="startPoint">
                                 <!-- more elements here -->
                              </KeyValue>
                              <KeyValue type="startPoint">
                                 <!-- more elements here -->
                              </KeyValue>
                           </InterpolationFunctions>
                        </Vertex>
                        <Vertex>
                           <WholeInterval>
                              <MediaDuration>PT2S</MediaDuration>
                           </WholeInterval>
                           <InterpolationFunctions>
                              <KeyValue type="startPoint">
                                 <!-- more elements here -->
                              </KeyValue>
```

```
                                    <KeyValue type="startPoint">
                                       <!-- more elements here -->
                                    </KeyValue>
                                 </InterpolationFunctions>
                              </Vertex>
                              <!-- more elements here -->
                           </FigureTrajectory>
                        </SpatioTemporalLocator>
                     </MovingRegion>
                  </SpatioTemporalDecomposition>
               </Video>
            </MultimediaContent>
         </Description>
      </Mpeg7>
```

3.9.4.9.2 MovingRegion DS extraction

Moving regions can be the result of spatio-temporal segmentation methods. This may be done automatically or by hand, based on semantics or other criteria. An overview of spatio-temporal segmentation can be found in Special issue on Object Based Video Coding and Description, 1999. This subclause describes the semi-automatic method used in the AMOS system (Zhong and Chang, 1998) to segment and track semantic objects in video sequences.

AMOS is a system that combines low level automatic region segmentation with an active method for defining and tracking high-level semantic video objects. A semantic object is represented as a set of underlying homogeneous regions. The system considers two stages (see Figure 28): an initial object segmentation stage where user input in the starting frame is used to create a semantic object, and an object tracking stage where underlying regions of the semantic object are automatically tracked and grouped through successive frames.

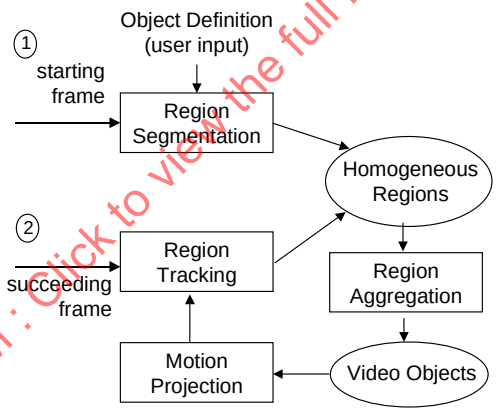


Figure 28 - General Structure of AMOS.

3.9.4.9.2.1 Initial Semantic Object Segmentation

Semantic object segmentation at the starting frame consists of several major processes as shown in Figure 29. First, users identify a semantic object by using tracing interfaces (e.g. mouse). The input is a polygon whose vertices and edges are roughly along the desired object boundary. To tolerate user-input error, a snake algorithm (Kass et al., 1988) may be used to align the user-specified polygon to the actual object boundary. The snake algorithm is based on minimizing a specific energy function associated with edge pixels. Users may also choose to skip the snake module if a relatively accurate outline is already provided.

After the object definition, users can start the tracking process by specifying a set of thresholds. These thresholds include a color merging threshold, weights on three color channels (i.e. L*u*v*), a motion merging threshold and a tracking buffer size (see following subclauses for their usage). These thresholds can be chosen based on the characteristic of a given video shot and experimental results. For example, for a video shot where foreground objects and background regions have similar luminance, users may choose a lower weight on the luminance channel. Users can start the tracking process for a few frames with the default thresholds, which are automatically generated by the system, and then adjust the thresholds based on the segmentation and tracking results. This system also allows a user to stop the tracking process at any frame, modify the object boundary that is being tracked and then restart the tracking process from the modified frame.

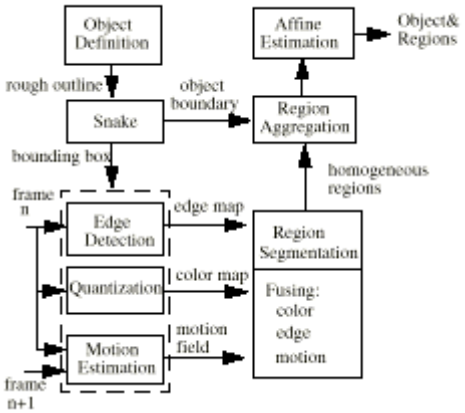


Figure 29 - Object segmentation at starting frame.

Given the initial object boundary from users (or the snake module), a slightly extended (~15 pixels) bounding box surrounding the arbitrarily shaped object is computed. Within the bounding box, three feature maps, edge map, color map, and motion field, are created from the original images. Color map is the major feature map in the following segmentation module. It is generated by first converting the original image into the CIE L*u*v* color space and then quantizing pixels to a limited number of colors (e.g. 32 or 16 bins) using a clustering based (e.g. K-Means) method. The edge map is a binary mask where edge pixels are set to 1 and non-edge-pixels are set to 0. It is generated by applying the Canny edge detection algorithm. The motion field is generated by a hierarchical block matching algorithm with a 3-level hierarchy (Special issue on Object Based Video Coding and Description, 1999).

The spatial intra-frame segmentation module is based on an automatic region segmentation algorithm using color and edge information (Zhong and Chang, 1997a, Zhong and Chang, 1997b). As stated in Zhong and Chang, 1997a, and Zhong and Chang, 1997b, color-based region segmentation can be greatly improved by fusion with edge information. Color based region merging works well on quantized and smoothed images. On the contrary, edge detection captures high-frequency details in an image. In AMOS, to further improve the accuracy, a motion-based segmentation process using the optical flow is applied to segmented color regions to check the uniformity of the motion distribution. Although the complete process utilizing color, edge, and motion is not trivial, the computational complexity is greatly reduced by applying the above region segmentation process only inside the bounding box of the snake object instead of the whole frame.

The region aggregation module takes homogeneous regions from the segmentation and the initial object boundary from the snake (or user input directly). Aggregation at the starting frame is relatively simple compared with that for the subsequent frames, as all regions are newly generated (not tracked) and the initial outline is usually not far from the real object boundary. A region is classified as foreground if more than a certain percentage (e.g. 90%) of the region is included in the initial object. On the other hand, if less than a certain percentage (e.g. 30%) of a region is covered, it is considered as background. Regions between the low and high thresholds are split into foreground and background regions according to the intersection with the initial object mask.

Finally, Affine motion parameters of all regions, including both foreground and background, are estimated by a multivariate linear regression process over the dense optical flow inside each region. In our system, a 2-D Affine model with 6 parameters is used. These Affine models will be used to help track the regions and object in the future frames, as will be discussed in the next subclause.

3.9.4.9.2.2 Semantic Object Tracking

Given the object with homogeneous regions constructed at the starting frame, tracking in the successive frames is achieved by motion projection and an inter-frame segmentation process. The main objectives of the tracking process are to avoid losing foreground regions and to avoid including false background regions. It contains the following steps (see Figure 30).

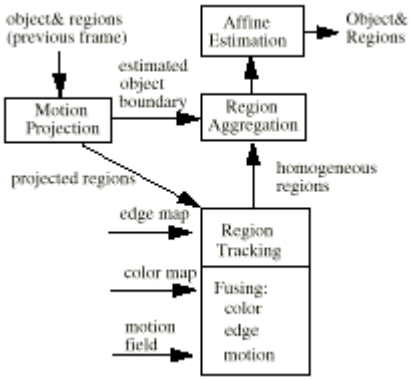


Figure 30 - Automatic semantic object tracking.

First, segmented regions from the previous frame, including both foreground and background, are projected onto the current frame (virtually) using their individual Affine motion models. Projected regions keep their labels and original classifications. For video shots with static or homogeneous background (i.e. only one moving object), users can choose not to project the background regions to save time.

Generation of the three feature maps (color, edge and motion) utilizes the same methods as described in the previous subclause. The only difference is that in the quantization step, the existing color palette computed at the starting frame is directly used to quantize the current frame. Using a consistent quantization palette enhances the color consistency of segmented regions between successive frames, and thus improves the performance of region based tracking. As object tracking is limited to single video shots, in which there is no abrupt scene change, using one color palette is generally valid. Certainly, a new quantization palette can be generated automatically when a large quantization error is found.

In the tracking module (i.e. inter-frame segmentation), regions are classified into *foreground*, *background* and *new* regions. Foreground or background regions tracked from the previous frame are allowed to be merged with regions of the same class, but merging across different classes is forbidden. New regions can be merged with each other or merged with foreground/background regions. When a new region is merged with a tracked region, the merging result inherits its label and classification from the tracked region. In motion segmentation, split regions remain in their original classes. After this inter-frame tracking process, a list of regions temporarily tagged as either foreground, background, or new is obtained. They are then passed to an iterative region aggregation process.

The region aggregation module takes two inputs: the homogeneous region and the estimated object boundary. The object boundary is estimated from projected foreground regions. Foreground regions from the previous frame are projected independently and the combination of projected regions forms the mask of the estimated object. The mask is refined with a morphological closing operation (i.e. dilation followed by erosion) with a size of several pixels in order to close tiny holes and smooth boundaries. To tolerate motion estimation error that may cause the loss of foreground regions around object boundary, the mask is further dilated with the tracking buffer size, which is specified by users at the beginning of the tracking.

The region aggregation module implements a region grouping and boundary alignment algorithm based on the estimated object boundary as well as the edge and motion features of the region. Background regions are first excluded from the semantic object. For every foreground or new region, intersection ratio of the region with the object mask is computed. Then if:

1) the region is *foreground*

If it is covered by the object mask by more than 80%, it belongs to the semantic object. Otherwise, the region is intersected with the object mask and split :

a) split regions inside the object mask are kept as foreground

b) split regions outside the object mask are tagged as new

2) the region is *new*

If it is covered by the object mask by less than 30%, keep it as new; else if the region is covered by the object mask by more than 80%, classify it as foreground.

Otherwise:

a) Compute the numbers of edge pixels (using the edge map) between this region and the current background and foreground regions. Compute the differences between the mean

motion vector of this region with those of its neighboring regions and find the neighbor with the most similar motion.

b) If the region is separated from background regions by more edge pixels than foreground regions (or if this region is not connected to any background regions) and its closest motion neighbor is a foreground region, intersect it with the object mask and split :

- split regions inside the object mask are classified as foreground
- split regions outside the object mask are tagged as new

c) Otherwise, keep the region as new.

Compared with the aggregation process in the previous subclause, a relatively lower ratio (80%) is used to include a foreground or new region. This is to handle motion projection errors. As it is possible to have multiple layers of new regions emerging between the foreground and the background, the above aggregation and boundary alignment process is iterated multiple times. This step is useful in correcting errors caused by rapid motions. At the end of the last iteration, all remaining new regions are classified into background regions. Finally, Affine models of all regions, including both foreground and background, are estimated. As described before, these Affine models are used to project regions onto the future frame in the motion projection module.

3.9.4.9.3 MovingRegion DS use

Moving region descriptions can be used for retrieval, browsing, and visualization applications. This subclause describes a query model for similarity searching of video objects based on localized visual features of the objects and the objects' regions, and spatio-temporal relations among the objects' regions (Zhong and Chang, 1999). In moving region descriptions, the video objects will correspond to the first level of moving regions (InterviewerMR in MovingRegion DS on Informative Examples subclause of the MovingRegion DS of ISO/IEC 15938-5); the objects' regions to the second level of moving regions (MR1 and MR2 MovingRegion DS on the Informative Examples of the MovingRegion DS of ISO/IEC 15938-5); the visual features to visual descriptors; and the spatio-temporal relations to segment relations in segment graphs.

Each video object has a unique ObjectID. Similarly each region also has a unique RegionID. Several visual descriptors (e.g. GoFColor) are associated with ObjectID and RegionID. In addition, ObjectID is associated with spatio-temporal descriptors as described on the Extraction subclause of the MovingRegion DS. These ID's are used as indexes in the description of the object matching and retrieval processes described below.

Given a query object with N regions, the searching approach in Zhong and Chang, 1999, consists of two stages:

(1) Region Search: to find a candidate region list for each query region based on visual features and spatio-temporal relations.

(2) Joint & Validation: to join these candidate region lists to produce the best matched video objects by combining visual and structure similarity metrics and to compute the final global distance measure.

The video object query model is shown in Figure 31.

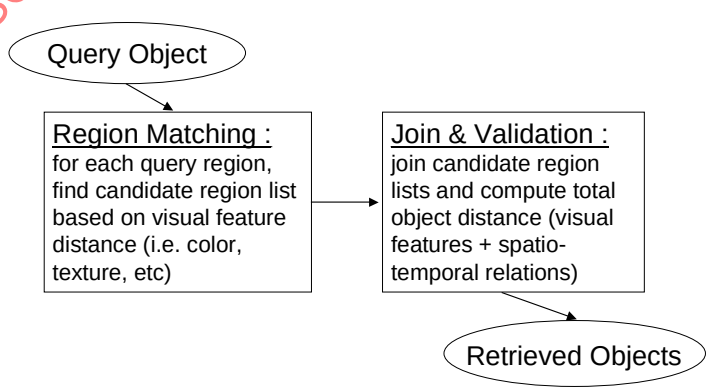


Figure 31 - The video object query model.

The detailed procedure follows:

1) For every query region, find a candidate region list based on the weighted sum (according to the weights given by users) of distance measures of different visual features (e.g., shape or trajectory). All individual feature distances are normalized to [0,1]. Only regions with distances

smaller than a threshold are added to a candidate list. Here the threshold is a pre-set value used to empirically control the number or percentage of objects that the query system will return. For example, a threshold 0.3 indicates that users want to retrieve around 30 percent of video objects in the database (assuming the descriptors of the video objects in the database have normal distribution in feature spaces). The threshold can be set to a large value to ensure completeness, or a small value to improve speed.

2) Sort regions in each candidate region list by their ObjectID's.

3) Perform join (outer join) of the region lists on ObjectID to create a candidate object list. Each candidate object, in turn, contains a list of regions. A "NULL" region is used when: (1) a region list does not contain regions with the ObjectID of a being-joined object and (2) a region appears (i.e. matched) more than once in a being-joined object.

4) Compute the distance between the query object and each object in the candidate object list as follows:

$$D = w\,0 \sum FD\,(q\,i, r\,i) + w\,1\,SD\,(sog\,q, sog\,o) +$$

$$w\,2\,SD\,(topo\,q, topo\,o) + w\,3\,SD\,(temp\,q, temp\,o)$$

where *q i* is the *i*th query region. *r i* is the *i*th region in a candidate object. FD(.) is the feature distance between a region and its corresponding query region. If *r i* is NULL, maximum distance (i.e., 1) is assigned. *sog q* (spatial orientation), *topo q* (topological relation) and *temp q* (temporal relation) are structure features of the query object *sog o, topo o,* and *temp o* are retrieved from database based on ObjectID, RegionID and temporal positions. When there is a NULL region (due to the above join process), the corresponding dimension of the retrieved descriptorwill have a NULL value. SD(.) is the L1-distance and a penalty of maximum difference is assigned to any dimension with a NULL value.

Sort the candidate object list according to the above distance measure D and return the result.

3.9.4.10 Moving region decomposition tools

3.9.4.10.1 Moving region decomposition tools examples

The following example illustrates the use of the `MovingRegionTemporalDecomposition DS` for describing a video object plane or key still region of the moving region `id` = "ManMR" in 3.9.3.1.4.1. In this example, the still region `id` = "ManKeySR" represents the still region of the object "Man" in a video frame. The segment decomposition has gaps but no overlaps. The spatial localization of the still region `id` = "ManKeySR" is described using the `SpatialLocator datatype`.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="VideoType">
         <Video id="VS1">
            <SpatioTemporalDecomposition>
               <MovingRegion id="ManMR">
                  <TextAnnotation>
                     <FreeTextAnnotation> Man (moving
region)</FreeTextAnnotation>
                  </TextAnnotation>
                  <TemporalDecomposition gap="true" overlap="false">
                     <StillRegion id="ManKeySR">
                        <MediaLocator>
                           <MediaUri>image.jpg</MediaUri>
                        </MediaLocator>
                        <TextAnnotation>
                           <FreeTextAnnotation> Man (still region)
                           </FreeTextAnnotation>
                        </TextAnnotation>
                        <VisualDescriptor xsi:type="ScalableColorType"
                           numOfCoeff="16" numOfBitplanesDiscarded="0">
                           <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                        </VisualDescriptor>
                     </StillRegion>
                  </TemporalDecomposition>
               </MovingRegion>
```

```
            </SpatioTemporalDecomposition>
         </Video>
      </MultimediaContent>
   </Description>
</Mpeg7>
```

3.9.4.11 VideoText DS

3.9.4.11.1 VideoText DS examples

The following example illustrates the use of the `VideoText DS` for describing a superimposed video text with text string "Victory".

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="VideoType">
         <Video id="VS1">
            <SpatioTemporalDecomposition>
               <MovingRegion xsi:type="VideoTextType" id="VideoText1"
                  textType="superimposed" fontSize="40" fontType="Courier
New">
                  <Text> Victory </Text>
               </MovingRegion>
            </SpatioTemporalDecomposition>
         </Video>
      </MultimediaContent>
   </Description>
</Mpeg7>
```

3.9.4.11.2 VideoText DS extraction

Extraction of videotext in a frame is the result of image analysis involving text character segmentation and location. This may be done automatically or by hand, based on semantics or other criteria. This subclause discusses how videotext can be extracted automatically from digital videos. Text can appear in a video anywhere in the frame and in different contexts. The algorithms presented here are designed to extract superimposed text and scene text, which possesses typical (superimposed) text attributes. No prior knowledge about frame resolution, text location, font styles, and text appearance modes such as *normal* and *inverse* video are assumed. Some common characteristics of text are exploited in the algorithms including monochromaticity of individual characters, size restrictions (characters cannot be too small to be read by humans or too big to occupy a large portion of the frame), and horizontal alignment of text (preferred for ease of reading).

Approaches to extracting text from videos can be broadly classified into three categories: (i) methods that use region analysis, (ii) methods that perform edge analysis, and (iii) methods that use texture information. The following subclause describes a region-based algorithm (Shim et al., 1998), which is followed by a subclause containing an edge-based algorithm (Agnihotri and Dimitrova, 1999).

3.9.4.11.2.1 Videotext Extraction Using Region Analysis

The region analysis algorithm (Shim et al., 1998) for videotext extraction works by extracting and analyzing regions in a video frame. The goals of this system are (i) isolating regions that may contain text characters, (ii) separating each character region from its surroundings and (iii) verifying the presence of text by consistency analysis across multiple text blocks.

3.9.4.11.2.1.1 Candidate Text Region Extraction

The first step in the region analysis system is to remove non-text background from an input gray scale image generated by scanning a paper document, or from downloading a Web image, or by decompressing an encoded (for example, in MPEG-1, 2) video stream. The generalized region labeling (GRL) algorithm (Shim and Dorai, 1999) is used to extract homogenous regions from this image. The GRL algorithm labels pixels in an image based on a given criterion (e.g., gray scale homogeneity) using contour traversal, thus partitioning the image into multiple regions, then groups pixels belonging to a region by determining its interior and boundaries, and extracts region features such as its MBR (minimum bounding rectangle), area, etc. The criterion used to group pixels into regions is that the gray level difference between any pair of pixels within the region cannot exceed ±10.

The GRL algorithm thus, segments the image into nonoverlapping homogenous regions. It also results in complete region information such as its label, outer and inner boundaries, number of holes within the regions, area, average gray level, gray level variance, centroid and the MBR. Next, non-text background regions among the detected regions are removed based on their size. A region is removed if the width and height of its MBR are greater than 24 and 32, respectively (can be adaptively modified depending on the image size). By employing a spatial proportion constraint, rather than area constraint, large homogeneous regions which are unlikely to be text are removed. Within the remaining candidate regions, candidate regions may be fragmented into multiple regions because of varying contrast in the regions surrounding the candidate regions. To group multiple touching regions into a single coherent region, a binary image from the labeled region image where all the regions which do not satisfy the size constraint are marked "0" and the remaining regions are marked "1" is generated. This binary image is processed using the GRL algorithm to obtain new connected regions. With the creation of a binary image, followed by a relabeling step, many small connected fragments of a candidate text region are merged together.

3.9.4.11.2.1.2 Text Region Refinement

Here the basic idea is to apply appropriate criteria to extract character segments within the candidate regions. Within a region, characters with holes can be present embedded in a complex background and since OCR systems require text to be printed against a clean background for processing, the second stage attempts to remove the background within the regions while preserving the candidate character outline. Since character outlines in these regions can be degraded and merged with the background, an iterative local thresholding operation is performed in each candidate region to separate the region from its surroundings and from other extraneous background contained within its interior. Once thresholds are determined automatically for all candidate regions, positive and negative images are computed. The positive image contains region pixels whose gray levels are above their respective local thresholds and the negative image contains region pixels whose gray levels fall below their respective thresholds. Observe that the negative image will contain candidate text regions if that text appears in inverse video mode. All the remaining processing steps are performed on both positive and negative images and their results are combined. Thus the region analysis system can handle normal and inverse video appearances of text.

The character region boundaries are further sharpened and separated by performing a region boundary analysis. This is necessary especially when characters within a text string appear connected with each other and they need to be separated for accurate text identification. This is achieved by examining the gray level contrast between the character region boundaries and the regions themselves. For each candidate region R, a threshold T is computed:

$$T = \left(\sum_k I_{cb_k} + \sum_l I_{i_l} \right) \Big/ \left(N_{cb} + N_i \right)$$

where I_{cbk} is the gray level of the pixel k on the circumscribing boundaries of the region and I_{il} is the gray level of the pixel l belonging to R (including interior and region boundary), N_{cb} is the number of pixels on the circumscribing boundaries of the region, and N_i is the number of pixels in the region. A pixel is defined to be on the circumscribing boundary of a region if it does not belong to the region but at least one of its four neighbors (using 4-connectivity) does. Those pixels in R whose gray level is less than T are marked as belonging to the background and discarded, while the others are retained in the region. Note that this condition is reversed for the negative image. This step is repeated until the value of T does not change over two consecutive iterations.

3.9.4.11.2.1.3 Text Characteristics Verification

The few candidate character regions are now tested for exhibiting typical text font characteristics. A candidate region is removed if its area is less than 12 or its height is less than 4 pixels because small fonts are difficult to be recognized by OCR systems. It is also removed if the ratio of the area of its MBR to the region area (fill factor) is greater than 4. Finally it may be removed if the gray level contrast with the background is low, i.e., if

$$\left| \sum_k I_{cb_k} - \sum_l I_{b_l} \right| < 20$$

where I_{cbk} is the gray level of the pixel k on the circumscribing boundaries of the region and I_{bl} is the gray level of the pixel l on the boundaries of the region. Since region boundary information is easily available owing to our GRL algorithm, this new boundary-based test can be easily performed to handle the removal of noisy non-text regions. Note also that the parameters used were determined with a study of a large number of SIF-resolution videos and were kept stable during our experimentation.

3.9.4.11.2.1.4 Text Consistency Analysis

Consistency between neighboring text regions is verified to eliminate false positive regions. The system attempts to ensure that the adjacent regions in a line exhibit the characteristics of a text string, thus locally verifying the global structure of the line. This text consistency test includes:

1. position analysis that checks inter-region spacing. The width between the centroids of the MBRs of a pair of neighboring regions that are retained is less than 50 pixels;
2. horizontal alignment analysis of regions. The vertical centers of neighboring MBRs is within 6 pixels of one another;
3. vertical proportions analysis of adjacent regions. The height of the larger of the two regions is less than twice the height of the smaller region.

Given a candidate text string, a final series of tests involving their MBRs are also performed. The MBRs of the regions (characters) are first verified to be present along a line within a given tolerance of 2 pixels. Observe that characters present along a diagonal line can be therefore easily identified as a string in the region analysis system. The inter-region distance in the string is verified to be less than 16 pixel. The MBRs of adjacent regions are ensured not to overlap by more than 2 pixels. If all three conditions are satisfied, the candidate word region is retained as a text string. The final output is a clean binary image containing only the detected text characters (appearing as black on white background) that can be directly used as input to an OCR system in order to be recognized.

3.9.4.11.2.1.5 Interframe Analysis For Text Refinement

Optionally, if consecutive frames in videos are being processed together in a batch job, then text regions determined from say, five consecutive frames can be analyzed together to add missing characters in frames and to delete incorrect regions posing as text. This interframe analysis used by the region analysis system to handle videos exploits the temporal persistence of videotext, and it involves examination of the similarity of text regions in terms of their positions, intensities and shape features and aids in omitting false positive regions.

3.9.4.11.2.2 Text Detection Based on Edge Characterization

The edge characterization algorithm (Agnihotri and Dimitrova, 1999) for text detection exploits the text properties namely, the height, width and area on the connected components (CC) of the edges detected in frames. Furthermore, horizontal alignment is used to merge multiple CC's into a single line of text. The purpose is to output a thresholded image of the detected text lines with text as foreground in black on a white background. This can be the input to an OCR to recognize the text characters.

Text extraction is performed on individual video frames. The steps involved in text extraction are given below. The origin (0,0) of the frame is the top-left corner. Any pixel is referenced by (*x, y*) location where *x*, is the position in columns and *y*, in rows.

3.9.4.11.2.2.1 Channel Separation

The red frame of the RGB color space is used to make it easy to differentiate the colors white, yellow and black, which dominate videotext. By using the red frame, sharp high-contrast edges for these frequent text colors are obtained. However, other color spaces such as HSB or YUV could be used.

3.9.4.11.2.2.2 Image Enhancement

The frame's edges are enhanced using a 3 × 3-mask. Noise is further removed using a median filter.

3.9.4.11.2.2.3 Edge Detection

On the enhanced image, edge detection is performed using the following 3 × 3 filter.

-1	-1	-1
-1	12	-1
-1	-1	-1

Excluding the image borders, edges are found when the output is smaller than *EdgeThreshold*. Currently, the threshold is fixed; however, a variable threshold could be used. The fixed threshold results in a lot of salt and pepper noise; also, the edges around the text may be broken and not connected. Hence, further processing is needed.

3.9.4.11.2.2.4 Edge Filtering

A preliminary edge filtering is performed to remove areas that possibly do not contain text or, even if they do, they cannot be reliably detected. Edge filtering can be performed at different levels. One is at a frame level and the other is at a sub-frame level. On the frame level, if more than a reasonable portion of the frame contains edge pixels, probably due to the number of scene objects, the frame is disregarded and the next one is taken. This can lead to the loss of text in some clean areas and result in false negatives. To overcome this problem, edge filtering is performed at a sub-frame level. To find text in an "over croCDed" frame, six counters are maintained with the count of the subdivided frame. Three counters are used for three vertical portions of the frame (one third of the area of the frame). Similarly, three counters are used for three horizontal stripes. Text lines found in high-density edge areas (stripes) are rejected in a subsequent step. This filtering could be done using smaller areas, to retain areas that are clean and contain text in a region smaller than one-third of an image.

3.9.4.11.2.2.5 Character Detection

Next a Connected Component (CC) analysis is performed on leftover edges. Text characters are assumed to give rise to connected components or a part thereof. All the edge pixels that are located within a certain distance from each other (an eight-pixel neighborhood is used) are merged in CCs. Each of the CCs is tested for size, height, width and area criteria before passing to the next stage.

3.9.4.11.2.2.6 Text Box Detection

The connected components that pass the criteria in the previous step are sorted in ascending order based on the location of the bottom left pixel. The sorting is done in raster scan. This list is traversed and the CCs are merged together to form boxes of text. The first connected component, CC_1 is assigned to the first box. Each subsequent CC_i is tested to see if the bottom most pixel lies within a preset acceptable "row" threshold from the bottom most pixel of the current text box. If the CC_i lies within a few rows (in this case 2 rows) of the current box, there is a good chance that they belong to the same line of text. The row difference threshold currently used, is a fixed one, but a variable one could also be used. It could be made a fraction of the height of the current text box. In order to avoid merging CCs that are too far away in the image, a second test is performed to see if the column distance between CC_i and the text boxes is less than a column threshold. This threshold is variable and is a multiple of the width of CC_i. CC_i is merged to the current text box if the above is true. If CC_i does not merge into the current text box, then a new text box is started with CC_i as its first component and the traversing is continued.

The above process could result in multiple text boxes for a single line of text in the image. Now for each of the text boxes formed by the character merging, a second level of merging is performed. This is to merge the text boxes that might have been mistakenly taken as separate lines of text, either due to strict CC merging criteria or due to poor edge detection process resulting in multiple CCs for the same character.

Each box is compared to the text boxes following it for a set of conditions. If two boxes are merged, the second box is deleted from the list of text boxes and merged into the first box. The multiple test conditions for two text boxes are:

1. The bottom of one box is within the row difference threshold of the other. Also the distance between the two boxes in the horizontal direction is less than a variable threshold depending on the average width of characters in the first box.
2. The center of either of the boxes lies within the area of the other text box
3. The text boxes overlap.

If any of the above conditions is satisfied, the two text boxes are merged until all text boxes are tested against each other.

3.9.4.11.2.2.7 Text Line Detection and Enhancement

The leftover boxes are accepted as text lines if they conform to the constraints of area, width and height. For each of the boxes, the corresponding original sub-image is thresholded to obtain the text as foreground in black and everything else in white. This is required so that the binary image can be inputted to an OCR. The average grayscale value of the pixels in the box is calculated. The average grayscale, *AvgBG*, value of a region (5 pixels in our case) around the box is calculated. Within the box, anything above the average is marked as white and anything below it is marked as black. The grayscale average for the pixels being marked as white, Avg_1, is calculated along the average of the black pixels, Avg_2. Once, the box is converted to a black and white image (binary image), the average of the "white region"(Avg_1) and the average of the "black region"(Avg_2) are compared to the *AvgBG* (as shown in Figure 32). The region that has its average closer to the *AvgBG* is assigned to be the background and the other region is assigned to be the foreground.

In other words, if the "black region" has its average closer to the other average, it is converted to white and vice versa. This assures that the text is always in black.

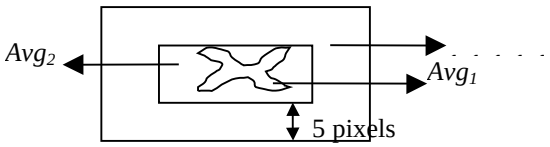


Figure 32- Separation of text foreground from background.

3.9.4.11.3 VideoText DS use

The applications described here highlight video browsing scenarios in which interesting events (i.e., the presence of videotext as an indicator of information pertaining to persons, locations, product advertisements, sports scores, etc) in the video are detected automatically and the video content is browsed based on these events, and video classification scenarios.

The application with an event-based video browsing capability shows that frames containing videotext can be automatically determined from a digital video stream. The stream can be marked as those segments containing videotext and those who do not by automatically determining the contiguous groups of time intervals of frames that contain text and which do not. Consequently, the video can be browsed in a nonlinear and random-access fashion based on the occurrence of a specific event. The event in this case is the presence or absence of videotext. A graphical summary of the video shows where videotext annotation is present along the video timeline.

With an application demonstrating video classification, the use of videotext in conjunction with other video features (annotations) for classification can be shown. Videotext annotation in news programs along with the detection of talking heads results in automatically labeled anchor shots.

3.9.5 Audio segment description tools

3.9.5.1 AudioSegment DS

3.9.5.1.1 AudioSegment DS examples

The following examples illustrate the use of the `AudioSegment DS` for describing audio content. The `MediaTime` describes the time information for the audio segment.

```
<AudioSegment>
   <MediaTime>
      <MediaTimePoint>T00:00:00</MediaTimePoint>
      <MediaDuration>PT1M30S</MediaDuration>
   </MediaTime>
</AudioSegment>
```

3.9.5.2 Audio segment decomposition tools

3.9.5.2.1 Audio segment decomposition tools examples

The following example illustrates the use of the `AudioSegmentTemporalDecomposition DS` for describing the temporal decomposition of audio content.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="AudioType">
         <Audio>
            <MediaTime>
               <MediaTimePoint>T00:00:00</MediaTimePoint>
               <MediaDuration>PT1M30S</MediaDuration>
            </MediaTime>
            <TemporalDecomposition gap="false" overlap="false">
               <AudioSegment>
                  <TextAnnotation>
                     <FreeTextAnnotation> Chase </FreeTextAnnotation>
                  </TextAnnotation>
                  <MediaTime>
                     <MediaTimePoint>T00:00:00</MediaTimePoint>
```

```
                        <MediaDuration>PT0M15S</MediaDuration>
                    </MediaTime>
                </AudioSegment>
                <AudioSegment>
                    <TextAnnotation>
                        <FreeTextAnnotation> Capture </FreeTextAnnotation>
                    </TextAnnotation>
                    <MediaTime>
                        <MediaTimePoint>T00:00:15</MediaTimePoint>
                        <MediaDuration>PT1M15S</MediaDuration>
                    </MediaTime>
                </AudioSegment>
            </TemporalDecomposition>
        </Audio>
    </MultimediaContent>
</Description>
</Mpeg7>
```

3.9.6 Audio-visual segment description tools

3.9.6.1 AudioVisualSegment DS

3.9.6.1.1 AudioVisualSegment DS examples

The following example illustrates the use of the `AudioVisualSegment DS` for describing an AV segment.

```
<AudioVisualSegment id="DocumentaryAVS">
    <MediaLocator>
        <MediaUri>movie.mpg</MediaUri>
    </MediaLocator>
    <TextAnnotation>
        <FreeTextAnnotation> Documentary about eagles </FreeTextAnnotation>
    </TextAnnotation>
    <MediaTime>
        <MediaTimePoint>T00:00:00</MediaTimePoint>
        <MediaDuration>PT1M30S</MediaDuration>
    </MediaTime>
</AudioVisualSegment>
```

3.9.6.2 Audio-visual segment decomposition tools

3.9.6.2.1 Audio-visual segment decomposition tools examples

The following example illustrates the use of the `AudioVisualSegmentMediaSourceDecomposition DS` in the `AudioVisualSegment DS` for describing the audio and video constituents of the AV segment "EagleDocumentaryAVS" in 3.9.6.1.1. In this example, the AV segment "EagleDocumentaryAVS" represents the full video sequence that is decomposed into one audio segment, "EagleDocumentaryAS" and one video segment, "EagleDocumentaryVS", corresponding to the audio and video tracks, respectively. Each segment is connected in space and/or time, as applicable.

```
<Mpeg7>
    <Description xsi:type="ContentEntityType">
        <MultimediaContent xsi:type="AudioVisualType">
            <AudioVisual>
                <MediaLocator>
                    <MediaUri>movie.mpg</MediaUri>
                </MediaLocator>
                <TextAnnotation>
                    <FreeTextAnnotation> Eagle Documentary </FreeTextAnnotation>
                </TextAnnotation>
                <MediaTime>
                    <MediaTimePoint>T00:00:00</MediaTimePoint>
                    <MediaDuration>PT1M30S</MediaDuration>
                </MediaTime>
```

```
            <TemporalDecomposition>
                <AudioVisualSegment id="EagleDocumentaryAVS">
                    <TextAnnotation>
                        <FreeTextAnnotation> Eagle Documentary
</FreeTextAnnotation>
                    </TextAnnotation>
                    <MediaTime>
                        <MediaTimePoint>T00:00:00</MediaTimePoint>
                        <MediaDuration>PT1M30S</MediaDuration>
                    </MediaTime>
                    <MediaSourceDecomposition gap="false" overlap="false">
                        <VideoSegment id="EagleDocumentaryVS">
                            <MediaTime>
                                <MediaTimePoint>T00:00:00</MediaTimePoint>
                                <MediaDuration>PT1M30S</MediaDuration>
                            </MediaTime>
                            <VisualDescriptor xsi:type="GoFGoPColorType"
                                aggregation="Average">
                                <ScalableColor numOfCoeff="16"
                                    numOfBitplanesDiscarded="0">
                                    <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6
</Coeff>
                                </ScalableColor>
                            </VisualDescriptor>
                        </VideoSegment>
                        <AudioSegment id="EagleDocumentaryAS">
                            <MediaTime>
                                <MediaTimePoint>T00:00:00</MediaTimePoint>
                                <MediaDuration>PT1M30S</MediaDuration>
                            </MediaTime>
                        </AudioSegment>
                    </MediaSourceDecomposition>
                </AudioVisualSegment>
            </TemporalDecomposition>
        </AudioVisual>
    </MultimediaContent>
</Description>
</Mpeg7>
```

3.9.6.3 AudioVisualRegion DS

3.9.6.3.1 AudioVisualRegion DS examples

The following example illustrates the use of the `AudioVisualRegion DS` for describing an AV Region. In this example, the AV region `id` = "NarratorAVR" represents the spatio-temporal region of the video and the temporal segment of the audio corresponding to the object "Narrator". The `VisualSpatioTemporalLocator` and the `AudioMediaTime` locate the AV region in the video and the audio, respectively.

```
<Mpeg7>
    <Description xsi:type="ContentEntityType">
        <MultimediaContent xsi:type="AudioVisualType">
            <AudioVisual>
                <MediaLocator>
                    <MediaUri>movie.mpg</MediaUri>
                </MediaLocator>
                <TextAnnotation>
                    <FreeTextAnnotation> Eagle Documentary </FreeTextAnnotation>
                </TextAnnotation>
                <MediaTime>
                    <MediaTimePoint>T00:00:00</MediaTimePoint>
                    <MediaDuration>PT1M30S</MediaDuration>
                </MediaTime>
                <SpatioTemporalDecomposition>
```

```
                <AudioVisualRegion id="NarratorAVR">
                    <TextAnnotation>
                        <FreeTextAnnotation> Video and audio of narrator
                        </FreeTextAnnotation>
                    </TextAnnotation>
                    <VisualSpatioTemporalLocator>
                        <FigureTrajectory type="rectangle">
                            <MediaTime>
                                <MediaTimePoint>T00:00:15</MediaTimePoint>
                                <MediaDuration>PT1M15S</MediaDuration>
                            </MediaTime>
                            <Vertex>
                                <WholeInterval>
                                    <MediaDuration>PT0S</MediaDuration>
                                </WholeInterval>
                                <InterpolationFunctions>
                                    <KeyValue type="startPoint">
                                        <!-- more elements here -->
                                    </KeyValue>
                                    <KeyValue type="startPoint">
                                        <!-- more elements here -->
                                    </KeyValue>
                                </InterpolationFunctions>
                            </Vertex>
                            <Vertex>
                                <WholeInterval>
                                    <MediaDuration>PT1S</MediaDuration>
                                </WholeInterval>
                                <InterpolationFunctions>
                                    <KeyValue type="startPoint">
                                        <!-- more elements here -->
                                    </KeyValue>
                                    <KeyValue type="startPoint">
                                        <!-- more elements here -->
                                    </KeyValue>
                                </InterpolationFunctions>
                            </Vertex>
                            <Vertex>
                                <WholeInterval>
                                    <MediaDuration>PT2S</MediaDuration>
                                </WholeInterval>
                                <InterpolationFunctions>
                                    <KeyValue type="startPoint">
                                        <!-- more elements here -->
                                    </KeyValue>
                                    <KeyValue type="startPoint">
                                        <!-- more elements here -->
                                    </KeyValue>
                                </InterpolationFunctions>
                            </Vertex>
                            <!-- more elements here -->
                        </FigureTrajectory>
                    </VisualSpatioTemporalLocator>
                    <AudioMediaTime>
                        <MediaTimePoint>T00:00:00</MediaTimePoint>
                        <MediaDuration>PT1M30S</MediaDuration>
                    </AudioMediaTime>
                </AudioVisualRegion>
            </SpatioTemporalDecomposition>
        </AudioVisual>
    </MultimediaContent>
</Description>
</Mpeg7>
```

3.9.6.4 Audio-visual region decomposition tools

3.9.6.4.1 Audio-visual region decomposition tools examples

The following example illustrates the use of the `AudioVisualRegionMediaSourceDecomposition DS` in the `AudioVisualRegion DS` for describing the video and audio constituents of the AV region "NarratorAVR" in 3.9.6.3.1. In this example, the AV region "NarratorAVR" is decomposed into the moving region "NarratorMR" and the audio segment "Narrator AS" corresponding to the video and audio data of the object "Narrator", respectively. Each segment is connected in space and/or time, as applicable.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="AudioVisualType">
         <AudioVisual>
            <MediaLocator>
               <MediaUri>movie.mpg</MediaUri>
            </MediaLocator>
            <TextAnnotation>
               <FreeTextAnnotation> Eagle Documentary </FreeTextAnnotation>
            </TextAnnotation>
            <MediaTime>
               <MediaTimePoint>T00:00:00</MediaTimePoint>
               <MediaDuration>PT1M30S</MediaDuration>
            </MediaTime>
            <SpatioTemporalDecomposition>
               <AudioVisualRegion id="NarratorAVR">
                  <TextAnnotation>
                     <FreeTextAnnotation> Video and audio of narrator
                     </FreeTextAnnotation>
                  </TextAnnotation>
                  <MediaSourceDecomposition gap="false" overlap="false">
                     <MovingRegion id="NarratorMR">
                        <TextAnnotation>
                           <FreeTextAnnotation> Moving region of narrator
                           </FreeTextAnnotation>
                        </TextAnnotation>
                     </MovingRegion>
                     <AudioSegment id="NarratorAS">
                        <MediaTime>
                           <MediaTimePoint>T00:00:00</MediaTimePoint>
                           <MediaDuration>PT01M30S</MediaDuration>
                        </MediaTime>
                     </AudioSegment>
                  </MediaSourceDecomposition>
               </AudioVisualRegion>
            </SpatioTemporalDecomposition>
         </AudioVisual>
      </MultimediaContent>
   </Description>
</Mpeg7>
```

3.9.7 Multimedia segment description tools

3.9.7.1 MultimediaSegment DS

3.9.7.1.1 MultimediaSegment DS examples

The following examples illustrate the use of the `MultimediaSegment DS` for describing multimedia content.

```
<MultimediaSegment>
   <TextAnnotation>
      <FreeTextAnnotation> Multimedia content </FreeTextAnnotation>
   </TextAnnotation>
</MultimediaSegment>
```

3.9.7.2 Multimedia segment decomposition tools

3.9.7.2.1 Multimedia segment decomposition tools examples

The following examples illustrate the use of the `MultimediaSegmentMediaSourceDecomposition DS` for describing the decomposition of multimedia content into its video, audio, and image components.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="MultimediaType">
         <Multimedia>
            <MediaSourceDecomposition gap="false" overlap="false">
               <Segment xsi:type="VideoSegmentType">
                  <TextAnnotation>
                     <FreeTextAnnotation> Chase video </FreeTextAnnotation>
                  </TextAnnotation>
                  <MediaTime>
                     <MediaTimePoint>T00:00:00</MediaTimePoint>
                     <MediaDuration>PT0M15S</MediaDuration>
                  </MediaTime>
                  <VisualDescriptor xsi:type="GoFGoPColorType"
                     aggregation="Average">
                     <ScalableColor numOfCoeff="16"
numOfBitplanesDiscarded="0">
                        <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                     </ScalableColor>
                  </VisualDescriptor>
               </Segment>
               <Segment xsi:type="AudioSegmentType">
                  <TextAnnotation>
                     <FreeTextAnnotation> Chase audio </FreeTextAnnotation>
                  </TextAnnotation>
               </Segment>
               <Segment xsi:type="StillRegionType">
                  <TextAnnotation>
                     <FreeTextAnnotation> Chase image </FreeTextAnnotation>
                  </TextAnnotation>
               </Segment>
            </MediaSourceDecomposition>
         </Multimedia>
      </MultimediaContent>
   </Description>
</Mpeg7>
```


3.9.8 Ink segment description tools

3.9.8.1 InkSegment DS

3.9.8.1.1 InkSegment DS examples

The following example illustrates the use of the `InkSegment DS` for describing the ink document, which consists of the word "Ana" surrounded by a circle keyword gesture. The strokes corresponding to the word "Ana" are a content ink segment; the strokes corresponding to the keyword gesture are a meta ink segment; finally, the full ink document is a mixed ink segment. In this example, the ink segments "ElecDoc1", "WordAna", and "KeywordGesture" represent the mixed ink segment, the content ink segment, and the meta ink segment, respectively. The ink segments "WordAna" and "KeywordGesture" are the result of the temporal decomposition of ink segment "ElecDoc1" because they have different temporal information.

In this example, the ink capture device records the temporal information of the ink data points with very low frequency so all the ink data points of ink segment "WordAna" carry the same temporal information and the ink segment "WordAna" can be spatially decomposed into ink segments that represent the different letters of the word, e.g., ink segment "LetterA".

```
<Mpeg7 xmlns="urn:mpeg:mpeg7:schema:2001"
xmlns:mpeg7="urn:mpeg:mpeg7:schema:2001"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="urn:mpeg:mpeg7:schema:2001 .\mdsfdisver3.3.xsd">
    <Description xsi:type="ContentEntityType">
        <MultimediaContent xsi:type="InkContentType">
            <InkContent id="ElecDoc1" type="mixed">
                <MediaLocator>
                    <MediaUri>ink.mpg</MediaUri>
                </MediaLocator>
                <InkMediaInformation>
                    <InputDevice resolutionS="133">
                        <Device>
                            <Name xml:lang="en">PenDevice</Name>
                        </Device>
                    </InputDevice>
                    <Handedness>right</Handedness>
                    <Style>mixed</Style>
                </InkMediaInformation>
                <TemporalDecomposition>
                    <InkSegment id="WordAna" type="content">
                        <MediaTime>
                            <MediaRelTimePoint

    mediaTimeBase="../../../../MediaLocator[1]">PT0S</MediaRelTimePoint>
                            <MediaDuration>PT3S</MediaDuration>
                        </MediaTime>
                        <HandWritingRecogResult>
                            <Quality>0.6</Quality>
                            <Result score="0.7">
                                <Text> Ana </Text>
                            </Result>
                            <Result score="0.54">
                                <Text> Ann </Text>
                            </Result>
                        </HandWritingRecogResult>
                        <SpatialDecomposition>
                            <InkSegment id="LetterA" type="content">
                                <OrderedGroupDataSetMask>
                                    <SubInterval setRef="#WordAna"
startComponent="1731"
                                        startUnit="36" endComponent="1742"
endUnit="47"/>
                                </OrderedGroupDataSetMask>
                                <HandWritingRecogResult>
                                    <Quality>0.4</Quality>
                                    <Result score="0.54">
                                        <Text> A </Text>
                                    </Result>
                                </HandWritingRecogResult>
                            </InkSegment>
                        </SpatialDecomposition>
                    </InkSegment>
                    <InkSegment id="KeywordGesture" type="meta">
                        <MediaTime>
                            <MediaRelTimePoint

    mediaTimeBase="../../../../MediaLocator[1]">PT3S</MediaRelTimePoint>
                            <MediaDuration>PT2S</MediaDuration>
                        </MediaTime>
                    </InkSegment>
                </TemporalDecomposition>
            </InkContent>
        </MultimediaContent>
```

```
    </Description>
</Mpeg7>
```

The following example illustrates the use of the `InkSegment` DS to describe the ink document shown in Figure 33. The last four lines in Figure 33 are part of the ink data file and describe the structure of the ink data points in segments. For example, the third to last line describes a line in the ink data file that consists of the ink data points from stroke number 1699 point 43 to stroke number 1748 point 90 with the following recognized text "cause. In 1988 it was …".

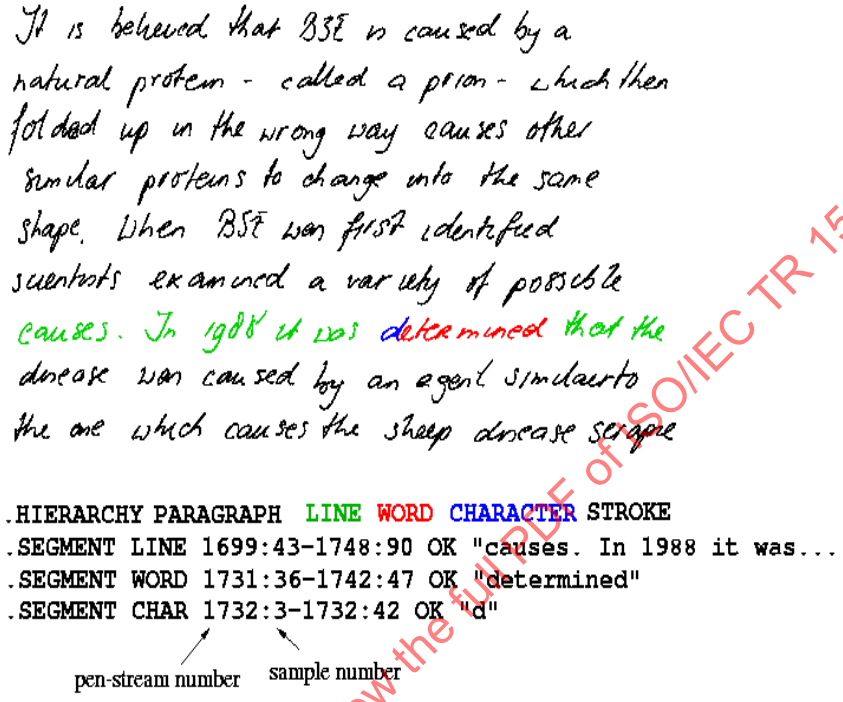


Figure 33 - Example of an ink document.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="InkContentType">
         <InkContent id="Paragraph-1">
            <MediaLocator>
               <MediaUri>http://www.mpeg7.org/demo.stk</MediaUri>
            </MediaLocator>
            <SpatialDecomposition gap="true" overlap="false">
               <InkSegment id="Line-7">
                  <InkMediaInformation>
                     <InputDevice resolutionS="120">
                        <Device>
                           <Name xml:lang="en">PenDevice</Name>
                        </Device>
                     </InputDevice>
                  </InkMediaInformation>
                  <OrderedGroupDataSetMask>
                     <SubInterval setRef="#Paragraph-1" startComponent="1699"
                        startUnit="43" endComponent="1748" endUnit="90"/>
                  </OrderedGroupDataSetMask>
                  <HandWritingRecogResult>
                     <Quality>0.9</Quality>
                     <Result score="1.0">
                        <Text> causes. In 1988 it was determined that the
</Text>
                     </Result>
```

```
                    </HandWritingRecogResult>
                    <SpatialDecomposition gap="true" overlap="false">
                        <InkSegment id="WORD-6">
                            <OrderedGroupDataSetMask>
                                <SubInterval setRef="#Paragraph-1"
                                    startComponent="1731" startUnit="36"
                                    endComponent="1742" endUnit="47"/>
                            </OrderedGroupDataSetMask>
                            <HandWritingRecogResult>
                                <Quality>0.9</Quality>
                                <Result score="1.0">
                                    <Text> determined </Text>
                                </Result>
                            </HandWritingRecogResult>
                        </InkSegment>
                    </SpatialDecomposition>
                </InkSegment>
            </SpatialDecomposition>
        </InkContent>
    </MultimediaContent>
</Description>
</Mpeg7>
```

The following example illustrates the use of the `StructuralUnit` element in the `InkSegment DS` for describing the grouping of ink data points into pages, paragraph and commands, as defined by the creator. The root ink segment contains one content ink segment and one meta ink segment. The content ink segment is a page and is composed of two other content ink segments that are paragraphs. This example also illustrate the use of the Param element and the `OverlaidMedia` element in `InkMediaInformation DS` for describing the two parameters and the operand of the command, respectively. The command mails the ink segment "data" from foo@columbia.edu to foo@mpeg.nist.gov.

```
<Mpeg7>
    <Description xsi:type="ContentEntityType">
        <MultimediaContent xsi:type="InkContentType">
            <InkContent type="mixed">
                <TemporalDecomposition>
                    <InkSegment id="data" type="content">
                        <StructuralUnit href="urn:example:acs">
                            <Name>Page</Name>
                        </StructuralUnit>
                        <TemporalDecomposition>
                            <InkSegment>
                                <StructuralUnit href="urn:example:acs">
                                    <Name>Paragraph</Name>
                                </StructuralUnit>
                                <MediaTime>
                                    <MediaTimePoint>T00:00:00</MediaTimePoint>
                                    <MediaDuration>PT1M30S</MediaDuration>
                                </MediaTime>
                            </InkSegment>
                            <InkSegment>
                                <StructuralUnit href="urn:example:acs">
                                    <Name>Paragraph</Name>
                                </StructuralUnit>
                                <MediaTime>
                                    <MediaTimePoint>T00:01:30</MediaTimePoint>
                                    <MediaDuration>PT1M04S</MediaDuration>
                                </MediaTime>
                            </InkSegment>
                        </TemporalDecomposition>
                    </InkSegment>
                    <InkSegment type="meta">
                        <StructuralUnit href="urn:example:acs">
```

```
                        <Name>MAIL command</Name>
                        <Definition>
                    MAIL command is used to mail the content specified by the
                    OverlaidMedia element in the InkMediaInformation DS. There are
two
                    Associated parameterName "From" and "To".
                    The associated parameterValues are to specify the sender and
                    receiver email address respectively.
                </Definition>
                    </StructuralUnit>
                    <InkMediaInformation>
                        <OverlaidMedia>
                            <OverlaidMediaRef href="#data"/>
                        </OverlaidMedia>
                        <Param name="From" value="foo@columbia.edu"/>
                        <Param name="To" value="foo@mpeg.nist.gov"/>
                    </InkMediaInformation>
                </InkSegment>
            </TemporalDecomposition>
        </InkContent>
    </MultimediaContent>
</Description>
</Mpeg7>
```

An example scenario to show the usage of the `InkSegment DS` is the following. At the end of the ink content creation, ink content is captured into an ink data file, and the metastrokes are described as a meta ink segment. At the same time, the scene graph, the media space, and the ordered group dataset masks locate the ink strokes stored in the ink document. A hand-writing recognition engine, described using `HandWritingRecogInformation DS`, can make use of the ink media and creation information and/or the stroke data to recognize words in ink strokes. If it suceeds, it reports the results using the `HandWritingRecogResult DS` in the `InkSegment DS`. As a result, a text keyword search can be used. However, if the hand-writing recognition engine fails to recognize the ink strokes, the time sequences of meta ink segments can be used for matching. Although the masks are designed for the ink documents, they are general enough to be used for other media.

3.9.8.2 InkMediaInformation DS

3.9.8.2.1 InkMediaInformation DS examples

The following example illustrates the use of the `InkMediaInformation DS` for describing the input device and handedness information for an ink segment.

```
<InkMediaInformation>
    <InputDevice resolutionS="133">
        <Device>
            <Name xml:lang="en">PenDevice</Name>
        </Device>
    </InputDevice>
    <Handedness>right</Handedness>
    <Style>mixed</Style>
</InkMediaInformation>
```

The following example illustrates the use of the `InkSegment DS` and the `OverlaidMedia` element in the `InkMediaInfo DS`, among others, for describing ink content overlaying on a text medical form as shown in Figure 34. An example of application scenario for these kind of descriptions is the automatic collection of patient medical records for which the medical paper form stays on top of the writing surface of the ink input device. When the patient fills in the information on the paper form with a electronic pen, the information is simultaneously available as ink content.

In this example, the content ink segment is composed of three ink segments, each representing one word in the ink content. The `WritingFieldLayout element` describes the three rectangular regions shown in Figure 34, the overlaying media. The `OverlaidMedia` element in the `InkSegment DS` uses each region to map each region of the ink segment with the overlaid media, in this case, the medical paper form. The `WritingFieldLayout` element is useful for a handwriting recognizer or any other application that

processes the ink content. It also provides the references for the ink content grouping (and segmentation). These guidelines may be visible in the input device writing surface depending on the application.

This example also illustrates the use of transformation and region mapping of the `OverlaidMedia` element for describing the overlaying of the ink content on the text medical paper form. The visual regions and the ink segment fragments are defined in two different coordinate systems but their sizes are proportional for the first two writing field layouts, such that a linearly mapping between two regions does not distort the shape of ink strokes. For the first two writing field layouts, the ink data points are also well aligned within the ink region, and there is no need for and ink data translation. For the last writing field layout, the width of ink region "HealthCondition" is only one third of the width of visual region but there is not data translation either. The linear mapping of the third ink segment fragment results in the distortion (in the width direction) of the ink data. Display applications may decide to scale down the width of the third ink segment mapping by one third to maintain the shape of ink strokes.

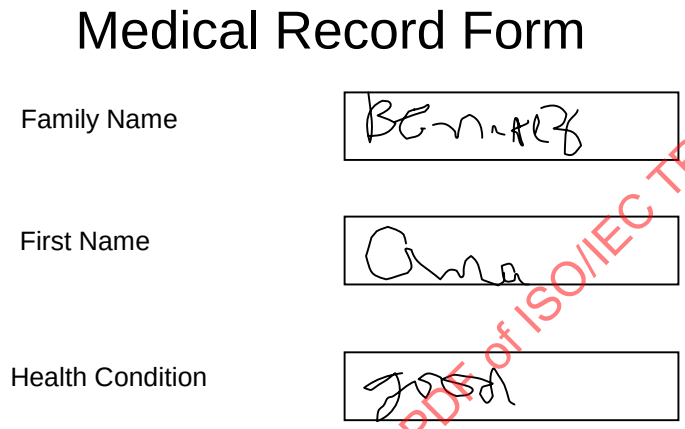


Figure 34 - Example of ink overlaid on a text medical form.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="InkContentType">
         <InkContent>
            <SpatialDecomposition>
               <InkSegment>
                  <InkMediaInformation>
                     <WritingFieldLayout fieldIDList="LastName">
                        <Polygon>
                           <Coords mpeg7:dim="8"> 15 75 0 -6 45 0 0 6
</Coords>
                        </Polygon>
                     </WritingFieldLayout>
                     <OverlaidMedia fieldIDRef="LastName">
                        <OverlaidMediaLocator>
                           <MediaUri>http://www.mpeg7.org/demo.txt</MediaUri>
                        </OverlaidMediaLocator>
                        <MediaRegionLocator>
                           <Polygon>
                              <Coords mpeg7:dim="8"> 5 25 0 -2 15 0 0 2
</Coords>
                           </Polygon>
                        </MediaRegionLocator>
                     </OverlaidMedia>
                  </InkMediaInformation>
                  <SceneGraphMask>
                     <SubGraphNum>0</SubGraphNum>
                  </SceneGraphMask>
               </InkSegment>
               <InkSegment>
                  <InkMediaInformation>
```

```
                        <WritingFieldLayout fieldIDList="FirstName">
                           <Polygon>
                              <Coords mpeg7:dim="8"> 15 150 -6 45 0 0 6
</Coords>
                           </Polygon>
                        </WritingFieldLayout>
                        <OverlaidMedia fieldIDRef="FirstName">
                           <OverlaidMediaLocator>
                              <MediaUri>http://www.mpeg7.org/demo.txt</MediaUri>
                           </OverlaidMediaLocator>
                           <MediaRegionLocator>
                              <Polygon>
                                 <Coords mpeg7:dim="8"> 5 50 0 -2 15 0 0 2
</Coords>
                              </Polygon>
                           </MediaRegionLocator>
                        </OverlaidMedia>
                     </InkMediaInformation>
                     <SceneGraphMask>
                        <SubGraphNum>1</SubGraphNum>
                     </SceneGraphMask>
                  </InkSegment>
                  <InkSegment>
                     <InkMediaInformation>
                        <WritingFieldLayout fieldIDList="HealthCondition">
                           <Polygon>
                              <Coords mpeg7:dim="8"> 15 225 -6 45 0 0 6
</Coords>
                           </Polygon>
                        </WritingFieldLayout>
                        <OverlaidMedia fieldIDRef="HealthCondition"
scaleX="0.3333">
                           <OverlaidMediaLocator>
                              <MediaUri>http://www.mpeg7.org/demo.txt</MediaUri>
                           </OverlaidMediaLocator>
                           <MediaRegionLocator>
                              <Polygon>
                                 <Coords mpeg7:dim="8"> 5 75 0 -2 15 0 0 2
</Coords>
                              </Polygon>
                           </MediaRegionLocator>
                        </OverlaidMedia>
                     </InkMediaInformation>
                     <SceneGraphMask>
                        <SubGraphNum>2</SubGraphNum>
                     </SceneGraphMask>
                  </InkSegment>
               </SpatialDecomposition>
            </InkContent>
         </MultimediaContent>
      </Description>
</Mpeg7>
```


3.9.8.3 HandWritingRecogInformation DS

3.9.8.3.1 HandWritingRecogInformation DS examples

The following example illustrates the use of the HandWritingRecogInformation DS for describing information about a hand-writing recognizer named "Super Recog 1", which uses a lexicon with 20 entries representing names of people.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="InkContentType">
```

```
          <InkContent>
             <HandWritingRecogInformation>
                <Recognizer>
                   <Name>
                      <Name> Super Recog 1 </Name>
                   </Name>
                </Recognizer>
                <InkLexicon>
                   <Entry index="item0">
                      <Text>
                         <Name> Ann </Name>
                      </Text>
                      <InkSegmentRef href="#Electro0"/>
                   </Entry>
                   <Entry index="item1">
                      <Text>
                         <Name> Juan </Name>
                      </Text>
                      <InkSegmentRef href="#Electro1"/>
                   </Entry>
                   <!-- more elements here -->
                   <Entry index="item20">
                      <Text>
                         <Name> Beatriz </Name>
                      </Text>
                      <InkSegmentRef href="#Electro20"/>
                   </Entry>
                </InkLexicon>
             </HandWritingRecogInformation>
          </InkContent>
       </MultimediaContent>
    </Description>
</Mpeg7>
```

3.9.8.4 HandWritingRecogResult DS

3.9.8.4.1 HandWritingRecogResult DS examples

The following example illustrates the use of the `HandWritingRecogResult DS` for describing the handwriting recognition results for the word "Ana". The recognizer returns two results one of which corresponds to a lexicon entry in the `HandWritingRecogInformation DS` example in 3.9.8.3.1.

```
<Mpeg7>
    <Description xsi:type="ContentEntityType">
       <MultimediaContent xsi:type="InkContentType">
          <InkContent>
             <HandWritingRecogResult>
                <Quality>0.6</Quality>
                <Result score="0.7">
                   <Text> Ana </Text>
                </Result>
                <Result score="0.54">
                   <LexiconIndexRef idref="#item0"/>
                </Result>
             </HandWritingRecogResult>
          </InkContent>
       </MultimediaContent>
    </Description>
</Mpeg7>
```

3.9.8.5 Ink segment decomposition tools

Information on extraction and use is not provided.

3.9.9 Video editing segment description tools

3.9.9.1 AnalyticEditedVideoSegment DS

Information on extraction and use is not provided.

3.9.9.2 Analytic edited video segment decomposition tools

3.9.9.3 EditedVideo DS

3.9.9.4 Edited video decomposition tools

3.9.9.5 AnalyticClip DS

3.9.9.6 Shot DS

Information on extraction and use is not provided.

3.9.9.7 Shot decomposition tools

Information on extraction and use is not provided.

3.9.9.8 CompositionShot DS

Information on extraction and use is not provided.

3.9.9.9 Composition shot decomposition tools

Information on extraction and use is not provided.

3.9.9.10 IntraCompositionShot DS

Information on extraction and use is not provided.

3.9.9.11 Intra-composition shot decomposition tools

Information on extraction and use is not provided.

3.9.9.12 AnalyticTransition DS

Information on extraction and use is not provided.

3.9.9.13 CompositionTransition DS

Information on extraction and use is not provided.

3.9.9.14 InternalTransition DS

Information on extraction and use is not provided.

3.9.9.15 EditedMovingRegion DS

Information on extraction and use is not provided.

3.9.9.16 Video editing segment description tools examples

3.9.9.16.1 Description of a sequence of composition shots and internal transitions

The following example illustrates the use of the `AnalyticClip DS` and the `AnalyticTransition DS` for describing a video content that contains a single shot with two composition shots and an internal transition.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="AnalyticEditedVideoType">
         <AnalyticEditedVideo xsi:type="EditedVideoType">
            <MediaLocator>
               <MediaUri>video.mpg</MediaUri>
            </MediaLocator>
            <!-- more elements here -->
            <AnalyticEditingTemporalDecomposition gap="false" overlap="false">
               <!-- Description of Eyexam -->
               <Shot id="ClipS_3" locationReliability="0.9"
                  editingLevelReliability="0.5">
                  <MediaTime>
```

```
                        <MediaRelIncrTimePoint mediaTimeUnit="PT1N25F"

   mediaTimeBase="../../../../MediaLocator[1]">35</MediaRelIncrTimePoint>
                        <MediaIncrDuration
                           mediaTimeUnit="PT1N25F">413</MediaIncrDuration>
                     </MediaTime>
                     <AnalyticEditingTemporalDecomposition gap="false"
                        overlap="false">
                        <CompositionShot id="ClipCS_1" locationReliability="0.9"
                           editingLevelReliability="0.5" type="simple">
                           <MediaTime>
                              <MediaRelIncrTimePoint mediaTimeUnit="PT1N25F"

   mediaTimeBase="../../../../../../../MediaLocator[1]">35</MediaRelIncrTimePoint>
                              <MediaIncrDuration
                                 mediaTimeUnit="PT1N25F">55</MediaIncrDuration>
                           </MediaTime>
                        </CompositionShot>
                        <CompositionTransition id="CT_1"
locationReliability="0.9"
                           editingLevelReliability="0.5"
evolutionReliability="0.5">
                           <MediaTime>
                              <MediaRelIncrTimePoint mediaTimeUnit="PT1N25F"

   mediaTimeBase="../../../../../../../MediaLocator[1]">90</MediaRelIncrTimePoint>
                              <MediaIncrDuration
                                 mediaTimeUnit="PT1N25F">10</MediaIncrDuration>
                           </MediaTime>
                           <EvolutionType href="...">
                              <Name>IrisOpen</Name>
                           </EvolutionType>
                        </CompositionTransition>
                        <CompositionShot id="ClipCS_2" locationReliability="0.9"
                           editingLevelReliability="0.5">
                           <MediaTime>
                              <MediaRelIncrTimePoint mediaTimeUnit="PT1N25F"

   mediaTimeBase="../../../../../../../MediaLocator[1]">100</MediaRelIncrTimePoint
>
                              <MediaIncrDuration

   mediaTimeUnit="PT1N25F">348</MediaIncrDuration>
                           </MediaTime>
                           <AnalyticEditingTemporalDecomposition gap="false"
                              overlap="false">
                              <IntraCompositionShot id="ClipICS_1"
                                 locationReliability="0.9"
                                 editingLevelReliability="0.5" type="simple">
                                 <MediaTime>
                                    <MediaRelIncrTimePoint
mediaTimeUnit="PT1N25F"
mediaTimeBase="../../../../../../../../../MediaLocator[1]">100</MediaRelIncrTimePoi
nt>
                                    <MediaIncrDuration

   mediaTimeUnit="PT1N25F">75</MediaIncrDuration>
                                 </MediaTime>
                              </IntraCompositionShot>
                              <InternalTransition id="IT_1"
locationReliability="0.9"
                                 editingLevelReliability="0.5"
                                 evolutionReliability="0.5">
                                 <MediaTime>
```

```
                                        <MediaRelIncrTimePoint
mediaTimeUnit="PT1N25F"
mediaTimeBase="../../../../../../../../MediaLocator[1]">175</MediaRelIncrTimePoi
nt>
                                        <MediaIncrDuration

    mediaTimeUnit="PT1N25F">8</MediaIncrDuration>
                                    </MediaTime>
                                    <EvolutionType href="...">
                                        <Name xml:lang="en">crossdissolve</Name>
                                    </EvolutionType>
                                </InternalTransition>
                                <IntraCompositionShot id="ClipICS_2"
                                    locationReliability="0.9"
                                    editingLevelReliability="0.5" type="simple">
                                    <MediaTime>
                                        <MediaRelIncrTimePoint
mediaTimeUnit="PT1N25F"
mediaTimeBase="../../../../../../../../MediaLocator[1]">183</MediaRelIncrTimePoi
nt>
                                        <MediaIncrDuration

    mediaTimeUnit="PT1N25F">265</MediaIncrDuration>
                                    </MediaTime>
                                </IntraCompositionShot>
                            </AnalyticEditingTemporalDecomposition>
                        </CompositionShot>
                    </AnalyticEditingTemporalDecomposition>
                </Shot>
            </AnalyticEditingTemporalDecomposition>
        </AnalyticEditedVideo>
    </MultimediaContent>
</Description>
</Mpeg7>
```

3.9.9.16.2 Description of a shot associated to a composite clip

The following examples illustrate the use of the `AnalyticClip DS`, the `AnalyticTransition DS`, and the `EditedMovingRegion DS` for describing a shot that is a composite clip. In the first example, there are no internal transitions: the analytic clip is a composite clip and a shot.

```
<Mpeg7>
    <Description xsi:type="ContentEntityType">
        <MultimediaContent xsi:type="AnalyticEditedVideoType">
            <AnalyticEditedVideo xsi:type="EditedVideoType">
                <MediaLocator>
                    <MediaUri>video.mpg</MediaUri>
                </MediaLocator>
                <AnalyticEditingTemporalDecomposition gap="false" overlap="false">
                    <Shot id="ClipS_3" locationReliability="0.9"
                        editingLevelReliability="0.5" type="composite">
                        <MediaTime>
                            <MediaRelIncrTimePoint mediaTimeUnit="PT1N25F"

    mediaTimeBase="../../../../MediaLocator[1]">35</MediaRelIncrTimePoint>
                            <MediaIncrDuration
                                mediaTimeUnit="PT1N25F">413</MediaIncrDuration>
                        </MediaTime>
                    </Shot>
                </AnalyticEditingTemporalDecomposition>
            </AnalyticEditedVideo>
        </MultimediaContent>
    </Description>
</Mpeg7>
```

In the second example, the shot is temporally decomposed into several composition shots; and the composition shots are temporally decomposed into intra-composition shots. The edition areas in the shot, composition shots and intra-composition shots are described using the `EditedMovingRegion DS` as the result of the spatio-temporal decomposition of the analytic edited video segments, i.e., using the `AnalyticEditedVideoSegmentSpatioTemporalDecomposition DS`. In composition and internal transition descriptions, the edited moving regions introduced or affected by the transitions are referenced by using the `EditedMovingRegionRef` element in the `AnalyticTransition DS`.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="AnalyticEditedVideoType">
         <AnalyticEditedVideo xsi:type="EditedVideoType">
            <MediaLocator>
               <MediaUri>video.mpg</MediaUri>
            </MediaLocator>
            <AnalyticEditingTemporalDecomposition gap="false" overlap="false">
               <!-- Description of Eyexam -->
               <Shot id="ClipS_3" locationReliability="0.9"
                  editingLevelReliability="0.5" type="composite">
                  <MediaTime>
                     <MediaRelIncrTimePoint mediaTimeUnit="PT1N25F"

   mediaTimeBase="../../../../MediaLocator[1]">35</MediaRelIncrTimePoint>
                     <MediaIncrDuration
                        mediaTimeUnit="PT1N25F">413</MediaIncrDuration>
                  </MediaTime>
                  <AnalyticEditionAreaDecomposition gap="false" overlap="true"
                     criteria="edition area">
                     <EditedMovingRegion id="editArea_1">
                        <TextAnnotation>
                           <FreeTextAnnotation> Frame area
</FreeTextAnnotation>
                        </TextAnnotation>
                        <SpatioTemporalLocator>
                           <FigureTrajectory type="rectangle">
                              <MediaTime>
                                 <MediaRelIncrTimePoint
mediaTimeUnit="PT1N25F"
mediaTimeBase="../../../../../../../../../MediaLocator[1]">35</MediaRelIncrTimePoin
t>
                                 <MediaIncrDuration

   mediaTimeUnit="PT1N25F">413</MediaIncrDuration>
                              </MediaTime>
                              <Vertex>
                                 <WholeInterval>
                                    <MediaDuration>PT0S</MediaDuration>
                                 </WholeInterval>
                                 <InterpolationFunctions>
                                    <KeyValue type="startPoint">
                                       <!-- more elements here -->
                                    </KeyValue>
                                    <KeyValue type="startPoint">
                                       <!-- more elements here -->
                                    </KeyValue>
                                 </InterpolationFunctions>
                              </Vertex>
                              <Vertex>
                                 <WholeInterval>
                                    <MediaDuration>PT1S</MediaDuration>
                                 </WholeInterval>
                                 <InterpolationFunctions>
```

```
                                        <KeyValue type="startPoint">
                                            <!-- more elements here -->
                                        </KeyValue>
                                        <KeyValue type="startPoint">
                                            <!-- more elements here -->
                                        </KeyValue>
                                    </InterpolationFunctions>
                                </Vertex>
                                <Vertex>
                                    <WholeInterval>
                                        <MediaDuration>PT2S</MediaDuration>
                                    </WholeInterval>
                                    <InterpolationFunctions>
                                        <KeyValue type="startPoint">
                                            <!-- more elements here -->
                                        </KeyValue>
                                        <KeyValue type="startPoint">
                                            <!-- more elements here -->
                                        </KeyValue>
                                    </InterpolationFunctions>
                                </Vertex>
                                <!-- more elements here -->
                            </FigureTrajectory>
                        </SpatioTemporalLocator>
                        <RegionDepthType href="...">
                            <Name xml:lang="en">background</Name>
                        </RegionDepthType>
                    </EditedMovingRegion>
                    <EditedMovingRegion id="editArea_2">
                        <TextAnnotation>

    <FreeTextAnnotation>CenteredCercle</FreeTextAnnotation>
                        </TextAnnotation>
                        <SpatioTemporalLocator>
                            <FigureTrajectory type="rectangle">
                                <MediaTime>
                                    <MediaRelIncrTimePoint
mediaTimeUnit="PT1N25F"
mediaTimeBase="../../../../../../../MediaLocator[1]">175</MediaRelIncrTimePoi
nt>
                                    <MediaIncrDuration

    mediaTimeUnit="PT1N25F">273</MediaIncrDuration>
                                </MediaTime>
                                <Vertex>
                                    <WholeInterval>
                                        <MediaDuration>PT0S</MediaDuration>
                                    </WholeInterval>
                                    <InterpolationFunctions>
                                        <KeyValue type="startPoint">
                                            <!-- more elements here -->
                                        </KeyValue>
                                        <KeyValue type="startPoint">
                                            <!-- more elements here -->
                                        </KeyValue>
                                    </InterpolationFunctions>
                                </Vertex>
                                <Vertex>
                                    <WholeInterval>
                                        <MediaDuration>PT1S</MediaDuration>
                                    </WholeInterval>
                                    <InterpolationFunctions>
                                        <KeyValue type="startPoint">
                                            <!-- more elements here -->
```

```
                                    </KeyValue>
                                    <KeyValue type="startPoint">
                                        <!-- more elements here -->
                                    </KeyValue>
                                </InterpolationFunctions>
                            </Vertex>
                            <Vertex>
                                <WholeInterval>
                                    <MediaDuration>PT2S</MediaDuration>
                                </WholeInterval>
                                <InterpolationFunctions>
                                    <KeyValue type="startPoint">
                                        <!-- more elements here -->
                                    </KeyValue>
                                    <KeyValue type="startPoint">
                                        <!-- more elements here -->
                                    </KeyValue>
                                </InterpolationFunctions>
                            </Vertex>
                            <!-- more elements here -->
                        </FigureTrajectory>
                    </SpatioTemporalLocator>
                    <RegionDepthType href="...">
                        <Name xml:lang="en">foreground</Name>
                    </RegionDepthType>
                </EditedMovingRegion>
            </AnalyticEditionAreaDecomposition>
            <AnalyticEditingTemporalDecomposition gap="false"
                overlap="false">
                <CompositionShot id="ClipCS_1" locationReliability="0.9"
                    editingLevelReliability="0.5" type="simple">
                    <MediaTime>
                        <MediaRelIncrTimePoint mediaTimeUnit="PT1N25F"

    mediaTimeBase="../../../../../../MediaLocator[1]">35</MediaRelIncrTimePoint>
                        <MediaIncrDuration
                            mediaTimeUnit="PT1N25F">55</MediaIncrDuration>
                    </MediaTime>
                </CompositionShot>
                <CompositionTransition id="CT_1"
locationReliability="0.9"
                    editingLevelReliability="0.5"
evolutionReliability="0.5">
                    <MediaTime>
                        <MediaRelIncrTimePoint mediaTimeUnit="PT1N25F"

    mediaTimeBase="../../../../../../MediaLocator[1]">90</MediaRelIncrTimePoint>
                        <MediaIncrDuration
                            mediaTimeUnit="PT1N25F">10</MediaIncrDuration>
                    </MediaTime>
                    <EvolutionType href="...">
                        <Name xml:lang="en">IrisOpen</Name>
                    </EvolutionType>
                    <!--Edition area introduced by composition transition
-->
                    <EditedMovingRegionRef href="#editArea_2"/>
                </CompositionTransition>
                <CompositionShot id="ClipCS_2" locationReliability="0.9"
                    editingLevelReliability="0.5" type="composite">
                    <MediaTime>
                        <MediaRelIncrTimePoint mediaTimeUnit="PT1N25F"

    mediaTimeBase="../../../../../../MediaLocator[1]">100</MediaRelIncrTimePoint
>
```

```
                                <MediaIncrDuration

   mediaTimeUnit="PT1N25F">348</MediaIncrDuration>
                            </MediaTime>
                            <AnalyticEditingTemporalDecomposition gap="false"
                                overlap="true">
                                <IntraCompositionShot id="ClipICS_1"
                                    locationReliability="0.9"
                                    editingLevelReliability="0.5" type="simple">
                                    <MediaTime>
                                        <MediaRelIncrTimePoint
mediaTimeUnit="PT1N25F"
mediaTimeBase="../../../../../../../../MediaLocator[1]">100</MediaRelIncrTimePoi
nt>
                                        <MediaIncrDuration

   mediaTimeUnit="PT1N25F">75</MediaIncrDuration>
                                    </MediaTime>
                                </IntraCompositionShot>
                                <InternalTransition id="IT_1"
locationReliability="0.9"
                                    editingLevelReliability="0.5"
                                    evolutionReliability="0.5">
                                    <MediaTime>
                                        <MediaRelIncrTimePoint
mediaTimeUnit="PT1N25F"
mediaTimeBase="../../../../../../../../MediaLocator[1]">175</MediaRelIncrTimePoi
nt>
                                        <MediaIncrDuration

   mediaTimeUnit="PT1N25F">1</MediaIncrDuration>
                                    </MediaTime>
                                    <EvolutionType href="...">
                                        <Name xml:lang="en">cut</Name>
                                    </EvolutionType>
                                    <!--Edition area affected by inter. transition
-->
                                    <EditedMovingRegionRef href="#editArea_2"/>
                                </InternalTransition>
                                <IntraCompositionShot id="ClipICS_2"
                                    locationReliability="0.9"
                                    editingLevelReliability="0.5" type="simple">
                                    <MediaTime>
                                        <MediaRelIncrTimePoint
mediaTimeUnit="PT1N25F"
mediaTimeBase="../../../../../../../../MediaLocator[1]">175</MediaRelIncrTimePoi
nt>
                                        <MediaIncrDuration

   mediaTimeUnit="PT1N25F">273</MediaIncrDuration>
                                    </MediaTime>
                                </IntraCompositionShot>
                            </AnalyticEditingTemporalDecomposition>
                        </CompositionShot>
                    </AnalyticEditingTemporalDecomposition>
                </Shot>
            </AnalyticEditingTemporalDecomposition>
        </AnalyticEditedVideo>
    </MultimediaContent>
</Description>
</Mpeg7>
```

3.9.10 Structural relation classification schemes

3.9.10.1 TemporalRelation CS examples

The following example illustrates the use of the `TemporalRelation CS` and the `Graph DS` for describing the relation that video segment *A* is before video segment *B*.

```
<VideoSegment id="segmentA"> <!-- more elements here --> </VideoSegment>
<VideoSegment id="segmentB"> <!-- more elements here --> </VideoSegment>
<Graph>
    <Node id="nodeA" href="#segmentA"/>
    <Node id="nodeB" href="#segmentB"/>
    <!-- Edge a->b -->
    <Relation type="urn:mpeg:mpeg7:cs:TemporalRelationCS:2001:before"
              source="#nodeB" target="#nodeA"/>
</Graph>
```

The following example illustrates the use of the `TemporalRelation CS` and the `Relation DS` for describing the relation that video segment C is before video segment D.

```
<VideoSegment id="segmentD">
    <Relation type="urn:mpeg:mpeg7:cs:TemporalRelationCS:2001:before"
              target="#segmentD"/>
    <MediaTime> <!-- more elements here --> </MediaTime>
</VideoSegment>

<VideoSegment id="segmentC">
    <MediaTime> <!-- more elements here --> </MediaTime>
</VideoSegment>
```

The following example illustrates the use of the `TemporalRelation CS` and the `Graph DS` for describing temporal relations between the narrator moving region ("narrator-movreg"), the rabbit moving region ("rabbit-movreg"), and the sun moving region ("sun-movreg") of a documentary video on the subject of nature. It is assumed that the segments have been described using the `Segment DSs` with the specified id attributes. There are two variations shown below: the first uses `Relation` and `Node` in the `Graph DS`, while the second uses only `Relation`.

```
<MovingRegion id="sun-movreg">
    <SpatioTemporalLocator> <!-- more elements here --> </SpatioTemporalLocator>
</MovingRegion>
<MovingRegion id="narrator-movreg">
    <SpatioTemporalLocator> <!-- more elements here --> </SpatioTemporalLocator>
</MovingRegion>
<MovingRegion id="rabbit-movreg">
    <SpatioTemporalLocator> <!-- more elements here --> </SpatioTemporalLocator>
</MovingRegion>

<!-- First variation of the temporal graph -->
<Graph type="temporal">
    <Node id="node1" href="#sun-movreg"/>
    <Node id="node2" href="#rabbit-movreg"/>
    <Node id="node3" href="#narrator-movreg"/>
    <Node id="node4" href="#sun-movreg"/>
    <Relation type="urn:mpeg:mpeg7:cs:TemporalRelationCS:2001:starts"
              source="#node2" target="#node1"/>
    <Relation type="urn:mpeg:mpeg7:cs:TemporalRelationCS:2001:before"
              source="#node4" target="#node3"/>
</Graph>

<!-- Second variation of the temporal graph -->
<Graph type="temporal">
    <Relation type="urn:mpeg:mpeg7:cs:TemporalRelationCS:2001:starts"
          source="#rabbit-movreg" target="#sun-movreg"/>
    <Relation type="urn:mpeg:mpeg7:cs:TemporalRelationCS:2001:before"
```

```
            source="#sun-movreg" target="#narrator-movreg"/>
</Graph>
```

3.9.10.2 SpatialRelation CS

3.9.10.2.1 SpatialRelation CS examples

The following example illustrates the use of the `SpatialRelation CS` for describing spatial relations among segments. The 2D-String is a data structure for spatial reasoning. In the following example, the 2D-string describes the spatial relations between the regions. In Figure 35, the regions correspond to the rabbit ("rabbit-rg"), cloud ("cloud-rg"), airplane ("airplane-rg"), and car ("car-rg"). The 2D-String is given as follows: (rabbit < cloud < car = airplane, rabbit = car < airplane < cloud), where the symbol "=" denotes the spatial relations "at the same x as" and "at the same y as", the symbol "<" denotes the spatial relations "left/right" and "below/above", and the symbol ":" denotes the spatial relation "in the same set as". The description of the associated 2D-String for the example in Figure 35 is included below. All the relations in this example are standard relations except for "sameX" and "sameY".

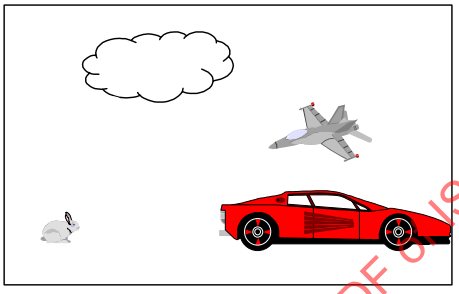


Figure 35 - Example description of spatial relations in an image using 2D string.

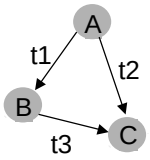
```
<!-- 2D String rabbit<cloud<car=airplane, rabbit=car<airplane<cloud -->
<Graph>
    <Relation type="urn:mpeg:mpeg7:cs:SpatialRelationCS:2001:left"
              source="#cloud-rg" target="#rabbit-rg"/>
    <Relation type="urn:mpeg:mpeg7:cs:SpatialRelationCS:2001:left"
              source="#car-rg" target="#cloud-rg"/>
    <Relation name=" urn:example:arelationcs:sameX"
              source="#airplane-rg" target="#car-rg"/>
    <Relation name=" urn:example:arelationcs:sameY"
              source="#car-rg" target="#rabbit-rg"/>
    <Relation type="urn:mpeg:mpeg7:cs:SpatialRelationCS:2001:below"
              source="#airplane-rg" target="#car-rg"/>
    <Relation type="urn:mpeg:mpeg7:cs:SpatialRelationCS:2001:below"
              source="#cloud-rg" target="#airplane-rg"/>
</Graph>
```

3.9.10.2.2 SpatialRelation CS extraction

The extraction of relations among segment can be done automatically or by hand based on different criteria (e.g. semantic and temporal information). This subclause describes the spatio-temporal structure (relation) features extracted for segmented video objects' regions in the AMOS system and latter used for retrieval. In this subclause, spatio-temporal structure of an object is understood as the spatio-temporal relations among its composing regions.

In AMOS, given a set of regions of a semantic video object, the structure descriptors are derived from their spatial and temporal positions and boundaries. These features are pre-computed and properly stored to allow quick access and examination in the similarity matching process. AMOS uses two spatial and one temporal structure features (Figure 36).

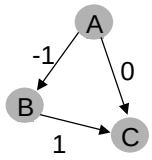
Ordered Region List : (A, B, C)



Relation vector: [t1,t2,t3]

t1 is *angle* of AB
t2 is *angle* of AC
t3 is *angle* of BC

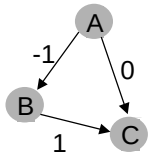
a) Spatial Orientation Graph



Relation vector: [-1,0,1]

A *is contained* by B
A, C *not contain* other
B *contains* C

b) Spatial Topological Graph



Relation vector: [-1,0,1]

A starts *after* B
A,C start *at same time*
B starts *before* C

c) Directional Temporal Graph

Figure 36 - Examples of spatio-temporal relation graphs.

There are several different ways to compare spatial structure, such as 2D-Strings 0 and spatio-temporal logics 0. AMOS uses a relatively fast and simple method, the spatial-orientation graph, to represent spatial relations as edges in a weighted graph 0. This graph can be easily constructed by computing the orientation of each edge between the centroids of a pair of query regions, and stored as a n*(n-1)/2-dimension descriptor, where n is the number of query regions (Figure 36.a). The spatial-orientation graph cannot handle the "contain" relation. AMOS complements it with a topological graph (Figure 36.b), which defines the contain relation between each pair of regions with three possible values: contains (1), is-contained (-1) or not containing each other (0).

In a similarly way, the temporal graph (Figure 36.c) defines whether one region starts before (1), after (-1) or at the same time (0) with another region. Note that, for simplicity, the temporal order according to the first appearing time (or starting time) of each region is only defined. By taking the ending time, a more complicated temporal relation graph can also be generated.

3.9.10.3 Structural relation classification schemes examples

The following example illustrates the use of the `TemporalRelation CS` and the `SpatialRelation CS` for describing structural relations among segments of a video segment capturing a goal in a soccer game. The video segment corresponds to `id` = "Goal-sg". The kick and not-catch events in the video shot are represented by video segments `id` = "Kick-sg" and `id` = "Not-Catch-sg", respectively. The spatio-temporal regions corresponding to the goal, the ball, the forward, and the goalkeeper are described by moving regions `id` = "Goal-rg", `id` = "Ball-rg", "Forward-rg", and `id` = "Goalkeeper-rg", respectively.

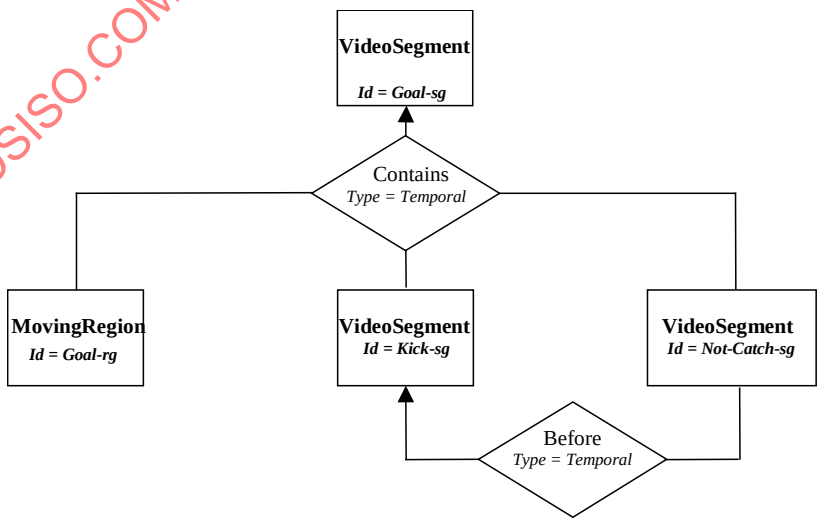


Figure 37 - Examples of relationships among video segments and moving regions.

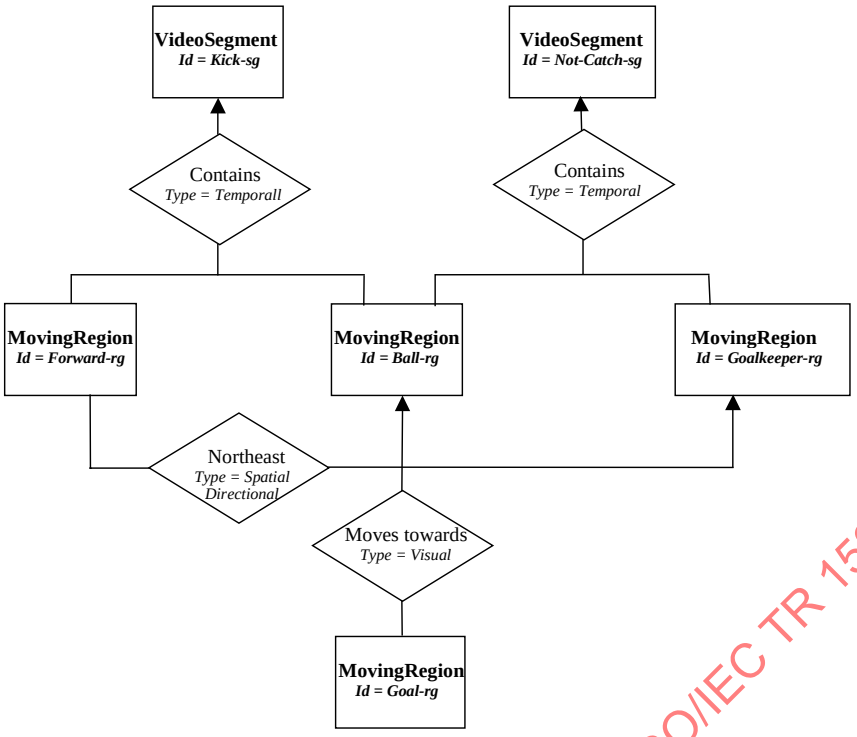


Figure 38 - Examples of relationships among video segments and moving regions.

The `Graph DS` describes the relations between the video segments and moving regions. Examples of relations between the segments are shown in Figure 37 and Figure 38. In Figure 37 (Graph 1), the region `id` = "Goal-rg", the video segment `id` = "Kick-sg", and the video segment `id` = "Not-Catch-sg" are described as being temporally contained in the segment `id` = "Goal-sg". The video segment `id` = "Kick-sg" is also described as happening before the video segment `id` = "Not-Catch-sg".

In Figure 38 (Graph 2), the video segment `id` = "Kick-sg" is described as temporally containing the moving regions `id` = "Forward-rg" and the `id` = "Ball-rg". Similarly, the video segment `id` = "Not-Catch-sg" is described as temporally containing the moving regions `id` = "Ball-rg" and the `id` = "Goalkeeper-rg". The region `id` = "Goalkeeper-rg" is related to the moving region `id` = "Forward-rg" by a spatial relation, "Northeast". The moving region `id` = "Ball-rg" is related to the moving region `id` = "Goal-rg" by a visual, global relation, "Moves towards".

The description of the segment graphs shown in Figure 37 and Figure 38 is included below.

```
<!-- Description of Graph 1 -->
<Graph>
   <Relation type="urn:mpeg:mpeg7:cs:TemporalRelationCS:2001:contains"
             source="#Goal-rg" target="#Goal-sg"/>
   <Relation type="urn:mpeg:mpeg7:cs:TemporalRelationCS:2001:contains"
             source="#Kick-sg" target="#Goal-sg"/>
   <Relation type="urn:mpeg:mpeg7:cs:TemporalRelationCS:2001:contains"
             source="#Not-Catch-sg" target="#Goal-sg"/>
   <Relation type="urn:mpeg:mpeg7:cs:TemporalRelationCS:2001:before"
             source="#Not-Catch-sg" target="#Kick-sg"/>
</Graph>

<!-- Description of Graph 2 -->
<Graph>
   <Relation type="urn:mpeg:mpeg7:cs:TemporalRelationCS:2001:contains"
             source="#Forward-rg" target="#Kick-sg"/>
   <Relation type="urn:mpeg:mpeg7:cs:TemporalRelationCS:2001:contains"
             source="#Ball-rg" target="#kick-sg"/>
   <Relation type="urn:mpeg:mpeg7:cs:TemporalRelationCS:2001:contains"
             source="#Ball-rg" target="#Not-Catch-sg"/>
   <Relation type="urn:mpeg:mpeg7:cs:TemporalRelationCS:2001:before"
             source="#Goalkeeper-rg" target="#Not-Catch-sg"/>
   <Relation type="urn:mpeg:mpeg7:cs:SpatialRelationCS:2001:northeast"
```

```
            source="#Goalkeeper-rg" target="#Forward-rg"/>
   <Relation name="urn:example:arelationcs:movesToward"
            source="#Goal-rg" target="#Ball-rg"/>
</Graph>
```

3.10 Semantics description tools

3.10.1 Introduction

3.10.1.1 Overview

The tools specified in this clause include the following:

Table 11 - Overview of the semantics description tools.

Tool	*Functionality*
Semantic entity description tools	Tools for describing semantic entities such as objects, agent objects, events, concepts, states, places, times, and narrative worlds.
Semantic attribute description tools	Tools for describing attributes of semantic entities related to abstraction in semantic descriptions and semantic measurements in time and space.
Semantic relation classification schemes	These classification schemes define semantic relations.

Figure 39 illustrates the organization of the tools for describing the semantics of multimedia content.

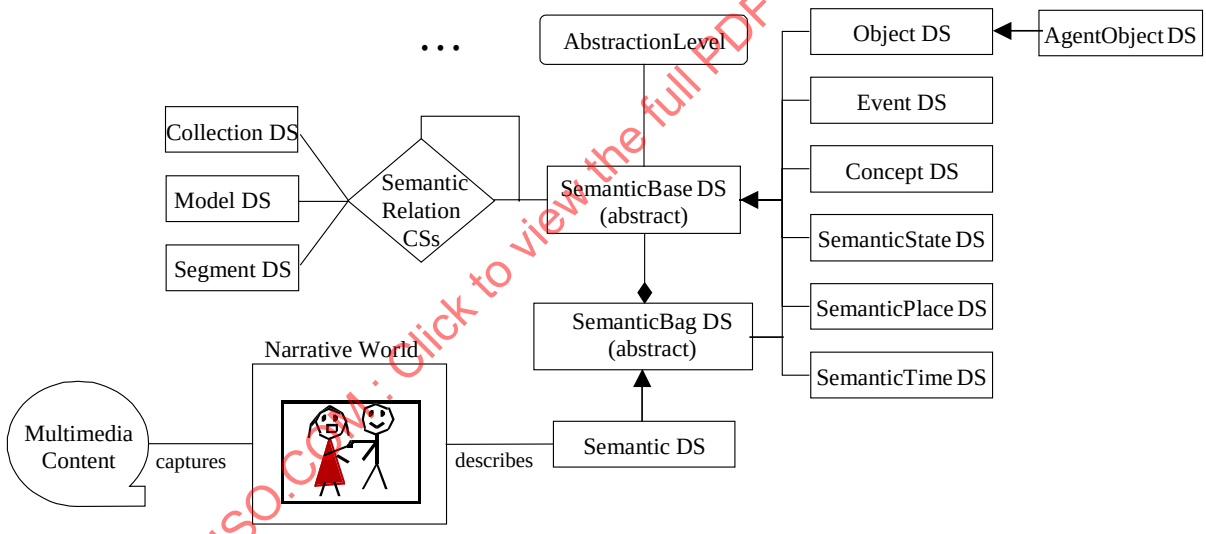


Figure 39 - Illustration of the relationships of the tools for describing the semantics of multimedia content.

3.10.1.2 Semantics description example

Figure 40 shows an informative example of how the semantic description tools describe the semantics of an image. The boxes in Figure 40 represent descriptions of different semantic entity description tools and semantic relation classification schemes.

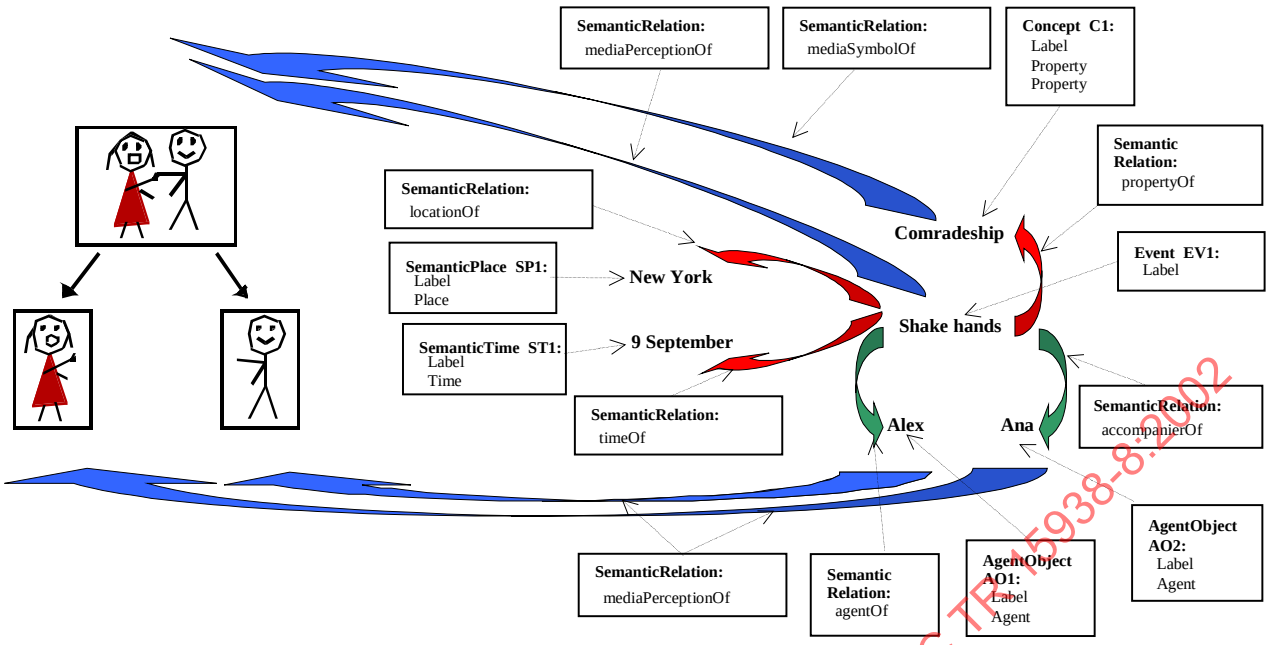


Figure 40 - Illustration of the description of a narrative world captured by an image using tools for describing the semantics of multimedia content.

The semantic description of the image is the following: "Alex is shaking hands with Ana in New York on the 9th of September. The event is showing "comradeship". In this example, the `AgentObject DS`, the `Event DS`, the `SemanticPlace DS`, the `SemanticTime DS`, and the `Concept DS` describe people, event, place, time and concept of the image, respectively. A `Label` element describes each semantic entity; the `Property`, `Time`, `Place` and `Agent` elements are also used to describe the attributes of people, event, place, time and concept of the image. The `SemanticRelation CS` describes the relations among semantic entities and possibly other non-semantic entities.

3.10.2 Abstraction model

Information on extraction and use is not provided.

3.10.3 Semantic entity description tools

3.10.3.1 SemanticBase DS

Information on extraction and use is not provided.

3.10.3.2 SemanticBag DS

Information on extraction and use is not provided.

3.10.3.3 Semantic DS

3.10.3.3.1 Semantic DS examples

The following example illustrates the use of the `Semantic DS` for describing the semantic entity "apple". The `Label` elements can be used as keywords or index terms for accessing this semantic description.

```
<Mpeg7>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics id="apple">
         <Label>
            <Name> Apple </Name>
         </Label>
         <Label>
            <Name> Fruit </Name>
         </Label>
         <Label>
            <Name> Pome </Name>
         </Label>
         <Definition>
```

```
            <FreeTextAnnotation>
               The fleshy usually rounded and red, yellow, or green edible
               pome fruit of a tree (genus Malus) of the rose family
            </FreeTextAnnotation>
         </Definition>
         <Property>
            <Name> Juicy </Name>
         </Property>
         <MediaOccurrence>
            <MediaLocator>
               <MediaUri> image.jpg </MediaUri>
            </MediaLocator>
         </MediaOccurrence>
      </Semantics>
   </Description>
</Mpeg7>
```

3.10.3.4 Object DS

3.10.3.4.1 Object DS examples

The following example illustrates the use of the `Object DS` for describing a table shown in an image. In this example, the table object is decomposed into one object "tabletop" and four objects "leg", i.e., a component type of decomposition. The `MediaOccurrence` element is used for locating the object within the media and describing the visual features of the image.

```
<Mpeg7>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics>
         <Label>
            <Name> Description of table </Name>
         </Label>
         <SemanticBase xsi:type="ObjectType">
            <Label>
               <Name> Table </Name>
            </Label>
            <Definition>
               <FreeTextAnnotation>
                  Piece of furniture consisting of a smooth flat slab
                  fixed on legs
               </FreeTextAnnotation>
            </Definition>
            <MediaOccurrence>
               <MediaLocator>
                  <MediaUri>image.jpg</MediaUri>
               </MediaLocator>
               <VisualDescriptor xsi:type="ScalableColorType" numOfCoeff="16"
                  numOfBitplanesDiscarded="0">
                  <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
               </VisualDescriptor>
            </MediaOccurrence>
            <Object id="tabletop-object">
               <Label>
                  <Name> Table top </Name>
               </Label>
               <MediaOccurrence>
                  <MediaLocator>
                     <MediaUri>image.jpg</MediaUri>
                  </MediaLocator>
                  <Mask xsi:type="SpatialMaskType">
                     <SubRegion>
                        <Polygon>
                           <Coords mpeg7:dim="2 5"> 5 25 10 20 15 15 10 10 5
15
```

```
                            </Coords>
                        </Polygon>
                    </SubRegion>
                </Mask>
                <VisualDescriptor xsi:type="ScalableColorType"
numOfCoeff="16"
                    numOfBitplanesDiscarded="0">
                    <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                </VisualDescriptor>
            </MediaOccurrence>
        </Object>
        <Object id="Leg1-object">
            <Label>
                <Name> Leg </Name>
            </Label>
            <MediaOccurrence>
                <MediaLocator>
                    <MediaUri>image.jpg</MediaUri>
                </MediaLocator>
                <Mask xsi:type="SpatialMaskType">
                    <SubRegion>
                        <Polygon>
                            <Coords mpeg7:dim="2 5"> 5 25 10 20 15 15 10 10 5
15
                            </Coords>
                        </Polygon>
                    </SubRegion>
                </Mask>
                <VisualDescriptor xsi:type="ScalableColorType"
numOfCoeff="16"
                    numOfBitplanesDiscarded="0">
                    <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                </VisualDescriptor>
            </MediaOccurrence>
        </Object>
        <Object id="Leg2-object">
            <Label>
                <Name> Leg </Name>
            </Label>
            <MediaOccurrence>
                <MediaLocator>
                    <MediaUri>image.jpg</MediaUri>
                </MediaLocator>
                <Mask xsi:type="SpatialMaskType">
                    <SubRegion>
                        <Polygon>
                            <Coords mpeg7:dim="2 5"> 5 25 10 20 15 15 10 10 5
15
                            </Coords>
                        </Polygon>
                    </SubRegion>
                </Mask>
                <VisualDescriptor xsi:type="ScalableColorType"
numOfCoeff="16"
                    numOfBitplanesDiscarded="0">
                    <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                </VisualDescriptor>
            </MediaOccurrence>
        </Object>
        <Object id="Leg3-object">
            <Label>
                <Name> Leg </Name>
            </Label>
            <MediaOccurrence>
```

```
                    <MediaLocator>
                        <MediaUri>image.jpg</MediaUri>
                    </MediaLocator>
                    <Mask xsi:type="SpatialMaskType">
                        <SubRegion>
                            <Polygon>
                                <Coords mpeg7:dim="2 5"> 5 25 10 20 15 15 10 10 5
15
                                </Coords>
                            </Polygon>
                        </SubRegion>
                    </Mask>
                    <VisualDescriptor xsi:type="ScalableColorType"
numOfCoeff="16"
                        numOfBitplanesDiscarded="0">
                        <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                    </VisualDescriptor>
                </MediaOccurrence>
            </Object>
            <Object id="Leg4-object">
                <Label>
                    <Name> Leg </Name>
                </Label>
                <MediaOccurrence>
                    <MediaLocator>
                        <MediaUri>image.jpg</MediaUri>
                    </MediaLocator>
                    <Mask xsi:type="SpatialMaskType">
                        <SubRegion>
                            <Polygon>
                                <Coords mpeg7:dim="2 5"> 5 25 10 20 15 15 10 10 5
15
                                </Coords>
                            </Polygon>
                        </SubRegion>
                    </Mask>
                    <VisualDescriptor xsi:type="ScalableColorType"
numOfCoeff="16"
                        numOfBitplanesDiscarded="0">
                        <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                    </VisualDescriptor>
                </MediaOccurrence>
            </Object>
        </SemanticBase>
    </Semantics>
</Description>
</Mpeg7>
```


3.10.3.5 AgentObject DS

3.10.3.5.1 AgentObject DS examples

The following example illustrates the use of the `AgentObject DS` for describing a person named Alexander (Alex) Green.

```
<Mpeg7>
    <Description xsi:type="SemanticDescriptionType">
        <Semantics>
            <Label>
                <Name> Description of person </Name>
            </Label>
            <SemanticBase xsi:type="AgentObjectType">
                <Label>
                    <Name> Student </Name>
```

```
            </Label>
            <Definition>
               <FreeTextAnnotation> Student named Alexander Green
               </FreeTextAnnotation>
            </Definition>
            <Agent xsi:type="PersonType">
               <Name>
                  <GivenName abbrev="Alex"> Alexander </GivenName>
                  <FamilyName> Green </FamilyName>
               </Name>
            </Agent>
         </SemanticBase>
      </Semantics>
   </Description>
</Mpeg7>
```

The following example illustrates the use of the AgentObject DS for describing members of a baseball team. In this example, the agent object (Baseball team) is composed of three agent objects (players – pitcher, catcher, and third base).

```
<Mpeg7>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics>
         <Label>
            <Name> Baseball team </Name>
         </Label>
         <SemanticBase xsi:type="AgentObjectType">
            <Label>
               <Name> NY Mets </Name>
            </Label>
            <Object xsi:type="AgentObjectType" id="player1-agent">
               <Label href="urn:example:baseball">
                  <Name> Pitcher </Name>
               </Label>
               <Agent xsi:type="PersonType">
                  <Name>
                     <GivenName> Al </GivenName>
                     <FamilyName> Leiter </FamilyName>
                  </Name>
               </Agent>
            </Object>
            <Object xsi:type="AgentObjectType" id="player1-agent">
               <Label href="urn:example:baseball">
                  <Name> Catcher </Name>
               </Label>
               <Agent xsi:type="PersonType">
                  <Name>
                     <GivenName> Mike </GivenName>
                     <FamilyName> Piazza </FamilyName>
                  </Name>
               </Agent>
            </Object>
               <Object xsi:type="AgentObjectType" id="player1-agent">
               <Label href="urn:example:baseball">
                  <Name> Third base </Name>
               </Label>
               <Agent xsi:type="PersonType">
                  <Name>
                     <GivenName> Robin </GivenName>
                     <FamilyName> Ventura </FamilyName>
                  </Name>
               </Agent>
            </Object>
```

```
          </SemanticBase>
       </Semantics>
   </Description>
</Mpeg7>
```

3.10.3.6 Event DS

3.10.3.6.1 Event DS examples

The following example illustrates the use of the `Event DS` for describing the event of a "handshake between two colleagues". In this example, the `Relation DS` uses the `SemanticRelation CS` to describe the `agentOf` and `accompanierOf` of the action, respectively.

```
<Mpeg7>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics>
         <Label>
            <Name> Shake hands </Name>
         </Label>
         <SemanticBase xsi:type="AgentObjectType" id="AOa">
            <Label href="urn:example:acs">
               <Name> Person A </Name>
            </Label>
         </SemanticBase>
         <SemanticBase xsi:type="AgentObjectType" id="AOb">
            <Label href="urn:example:acs">
               <Name> Person B </Name>
            </Label>
         </SemanticBase>
         <SemanticBase xsi:type="EventType" id="EV1">
            <Label href="urn:example:acs">
               <Name> Shake hands </Name>
            </Label>
            <Definition>
               <FreeTextAnnotation>
            Clasping of right hands by two people.
         </FreeTextAnnotation>
            </Definition>
            <Relation type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:agentOf"
               source="#AOa" target="#AOb"/>
            <Relation
               type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:accompanierOf"
               source="#AOb" target="#AOa"/>
         </SemanticBase>
      </Semantics>
   </Description>
</Mpeg7>
```

3.10.3.7 Concept DS

3.10.3.7.1 Concept DS examples

The following example illustrates the use of the `Concept DS` for describing the concept "freedom" as as having properties of "open", "outspoken", and "frank". In this example, the description identifies an image of the Statue of Liberty that symbolizes "freedom".

```
<Mpeg7>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics>
         <Label>
            <Name> Concept of freedom </Name>
         </Label>
         <SemanticBase xsi:type="ConceptType" id="freedom">
            <Label>
```

```
                <Name> Freedom </Name>
            </Label>
            <Property>
                <Name> Open </Name>
            </Property>
            <Property>
                <Name> Outspoken </Name>
            </Property>
            <Property>
                <Name> Frank </Name>
            </Property>
            <MediaOccurrence type="symbol">
                <MediaLocator>
                    <MediaUri> liberty.gif
                    </MediaUri>
                </MediaLocator>
            </MediaOccurrence>
        </SemanticBase>
    </Semantics>
</Description>
</Mpeg7>
```

3.10.3.8 SemanticState DS

3.10.3.8.1 SemanticState DS examples

The following example illustrates the use of the SemanticState DS for describing semantic attributes of a sunset. In this example, the event "sunset-event" represents the event "sunset" and the semantic state "sunset-state" describes the semantic attributes of the event "sunset". A graph relates the event "sunset-event" and the semantic state "sunset-state". A sunset is considered as an event because it can be nominalized: "The sunset is beautiful".

```
<Mpeg7>
    <Description xsi:type="SemanticDescriptionType">
        <Semantics>
            <Label>
                <Name> Sunset </Name>
            </Label>
            <SemanticBase xsi:type="EventType" id="sunset-event">
                <Label>
                    <Name> Sunset </Name>
                </Label>
            </SemanticBase>
            <SemanticBase xsi:type="SemanticStateType" id="sunset-state">
                <Label>
                    <Name> State of sunset </Name>
                </Label>
                <AttributeValuePair>
                    <Attribute>
                        <Name> Blue </Name>
                    </Attribute>
                    <IntegerValue>90</IntegerValue>
                </AttributeValuePair>
                <AttributeValuePair>
                    <Attribute>
                        <Name> Pink </Name>
                    </Attribute>
                    <IntegerValue>9</IntegerValue>
                </AttributeValuePair>
                <AttributeValuePair>
                    <Attribute>
                        <Name> Orange </Name>
                    </Attribute>
                    <IntegerValue>50</IntegerValue>
```

```
            </AttributeValuePair>
            <AttributeValuePair>
               <Attribute>
                  <Name> Yellow </Name>
               </Attribute>
               <IntegerValue>45</IntegerValue>
            </AttributeValuePair>
         </SemanticBase>
         <Graph>
            <!-- Relate event sunset-event and state sunset-state -->
            <Relation
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:hasStateOf"
               source="#sunset-state" target="#sunset-event"/>
         </Graph>
      </Semantics>
   </Description>
</Mpeg7>
```

The following example illustrates the use of the SemanticState DS for describing the place and event for a person. In this example, "John is in Singapore today" is described by linking the AgentObject DS description corresponding to "John", the SemanticPlace DS description of "Singapore", and the SemanticTime DS description of "today" using the state "position-state". This description may be represented by an event "Being" taking place during semantic time "today" in semantic place "Singapore".

```
<Mpeg7>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics>
         <Label>
            <Name> Place and time for a person </Name>
         </Label>
         <SemanticBase xsi:type="AgentObjectType" id="agent-person">
            <Label>
               <Name> John </Name>
            </Label>
            <Relation type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:stateOf"
               target="#position-state"/>
         </SemanticBase>
         <SemanticBase xsi:type="SemanticStateType" id="position-state">
            <Label>
               <Name> Position </Name>
            </Label>
            <AttributeValuePair>
               <Attribute>
                  <Name> Position </Name>
               </Attribute>
               <IntegerValue>1</IntegerValue>
            </AttributeValuePair>
            <SemanticTime>
               <Label>
                  <Name> today </Name>
               </Label>
            </SemanticTime>
            <SemanticPlace>
               <Label>
                  <Name> Singapore </Name>
               </Label>
            </SemanticPlace>
         </SemanticBase>
      </Semantics>
   </Description>
</Mpeg7>
```

3.10.3.9 SemanticPlace DS

3.10.3.9.1 SemanticPlace DS examples

The following example illustrates the use of the SemanticPlace DS for describing the location "Columbia University in the City of New York".

```
<Mpeg7>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics>
         <Label>
            <Name> Semantic place for Columbia University </Name>
         </Label>
         <SemanticBase xsi:type="SemanticPlaceType" id="columbia-location">
            <Label>
               <Name> Columbia University </Name>
            </Label>
            <Place>
               <Name xml:lang="en">
                  Columbia University in the City of New York </Name>
               <Region> us </Region>
               <PostalAddress>
                  <AddressLine>600 West 116th Street, New York,
NY</AddressLine>
                  <PostingIdentifier> U-10027 </PostingIdentifier>
               </PostalAddress>
            </Place>
         </SemanticBase>
      </Semantics>
   </Description>
</Mpeg7>
```

The following example illustrates the use of the SemanticPlaceInterval element in SemanticPlace DS for describing the location "4 miles".

```
<Mpeg7>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics>
         <Label>
            <Name> Semantic place for location four miles </Name>
         </Label>
         <SemanticBase xsi:type="SemanticPlaceType" id="miles4-place">
            <Label>
               <Name> 4 miles </Name>
            </Label>
            <SemanticPlaceInterval>
               <Extent measurementType="length" unit="mile" value="4"/>
            </SemanticPlaceInterval>
         </SemanticBase>
      </Semantics>
   </Description>
</Mpeg7>
```

The following example illustrates the use of the SemanticPlaceInterval element in SemanticPlace DS for describing the location "Within 4 miles radius of New York City".

```
<Mpeg7>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics>
         <Label>
            <Name> Semantic place for four mile radius of NYC </Name>
         </Label>
         <SemanticBase xsi:type="SemanticPlaceType" id="miles4NYC-place">
            <Label>
```

```
                <Name> Within 4 miles radius of New York City </Name>
            </Label>
            <SemanticPlaceInterval>
                <Position origin="New York City"/>
                <Extent measurementType="area" unit="square miles"
value="16*pi"/>
            </SemanticPlaceInterval>
        </SemanticBase>
    </Semantics>
</Description>
</Mpeg7>
```

The following example illustrates the use of the SemanticPlaceInterval element in SemanticPlace DS for describing the location "5 kilometers north of New York City and 40 kilometers east of Boston".

```
<Mpeg7>
    <Description xsi:type="SemanticDescriptionType">
        <Semantics>
            <Label>
                <Name> Semantic place for location near NYC and Boston </Name>
            </Label>
            <SemanticBase xsi:type="SemanticPlaceType" id="NYCBoston-place">
                <Label>
                    <Name>
                        5 kilometers north of New York City and
                        40 kilometers east of Boston
                    </Name>
                </Label>
                <SemanticPlaceInterval>
                    <Position origin="New York City">
                        <Displacement measurementType="length" unit="kilometers"
                            value="5"/>
                        <Direction measurementType="direction" unit="direction"
                            value="north"/>
                    </Position>
                </SemanticPlaceInterval>
                <SemanticPlaceInterval>
                    <Position origin="Boston">
                        <Displacement measurementType="length" unit="kilometers"
                            value="40"/>
                        <Direction measurementType="direction" unit="direction"
                            value="east"/>
                    </Position>
                </SemanticPlaceInterval>
            </SemanticBase>
        </Semantics>
    </Description>
</Mpeg7>
```


If a semantic place is complex, relations may relate the location to the other semantic entities such as objects and events needed to fully describe it. The following example illustrates the use of the SemanticPlace DS for describing the location "the place where Cri and Ale got engaged."

In this example, the location "at the Eiffel Tower in the same spot where Cri and Ale were engaged last year" and the event "Spot at the Eiffel Tower" are described in the semantic entities "sem2-loc" and "engagement-event", respectively. The new semantic place ("sem2-loc") can be defined as the same as the SemanticPlace DS description of the event "engagement-event" – relation identifiedWith to semantic place "Eiffel-loc" (possibility one) - or as being the location where that event took place– relation hasLocationOf to the event "engagement-event" (possibility two). In general, if the same semantic entity is described by multiple semantic descriptions, the relationship of the descriptions can be described using the semantic relation identifiedWith.

```
<Mpeg7>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics>
         <Label>
            <Name> The place where Cri and Ale got engaged </Name>
         </Label>
         <SemanticBase xsi:type="SemanticPlaceType" id="sem2-loc">
            <Label>
               <Name> Eiffel Tower </Name>
            </Label>
            <Relation
               type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:identifiedWith"
               target="#Eiffel-loc"/>
            <Relation
               type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:hasLocationOf"
               target="#engagement-event"/>
         </SemanticBase>
         <SemanticBase xsi:type="EventType" id="engagement-event">
            <Label>
               <Name> Engagement </Name>
            </Label>
            <Definition>
               <FreeTextAnnotation>
                  Engagement of Cri and Ale, at the Eiffel Tower in Paris
               </FreeTextAnnotation>
            </Definition>
            <Relation
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:locationOf"
               target="#Eiffel-loc"/>
            <Relation type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:timeOf"
               target="#lastyear-time"/>
         </SemanticBase>
         <SemanticBase xsi:type="SemanticPlaceType" id="Eiffel-loc">
            <Label>
               <Name> Spot at the Eiffel Tower </Name>
            </Label>
         </SemanticBase>
         <SemanticBase xsi:type="SemanticTimeType" id="lastyear-time">
            <Label>
               <Name> Last year </Name>
            </Label>
            <SemanticTimeInterval>
               <TimePoint origin="now">
                  <Displacement measurementType="length" unit="year"
value="1"/>
                  <Direction measurementType="direction" unit="direction"
                     value="before"/>
               </TimePoint>
            </SemanticTimeInterval>
         </SemanticBase>
      </Semantics>
   </Description>
</Mpeg7>
```


3.10.3.10 SemanticTime DS

3.10.3.10.1 SemanticTime DS examples

The following example illustrates the use of the `Time DS` in `SemanticTime DS` for describing the time "10 days starting at 14:13:00 hours, 12 November, 2001".

```
<Mpeg7>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics>
         <Label>
```

```
            <Name> 10 days </Name>
         </Label>
         <SemanticBase xsi:type="SemanticTimeType">
            <Label>
               <Name>
                  10 days starting at 14:13:00 hours, 12 November, 2001
               </Name>
            </Label>
            <Time>
               <TimePoint>2001-11-12T14:13+01:00</TimePoint>
               <Duration>P10D</Duration>
            </Time>
         </SemanticBase>
      </Semantics>
   </Description>
</Mpeg7>
```

The following example illustrates the use of the SemanticTimeInterval element in SemanticTime DS for describing the time "4 weeks".

```
<Mpeg7>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics>
         <Label>
            <Name> Description of 4 weeks </Name>
         </Label>
         <SemanticBase xsi:type="SemanticTimeType">
            <Label>
               <Name> 4 weeks </Name>
            </Label>
            <SemanticTimeInterval>
               <Duration measurementType="length" unit="week" value="4"/>
            </SemanticTimeInterval>
         </SemanticBase>
      </Semantics>
   </Description>
</Mpeg7>
```

The following example illustrates the use of the SemanticTimeInterval element in SemanticTime DS for describing the time "during 1997".

```
<Mpeg7>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics>
         <Label>
            <Name> Description of 1997 </Name>
         </Label>
         <SemanticBase xsi:type="SemanticTimeType">
            <Label>
               <Name> During 1997 </Name>
            </Label>
            <SemanticTimeInterval>
               <TimePoint origin="January 1, 1997">
                  <Displacement measurementType="length" unit="year"
value="1"/>
                  <Direction measurementType="during" unit="direction"
                     value="after"/>
               </TimePoint>
            </SemanticTimeInterval>
         </SemanticBase>
      </Semantics>
   </Description>
</Mpeg7>
```

The following example illustrates the use of the SemanticTimeInterval element in SemanticTime DS for describing the time "last year".

```
<Mpeg7>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics>
         <Label>
            <Name> Description of last year </Name>
         </Label>
         <SemanticBase xsi:type="SemanticTimeType">
            <Label>
               <Name> Last year </Name>
            </Label>
            <SemanticTimeInterval>
               <TimePoint origin="now">
                  <Displacement measurementType="length" unit="year"
value="1"/>
                  <Direction measurementType="direction" unit="direction"
                     value="before"/>
               </TimePoint>
            </SemanticTimeInterval>
         </SemanticBase>
      </Semantics>
   </Description>
</Mpeg7>
```

The following example illustrates the use of the SemanticTimeInterval element in SemanticTime DS for describing the time "the third and fourth day in April".

```
<Mpeg7>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics>
         <Label>
            <Name> Description of April 3 to 4 </Name>
         </Label>
         <SemanticBase xsi:type="SemanticTimeType">
            <Label>
               <Name> The third and fourth day in April </Name>
            </Label>
            <SemanticTimeInterval>
               <TimePoint origin="April">
                  <Displacement measurementType="length" unit="day"
value="3"/>
                  <Direction measurementType="direction" unit="direction"
                     value="after"/>
               </TimePoint>
               <Duration measurementType="length" unit="day" value="2"/>
            </SemanticTimeInterval>
         </SemanticBase>
      </Semantics>
   </Description>
</Mpeg7>
```

The following example illustrates the use of the SemanticTimeInterval element in SemanticTime DS for describing the time "Monday and Friday from 9am to 5pm".

```
<Mpeg7>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics>
         <Label>
            <Name> Description of the time Monday and Friday 9-5 </Name>
         </Label>
```

```
          <SemanticBase xsi:type="SemanticTimeType">
             <Label>
                <Name> Monday and Friday from 9am to 5pm </Name>
             </Label>
             <SemanticTimeInterval>
                <TimePoint origin="Monday">
                   <Displacement measurementType="length" unit="hour"
value="9"/>
                   <Direction measurementType="direction" unit="direction"
                      value="after"/>
                </TimePoint>
                <Duration measurementType="length" unit="hour" value="8"/>
             </SemanticTimeInterval>
             <SemanticTimeInterval>
                <TimePoint origin="Friday">
                   <Displacement measurementType="length" unit="hour"
value="9"/>
                   <Direction measurementType="direction" unit="direction"
                      value="after"/>
                </TimePoint>
                <Duration measurementType="length" unit="hour" value="8"/>
             </SemanticTimeInterval>
          </SemanticBase>
       </Semantics>
    </Description>
</Mpeg7>
```

If a semantic time is complex, relations may relate the time to the semantic entities such as objects and events needed to fully describe it. The following example illustrates the use of the SemanticTime DS for describing the time "in the year 1899 at the same time when the earthquake happened in San Francisco".

In this example, the time "in the year 1899 at the same time when the earthquake happened in San Francisco" and the event "Earthquake in San Francisco in 1899" are described in the semantic entities "sem3-time" and "earthquake-event", respectively. The new semantic time ("sem3-time") can be defined as the same as the SemanticTime DS description of the event "earthquake-event" – relation identifiedWith to semantic time "m3_1899-time" (possibility one) – or as being the time when that event happened – relation hasTimeOf to the event "earthquake-event" (possibility two).

```
<Mpeg7>
    <Description xsi:type="SemanticDescriptionType">
       <Semantics>
          <Label>
             <Name> Description of time of the earthquake </Name>
          </Label>
          <SemanticBase xsi:type="SemanticTimeType" id="sem3-time">
             <Label>
                <Name> Time </Name>
             </Label>
             <Relation
                type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:identifiedWith"
                target="#m3_1899-time"/>
             <Relation
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:hasTimeOf"
                target="#earthquake-event"/>
          </SemanticBase>
          <SemanticBase xsi:type="EventType" id="earthquake-event">
             <Label>
                <Name> Earthquake </Name>
             </Label>
             <Relation type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:timeOf"
                target="#m3_1899-time"/>
             <Relation
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:locationOf"
                target="#sanfran-loc"/>
```

```
            </SemanticBase>
            <SemanticBase xsi:type="SemanticTimeType" id="m3_1899-time">
               <Label>
                  <Name> 12 November, 1899 </Name>
               </Label>
               <Time>
                  <TimePoint>1899-11-12T14:13:00</TimePoint>
                  <Duration>PT3M</Duration>
               </Time>
            </SemanticBase>
            <SemanticBase xsi:type="SemanticPlaceType" id="sanfran-loc">
               <Label>
                  <Name> San Francisco </Name>
               </Label>
            </SemanticBase>
         </Semantics>
      </Description>
</Mpeg7>
```

3.10.3.11 Semantic entity description tools examples

The following example illustrates the use of the Semantic DS and other SemanticBase DSs for describing the narrative world of an image as shown in Figure 40. In this example, the AgentObject DS, the Event DS, the SemanticPlace DS, the SemanticTime DS, and the Concept DS describe the people, the event, the place, the time and a concept depicted or symbolized in the image. The semantic description of the image is the following: "Alex is shaking hands with Ana in New York during 1997. The event is showing as comradeship". The example assumes the image and the regions of the two persons have been described using the StillRegion DS and the StillRegionSpatialDecomposition DS.

```
<Mpeg7 xmlns="urn:mpeg:mpeg7:schema:2001"
xmlns:mpeg7="urn:mpeg:mpeg7:schema:2001"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="urn:mpeg:mpeg7:schema:2001 .\mdsfdisver3.3.xsd">
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="ImageType">
         <Image id="SR1">
            <SpatialDecomposition gap="true" overlap="false">
               <StillRegion id="SR2">
                  <TextAnnotation>
                     <FreeTextAnnotation> Alex </FreeTextAnnotation>
                  </TextAnnotation>
                  <VisualDescriptor xsi:type="ScalableColorType"
numOfCoeff="16"
                     numOfBitplanesDiscarded="0">
                     <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                  </VisualDescriptor>
               </StillRegion>
               <StillRegion id="SR3">
                  <TextAnnotation>
                     <FreeTextAnnotation> Ana </FreeTextAnnotation>
                  </TextAnnotation>
                  <VisualDescriptor xsi:type="ScalableColorType"
numOfCoeff="16"
                     numOfBitplanesDiscarded="0">
                     <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                  </VisualDescriptor>
               </StillRegion>
            </SpatialDecomposition>
         </Image>
      </MultimediaContent>
   </Description>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics>
```

```
          <Label>
             <Name>Semantic description of the handshake </Name>
          </Label>
          <SemanticBase xsi:type="EventType" id="EV1">
             <Label>
                <Name>Shake hands</Name>
             </Label>
             <Relation type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:agentOf"
                target="#AO1"/>
             <Relation
                type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:accompanierOf"
                target="#AO2"/>
             <Relation
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:propertyOf"
                target="#C1"/>
             <Relation

   type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:mediaPerceptionOf"
                target="#SR1"/>
             <Relation
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:locationOf"
                target="#SP1"/>
             <Relation type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:timeOf"
                target="#ST1"/>
          </SemanticBase>
          <SemanticBase xsi:type="AgentObjectType" id="AO1">
             <Label>
                <Name>Alex</Name>
             </Label>
             <Relation

   type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:mediaPerceptionOf"
      target="#SR2"/>
             <Agent xsi:type="PersonType">
                <Name>
                   <GivenName>Alex</GivenName>
                </Name>
             </Agent>
          </SemanticBase>
          <SemanticBase xsi:type="AgentObjectType" id="AO2">
             <Label>
                <Name>Ana</Name>
             </Label>
             <Relation

   type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:mediaPerceptionOf"
                target="#SR3"/>
             <Agent xsi:type="PersonType">
                <Name>
                   <GivenName>Ana</GivenName>
                </Name>
             </Agent>
          </SemanticBase>
          <SemanticBase xsi:type="ConceptType" id="C1">
             <Label>
                <Name> Comradeship</Name>
             </Label>
             <Property>
                <Name> Partnership</Name>
             </Property>
             <Property>
                <Name> Friendship</Name>
             </Property>
             <Relation
```

```
   type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:symbolPerceptionOf"
                target="#SR1"/>
         </SemanticBase>
         <SemanticBase xsi:type="SemanticPlaceType" id="SP1">
            <Label>
               <Name>New York</Name>
            </Label>
            <Place>
               <!-- more elements here -->
            </Place>
         </SemanticBase>
         <SemanticBase xsi:type="SemanticTimeType" id="ST1">
            <Label>
               <Name> During 1997 </Name>
            </Label>
            <SemanticTimeInterval>
               <TimePoint origin="January 1, 1997">
                  <Displacement measurementType="length" unit="year"
value="1"/>
                  <Direction measurementType="during" unit="direction"
                     value="after"/>
               </TimePoint>
            </SemanticTimeInterval>
         </SemanticBase>
      </Semantics>
   </Description>
</Mpeg7>
```

3.10.4 Semantic attribute description tools

3.10.4.1.1 AbstractionLevel datatype examples

The following example illustrates the use of the `AbstractionLevel` datatype in the `SemanticBase DS` for describing a media abstraction of the concrete semantic description shown in Figure 40. In this example, the media abstraction is the description "Alex is shaking hands with Ana in NewYork on the 9th of September" with no links to the image; this description is, therefore, applicable to any image or video depicting the event.

```
<!-- Media abstraction: AbstractionLevel dimension = 0 -->
<Mpeg7>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics>
         <AbstractionLevel dimension="0"/>
         <Label>
            <Name>Alex shakes hands with Ana </Name>
         </Label>
         <SemanticBase xsi:type="EventType" id="EV1-MA">
            <Label>
               <Name>Shake hands</Name>
            </Label>
            <Relation type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:agentOf"
               target="#AO1-MA"/>
            <Relation
               type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:acccompanierOf"
               target="#AO2-MA"/>
            <Relation
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:propertyOf"
               target="#C1-MA"/>
            <Relation
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:locationOf"
               target="#SP1-MA"/>
            <Relation type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:timeOf"
               target="#ST1-MA"/>
```

```
            </SemanticBase>
            <SemanticBase xsi:type="AgentObjectType" id="AO1-MA">
                <Label>
                    <Name>Alex</Name>
                </Label>
                <Agent xsi:type="PersonType">
                    <Name>
                        <GivenName>Alex</GivenName>
                    </Name>
                </Agent>
            </SemanticBase>
            <SemanticBase xsi:type="AgentObjectType" id="AO2-MA">
                <Label>
                    <Name>Ana</Name>
                </Label>
                <Agent xsi:type="PersonType">
                    <Name>
                        <GivenName>Ana</GivenName>
                    </Name>
                </Agent>
            </SemanticBase>
            <SemanticBase xsi:type="ConceptType" id="C1-MA">
                <Label>
                    <Name> Comradeship</Name>
                </Label>
                <Property>
                    <Name> Friendship</Name>
                </Property>
            </SemanticBase>
            <SemanticBase xsi:type="SemanticPlaceType" id="SP1-MA">
                <Label>
                    <Name>Columbia University</Name>
                </Label>
            </SemanticBase>
            <SemanticBase xsi:type="SemanticTimeType" id="ST1-MA">
                <Label>
                    <Name>September 9</Name>
                </Label>
            </SemanticBase>
        </Semantics>
    </Description>
</Mpeg7>
```

The following example illustrates the use of the `AbstractionLevel` datatype in the `SemanticBase DS` for describing a formal abstraction of the concrete semantic description. In this example, the formal abstraction is the description "Alex is shaking hands with any woman in NewYork on the 9th of September", where "any woman" is the variable of the formal abstraction.

```
<Mpeg7>
    <Description xsi:type="SemanticDescriptionType">
        <Semantics>
            <AbstractionLevel dimension="1"/>
            <Label>
                <Name>Alex shakes hands with any woman </Name>
            </Label>
            <SemanticBase xsi:type="EventType" id="EV1-FA">
                <Label>
                    <Name>Shake hands</Name>
                </Label>
                <Relation type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:agentOf"
                    target="#AO1-FA"/>
                <Relation
                    type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:accompanierOf"
```

```
                target="#AO2-FA"/>
            <Relation
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:propertyOf"
                target="#C1-FA"/>
            <Relation
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:locationOf"
                target="#SP1-FA"/>
            <Relation type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:timeOf"
                target="#ST1-FA"/>
        </SemanticBase>
        <SemanticBase xsi:type="AgentObjectType" id="AO1-FA">
            <Label>
                <Name>Alex</Name>
            </Label>
            <Agent xsi:type="PersonType">
                <Name>
                    <GivenName>Alex</GivenName>
                </Name>
            </Agent>
        </SemanticBase>
        <SemanticBase xsi:type="AgentObjectType" id="AO2-FA">
            <AbstractionLevel dimension="1"/>
            <Label>
                <Name>Any woman</Name>
            </Label>
        </SemanticBase>
        <SemanticBase xsi:type="AgentObjectType" id="AO1-MA">
            <Label>
                <Name>Alex</Name>
            </Label>
            <Agent xsi:type="PersonType">
                <Name>
                    <GivenName>Alex</GivenName>
                </Name>
            </Agent>
        </SemanticBase>
        <SemanticBase xsi:type="AgentObjectType" id="AO2-MA">
            <Label>
                <Name>Ana</Name>
            </Label>
            <Agent xsi:type="PersonType">
                <Name>
                    <GivenName>Ana</GivenName>
                </Name>
            </Agent>
        </SemanticBase>
        <SemanticBase xsi:type="ConceptType" id="C1-MA">
            <Label>
                <Name> Comradeship</Name>
            </Label>
            <Property>
                <Name> Friendship</Name>
            </Property>
        </SemanticBase>
        <SemanticBase xsi:type="SemanticPlaceType" id="SP1-MA">
            <Label>
                <Name>Columbia University</Name>
            </Label>
        </SemanticBase>
        <SemanticBase xsi:type="SemanticTimeType" id="ST1-MA">
            <Label>
                <Name>September 9</Name>
            </Label>
        </SemanticBase>
```

```
        </Semantics>
    </Description>
</Mpeg7>
```

The following example illustrates the use of the SemanticRelation CS for creating a concrete semantic description from the formal abstraction above. In this example, the variable "any woman" in the formal abstraction is filled in with the concrete instance "Joana" using the semantic relation exampleOf.

```
<Mpeg7>
    <Description xsi:type="SemanticDescriptionType">
        <Semantics>
            <Label>
                <Name> Alex shaking hands with Joana </Name>
            </Label>
            <MediaOccurrence>
                <MediaLocator>
                    <MediaUri>content.mpg</MediaUri>
                </MediaLocator>
            </MediaOccurrence>
            <Relation
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:hasExampleOf"
                target="#SM1-FA"/>
            <SemanticBase xsi:type="AgentObjectType" id="AO3">
                <Label>
                    <Name> Joana </Name>
                </Label>
                <Relation
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:hasExampleOf"
                    target="#AO2-FA"/>
                <Agent xsi:type="PersonType">
                    <Name>
                        <GivenName>Joana</GivenName>
                    </Name>
                </Agent>
            </SemanticBase>
        </Semantics>
    </Description>
</Mpeg7>
```

3.10.4.2 Extent datatype

Information on extraction and use is not provided.

3.10.4.3 Position datatype

Information on extraction and use is not provided.

3.10.5 Semantic relation classification schemes

3.10.5.1.1 SemanticRelation CS examples

The following example illustrates the use of the SemanticRelations CS and the Graph DS for describing the relation that object *A* is an agent of event *B*.

```
<Mpeg7>
    <Description xsi:type="SemanticDescriptionType">
        <Semantics>
            <Label>
                <Name> Example 1 </Name>
            </Label>
            <SemanticBase xsi:type="ObjectType" id="objectA">
                <Label>
                    <Name> Object A </Name>
                </Label>
            </SemanticBase>
```

```
            <SemanticBase xsi:type="EventType" id="eventB">
               <Label>
                  <Name> Event B </Name>
               </Label>
            </SemanticBase>
            <Graph>
               <Node id="nodeA" href="#objectA"/>
               <Node id="nodeB" href="#eventB"/>
               <!-- Edge from a->b -->
               <Relation type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:agentOf"
                  source="#nodeB" target="#nodeA"/>
            </Graph>
         </Semantics>
      </Description>
</Mpeg7>
```

The following example illustrates the use of the SemanticRelation CS and the SemanticBase DS for describing the relation that object C is an agent of event D.

```
<Mpeg7>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics>
         <Label>
            <Name> Example 2 </Name>
         </Label>
         <SemanticBase xsi:type="ObjectType" id="objectC">
            <Label>
               <Name> Object C </Name>
            </Label>
         </SemanticBase>
         <SemanticBase xsi:type="EventType" id="eventD">
            <Label>
               <Name> Event D </Name>
            </Label>
            <Relation type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:agentOf"
               target="#objectC"/>
         </SemanticBase>
      </Semantics>
   </Description>
</Mpeg7>
```

The following example illustrates the use of the Relation DS and several semantic relations for describing the semantics of an image showing a Mayan vessel as follows: "The vessel is an example of Maya art created in Guatemala in the 8th Century. The vessel's height is 14 cm and it has several paintings. The paintings show the realm of the lords of death with a death figure that dances and another figure that holds an axe and a handstone. The paintings represent sacrifice". The semantic description uses several semantic entities described using DSs derived from the SemanticBase DS as indicated within parenthesis in Figure 41 related by several semantic relations.

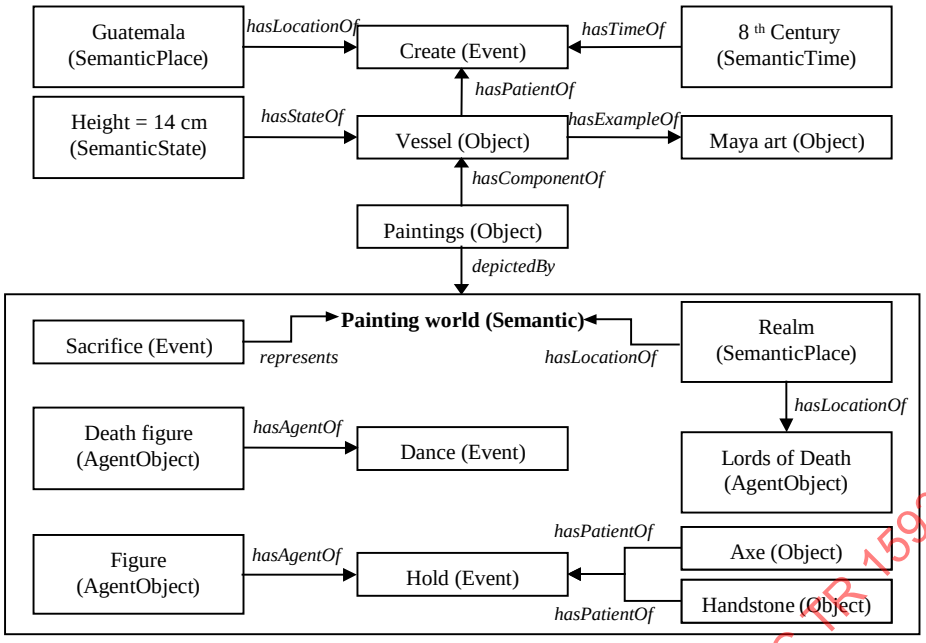


Figure 41 - Example semantic description of a Mayan vessel.

```
<Mpeg7>
   <Description xsi:type="SemanticDescriptionType">
      <Semantics>
         <Label>
            <Name>Maya vessel</Name>
         </Label>
         <!-- Semantic entities -->
         <SemanticBase xsi:type="EventType" id="Create">
            <Label>
               <Name>Create</Name>
            </Label>
         </SemanticBase>
         <SemanticBase xsi:type="SemanticPlaceType" id="Guatemala">
            <Label>
               <Name>Guatemala</Name>
            </Label>
         </SemanticBase>
         <SemanticBase xsi:type="SemanticTimeType" id="Century8">
            <Label>
               <Name>8th Century</Name>
            </Label>
         </SemanticBase>
         <SemanticBase xsi:type="ObjectType" id="Vessel">
            <Label>
               <Name>Vessel</Name>
            </Label>
         </SemanticBase>
         <SemanticBase xsi:type="ObjectType" id="MayaArt">
            <Label>
               <Name>Maya art</Name>
            </Label>
         </SemanticBase>
         <SemanticBase xsi:type="ObjectType" id="Paintings">
            <Label>
               <Name>Paintings</Name>
            </Label>
         </SemanticBase>
         <SemanticBase xsi:type="SemanticStateType" id="Height">
            <Label>
               <Name> Height </Name>
```

```
            </Label>
            <AttributeValuePair>
               <Attribute>
                  <Name> Height </Name>
               </Attribute>
               <Unit>
                  <Name> cm </Name>
               </Unit>
               <IntegerValue>14</IntegerValue>
            </AttributeValuePair>
         </SemanticBase>
         <SemanticBase xsi:type="SemanticType" id="PaintingWorld">
            <Label>
               <Name> World in the paintings </Name>
            </Label>
            <SemanticBase xsi:type="SemanticPlaceType" id="Realm">
               <Label>
                  <Name>Realm</Name>
               </Label>
            </SemanticBase>
            <SemanticBase xsi:type="AgentObjectType" id="DeathLords">
               <Label>
                  <Name>Lords of Death</Name>
               </Label>
            </SemanticBase>
            <SemanticBase xsi:type="EventType" id="Sacrifice">
               <Label>
                  <Name>Sacrifice</Name>
               </Label>
            </SemanticBase>
            <SemanticBase xsi:type="EventType" id="Dance">
               <Label>
                  <Name>Dance</Name>
               </Label>
            </SemanticBase>
            <SemanticBase xsi:type="EventType" id="Hold">
               <Label>
                  <Name>Hold</Name>
               </Label>
            </SemanticBase>
            <SemanticBase xsi:type="AgentObjectType" id="DeathFigure">
               <Label>
                  <Name>Death figure</Name>
               </Label>
            </SemanticBase>
            <SemanticBase xsi:type="AgentObjectType" id="Figure">
               <Label>
                  <Name>Figure</Name>
               </Label>
            </SemanticBase>
            <SemanticBase xsi:type="ObjectType" id="Axe">
               <Label>
                  <Name>Axe</Name>
               </Label>
            </SemanticBase>
            <SemanticBase xsi:type="ObjectType" id="Handstone">
               <Label>
                  <Name>Handstone</Name>
               </Label>
            </SemanticBase>
            <!-- Semantic relation graph within "PaintingWorld" -->
            <Graph>
               <Relation
```

```
   type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:hasLocationOf"
                  source="#Realm" target="#PaintingWorld"/>
               <Relation

   type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:hasLocationOf"
                  source="#Realm" target="#DeathLords"/>
               <Relation
                  type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:represents"
                  source="#Sacrifice" target="#PaintingWorld"/>
               <Relation
                  type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:hasAgentOf"
                  source="#DeathFigure" target="#Dance"/>
               <Relation
                  type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:hasAgentOf"
                  source="#Figure" target="#Hold"/>
               <Relation

   type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:hasPatientOf"
                  source="#Axe" target="#Hold"/>
               <Relation

   type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:hasPatientOf"
                  source="#Handstone" target="#Hold"/>
            </Graph>
         </SemanticBase>
         <!-- Semantic relation graph -->
         <Graph>
            <Relation
               type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:hasLocationOf"
               source="#Guatemala" target="#Create"/>
            <Relation
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:hasTimeOf"
               source="#Century8" target="#Create"/>
            <Relation
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:hasExampleOf"
               source="#Vessel" target="#MayaArt"/>
            <Relation
               type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:hasComponentOf"
               source="#Paintings" target="#Vessel"/>
            <Relation
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:hasStateOf"
               source="#Height" target="#Vessel"/>
            <Relation
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:depictedBy"
               source="#Paintings" target="#PaintingWorld"/>
         </Graph>
      </Semantics>
   </Description>
</Mpeg7>
```


3.11 Navigation and access tools

3.11.1 Introduction

This clause specifies description tools for navigation and access of multimedia content.

Table 12 - Overview of Navigation and Access Tools.

Tool	*Functionality*
Summarization	Tools for describing multimedia summaries and abstracts for efficient browsing and navigation of multimedia content (e.g. based on key video clips, key frames etc). See 3.11.2.

Tool	*Functionality*
Partitions, Views and View Decompositions	Tools for describing partitions, views and decompositions of image, video, and audio signals in space, time and frequency (e.g. low-resolution views or sub-regions of images). See 3.11.3.
Variations	Tools for describing the relationships between different variations of multimedia content (e.g. conversion, revisions, summaries, etc). See 3.11.4.

3.11.2 Summarization

This subclause discusses the following tools.

Table 13 - Overview of Summarization Tools

Tools	*Functionality*
Hierarchical Summary	Tool for describing summaries of time-varying audio, video or audiovisual data that support sequential and hierarchical navigation. See 3.11.2.1 – 3.11.2.6.
Sequential Summary	Tool for describing summaries of time-varying audio, video or audiovisual data that support sequential navigation. See 3.11.2.1 and 3.11.2.7 - 3.11.2.10.

3.11.2.1 Summarization DS

3.11.2.1.1 Summarization DS examples

The following example describes a set of two summaries: the first summary is a `HierarchicalSummary`, and the second summary is a `SequentialSummary`. In each summary, the SourceID element identifies the source (original) content being summarized. Each summary is named by a Name element. Other subelements of the `HierarchicalSummary` and `SequentialSummary` are introduced in later subclauses. Note that XML comments are used to replace description details.

```
<Mpeg7>
   <Description xsi:type="SummaryDescriptionType">
      <Summarization>
         <Summary xsi:type="HierarchicalSummaryType">
            components="keyAudioVisualClips" hierarchy="independent">
            <Name>Audiovisual summary</Name>
            <SourceID>urn:mycontent:av:aaa-001</SourceID>
            <SummarySegmentGroup>
               <SummarySegment> <!-- audiovisual clip #1 -->
               </SummarySegment>
               <SummarySegment> <!-- audiovisual clip #2 -->
               </SummarySegment>
               <!-- More audiovisual clips -->
            </SummarySegmentGroup>
         </Summary>
         <Summary xsi:type="SequentialSummaryType"
            components="audio">
            <Name>Audio summary</Name>
            <SourceID>urn:mycontent:av:aaa-001</SourceID>
            <AudioSummaryComponent> <!-- audio clip #1 -->
            </AudioSummaryComponent>
            <AudioSummaryComponent> <!-- audio clip #2 -->
            </AudioSummaryComponent>
            <!-- More audio clips -->
         </Summary>
      </Summarization>
   </Description>
</Mpeg7>
```

3.11.2.2 Summary DS

Information on extraction and use is not provided.

3.11.2.3 HierarchicalSummary DS

3.11.2.3.1 HierarchicalSummary DS examples

The `HierarchicalSummary` DS is built from temporal segments of audio, video or AV data, each of which is described by a `SummarySegment`. Each `SummarySegment` contains locators to the audio, video or AV data, to provide access to the associated key video clip or key audio clip, to key frames and to key sounds and may also contain textual annotation referring to key themes. `SummarySegments` are grouped into a single summary using the `SummarySegmentGroup` DS. For example, in Figure 42, the `HierarchicalSummary` contains two summaries, where the first summary consists of four `SummarySegments` and the second summary consists of three `SummarySegments`. Such summaries may correspond to two different themes and may provide alternative views of the source content, grouped together using the `HierarchicalSummary` DS. Note that in this case, there is no notion of hierarchy in the underlying real-world events.

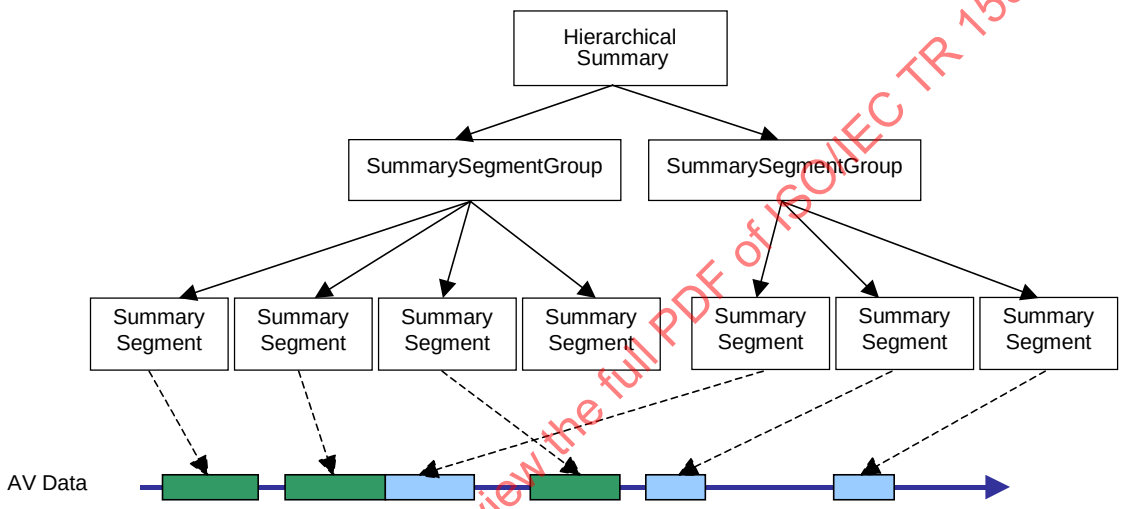


Figure 42 - Illustration of HierarchicalSummary DS containing two summaries, each described by a SummarySegmentGroup. In this example, each SummarySegment refers to a key audiovisual clip.

The following is an example of a set of two video summaries referring to particular events in a program, in particular "slam dunks" and "three-point shots" in a basketball game. This description corresponds to the diagram shown in Figure 42. The `SourceID` element identifies the source content, while the `SourceLocator` element locates the source content. The first summary contains four AV clips, each showing a slam dunk; the second summary contains three AV clips, each showing a three-point shot. By grouping the clips into summaries of events, a user may choose to view only the clips of slam dunks; alternatively, the user may view all three-point shots. The names of themes or event types are defined using the `SummaryThemeList` element. Each AV clip is defined by a start time and duration. Note that temporal locations and durations correspond directly to frame numbers, because the unit in which this temporal data is defined is equal to the inverse of the frame rate (25 frames/sec).

```
<Mpeg7>
   <Description xsi:type="SummaryDescriptionType">
      <Summarization mediaTimeUnit="PT1N25F"
         mediaTimeBase="Summary/SourceLocator/MediaUri">
         <Summary xsi:type="HierarchicalSummaryType"
            components="keyAudioVisualClips keyThemes"
            hierarchy="independent">
            <SourceID>urn:mycontent:av:av01</SourceID>
            <SourceLocator>
               <MediaUri>http://www.mycontent.com/av/av01.mpg</MediaUri>
            </SourceLocator>
            <SummaryThemeList>
               <SummaryTheme id="E0"> slam dunk </SummaryTheme>
               <SummaryTheme id="E1"> three-point shot </SummaryTheme>
```

```
            </SummaryThemeList>
            <SummarySegmentGroup themeIDs="E0">
               <Name>Slam dunks</Name>
               <Caption>The L.A. Lakers scored four slam dunks
                  in the second half.
               </Caption>
               <SummarySegment>       <!-- segment #1 with slam dunk -->
                  <KeyAudioVisualClip>
                     <MediaTime>
                        <MediaRelIncrTimePoint>10476
                        </MediaRelIncrTimePoint>
                        <MediaIncrDuration>475</MediaIncrDuration>
                     </MediaTime>
                  </KeyAudioVisualClip>
               </SummarySegment>
               <SummarySegment>       <!-- segment #2 with slam dunk -->
                  <KeyAudioVisualClip>
                     <MediaTime>
                        <MediaRelIncrTimePoint>12678
                        </MediaRelIncrTimePoint>
                        <MediaIncrDuration>250</MediaIncrDuration>
                     </MediaTime>
                  </KeyAudioVisualClip>
               </SummarySegment>
               <SummarySegment>       <!-- segment #3 with slam dunk -->
                  <KeyAudioVisualClip>
                     <MediaTime>
                        <MediaRelIncrTimePoint>24125
                        </MediaRelIncrTimePoint>
                        <MediaIncrDuration>325</MediaIncrDuration>
                     </MediaTime>
                  </KeyAudioVisualClip>
               </SummarySegment>
               <SummarySegment>       <!-- segment #4 with slam dunk -->
                  <KeyAudioVisualClip>
                     <MediaTime>
                        <MediaRelIncrTimePoint>30756
                        </MediaRelIncrTimePoint>
                        <MediaIncrDuration>525</MediaIncrDuration>
                     </MediaTime>
                  </KeyAudioVisualClip>
               </SummarySegment>
            </SummarySegmentGroup>
            <SummarySegmentGroup themeIDs="E1">
               <Name>3-Point shots</Name>
               <Caption>The L.A. Lakers scored three 3-point shots
                  in this game.
               </Caption>
               <SummarySegment>       <!-- segment #1 with 3-pt shot -->
                  <KeyAudioVisualClip>
                     <MediaTime>
                        <MediaRelIncrTimePoint>8125
                        </MediaRelIncrTimePoint>
                        <MediaIncrDuration>125</MediaIncrDuration>
                     </MediaTime>
                  </KeyAudioVisualClip>
               </SummarySegment>
               <SummarySegment>       <!-- segment #2 with 3-pt shot -->
                  <KeyAudioVisualClip>
                     <MediaTime>
                        <MediaRelIncrTimePoint>14600
                        </MediaRelIncrTimePoint>
                        <MediaIncrDuration>275</MediaIncrDuration>
                     </MediaTime>
```

```
                    </KeyAudioVisualClip>
                </SummarySegment>
                <SummarySegment>       <!-- segment #3 with 3-pt shot -->
                    <KeyAudioVisualClip>
                        <MediaTime>
                            <MediaRelIncrTimePoint>18670
                            </MediaRelIncrTimePoint>
                            <MediaIncrDuration>625</MediaIncrDuration>
                        </MediaTime>
                    </KeyAudioVisualClip>
                </SummarySegment>
            </SummarySegmentGroup>
        </Summary>
    </Summarization>
</Description>
</Mpeg7>
```

The HierarchicalSummary DS can be used to summarize content at different levels of detail. The following example contains two summaries: one with 2.5 minute duration, and one with 5 minute duration. Each summary is formed by a group of summary segments, each defined by a key AV clip. These key clips may, for example, be used to play back a visual summary of the source content. Note that the two summaries have a number of summary segments in common. That is, the segments in the short summary are also part of the longer summary.

```
<Mpeg7>
    <Description xsi:type="SummaryDescriptionType">
        <Summarization mediaTimeUnit="PT1N25F"
            mediaTimeBase="Summary/SourceLocator/MediaUri">
            <Summary xsi:type="HierarchicalSummaryType"
                components="keyAudioVisualClips keyFrames"
                hierarchy="independent">
                <SourceID>urn:mycontent:av:av02</SourceID>
                <SourceLocator>
                    <MediaUri>http://www.mycontent.com/av/av02.mpg</MediaUri>
                </SourceLocator>
                <!-- This SummarySegmentGroup is the 1st summary -->
                <SummarySegmentGroup duration="PT2M30S">
                    <Name>150 Second Highlight Summary</Name>
                    <SummarySegment>
                        <KeyAudioVisualClip>
                            <MediaTime>
                                <MediaRelIncrTimePoint>10948
                                </MediaRelIncrTimePoint>
                                <MediaIncrDuration>1040</MediaIncrDuration>
                            </MediaTime>
                        </KeyAudioVisualClip>
                    </SummarySegment>
                    <SummarySegment>
                        <KeyAudioVisualClip>
                            <MediaTime>
                                <MediaRelIncrTimePoint>13301
                                </MediaRelIncrTimePoint>
                                <MediaIncrDuration>1790</MediaIncrDuration>
                            </MediaTime>
                        </KeyAudioVisualClip>
                    </SummarySegment>
                    <SummarySegment>
                        <KeyAudioVisualClip>
                            <MediaTime>
                                <MediaRelIncrTimePoint>15364
                                </MediaRelIncrTimePoint>
                                <MediaIncrDuration>920</MediaIncrDuration>
                            </MediaTime>
```

```
                </KeyAudioVisualClip>
            </SummarySegment>
        </SummarySegmentGroup>

        <!-- This SummarySegmentGroup is the 2nd summary -->
        <SummarySegmentGroup duration="PT3M54S">
            <Name>234 Second Highlight Summary</Name>
            <SummarySegment>
                <KeyAudioVisualClip>
                    <MediaTime>
                        <MediaRelIncrTimePoint>10474
                        </MediaRelIncrTimePoint>
                        <MediaIncrDuration>474</MediaIncrDuration>
                    </MediaTime>
                </KeyAudioVisualClip>
            </SummarySegment>
            <SummarySegment>
                <KeyAudioVisualClip>
                    <MediaTime>
                        <MediaRelIncrTimePoint>10948
                        </MediaRelIncrTimePoint>
                        <MediaIncrDuration>1040</MediaIncrDuration>
                    </MediaTime>
                </KeyAudioVisualClip>
            </SummarySegment>
            <SummarySegment>
                <KeyAudioVisualClip>
                    <MediaTime>
                        <MediaRelIncrTimePoint>11948
                        </MediaRelIncrTimePoint>
                        <MediaIncrDuration>1353</MediaIncrDuration>
                    </MediaTime>
                </KeyAudioVisualClip>
            </SummarySegment>
            <SummarySegment>
                <KeyAudioVisualClip>
                    <MediaTime>
                        <MediaRelIncrTimePoint>13301
                        </MediaRelIncrTimePoint>
                        <MediaIncrDuration>1790</MediaIncrDuration>
                    </MediaTime>
                </KeyAudioVisualClip>
            </SummarySegment>
            <SummarySegment>
                <KeyAudioVisualClip>
                    <MediaTime>
                        <MediaRelIncrTimePoint>15091
                        </MediaRelIncrTimePoint>
                        <MediaIncrDuration>273</MediaIncrDuration>
                    </MediaTime>
                </KeyAudioVisualClip>
            </SummarySegment>
            <SummarySegment>
                <KeyAudioVisualClip>
                    <MediaTime>
                        <MediaRelIncrTimePoint>15364
                        </MediaRelIncrTimePoint>
                        <MediaIncrDuration>920</MediaIncrDuration>
                    </MediaTime>
                </KeyAudioVisualClip>
            </SummarySegment>
        </SummarySegmentGroup>
    </Summary>
</Summarization>
```

```
    </Description>
</Mpeg7>
```

3.11.2.3.2 HierarchicalSummary DS extraction

In general, HierarchicalSummary descriptions can be constructed manually or automatically. To construct a HierarchicalSummary description, key audio- or video-clips and key-frames are extracted, selected and composed into a summary. In addition, textual annotation may be added to the HierarchicalSummary description.

Key-frames

In the following, an algorithm is described for automatic hierarchical key-frame extraction. Note that parts of this algorithm may also be used to create other types of summary descriptions. This algorithm uses measures of scene action to detect shot boundaries and to determine the number and position of key-frames allocated to each shot, as follows. Each video frame s_i within shot s is represented by its color histogram vector $h_{s_i}(q)$, where q is the color index. Define a measure of action between two frames by the difference of their histograms h_{s_i} and $h_{s_{i-1}}$, i.e., $A\left(h_{s_i}, h_{s_{i-1}}\right) = \sum_q \left| h_{s_i}(q) - h_{s_{i-1}}(q) \right|$.

Shot boundaries are determined by thresholding the action measure $A(.,.)$ as follows. Assume that the first p frames (e.g., p = 3) of the sequence do not correspond to shot boundaries. Compute the mean action measure A_m across the first p frames. Set the threshold for shot boundary detection to $\lambda = \alpha A_{sd} + A_m$, where A_{sd} is the standard variation of the action measure and α is a predetermined parameter (e.g., α = 10). Once a boundary is detected, a new threshold is determined in the same manner using the first p frames of the next shot.

Define a cumulative action measure for the first n frames in a shot as $C(n) = \sum_{i=1}^{i=n} A\left(h_{s_i}, h_{s_{i-1}}\right)$. Given a total number of K key-frames to be allocated to the entire video, allocate each shot a number of key-frames, K_s, proportional to the total cumulative action in that shot.

For each shot, approximate the area under the cumulative action curve with K_s rectangles with variable width, where the density of the rectangles increases with the slope of this curve. Along the temporal axis, the rectangles partition a shot into contiguous shot segments separated by breakpoints. The frame that is situated at the midpoint of a shot segment is defined as the key-frame representing that shot. The following iterative algorithm determines the breakpoints $\{t_0, t_1, ..., t_{K_s}\}$ and the time instances of associated key-frames $\{k_1, k_2, ..., K_s\}$.

Let the time instance of the first break-point be t_0 = 0;

Let the location of the first key-frame be k_1 = 1;

FOR j = 1 through K_s – 1 DO {

Compute the next break-point as $t_j = 2k_j - t_{j-1}$;

IF t_j exceeds the shot boundary t_{K_s} THEN STOP;

ELSE Let k_{j+1} be the first frame past t_j for which

$$2C(t_j) - C(k_j) \le C(k_{j+1});$$

}

Optimize the time instances of key-frames starting from the second key-frame positioned at k_2 as follows. Determine k_j ($j \ge 2$) by choosing that frame between t_{j-1} and t_j that produces the largest value of the action measure with respect to the previous key-frame k_{j-1}. This criterion can be referred to as the "largest successive difference" criterion.

A hierarchical key-frame summary is generated by clustering the key-frames extracted by the algorithm described above. Clustering is performed using the histogram vectors of key-frames. The clustering algorithm considers pairs of clusters of key-frames, where key-frames belonging to the same cluster are consecutive in time. Let K_s be the number of key-frames in the most detailed summary of a particular shot. The next coarser level has K_s/ρ key-frames, where ρ is an arbitrary but predetermined compaction ratio. Start with an equally spaced partitioning of the key-frame histograms where each of the resulting partitions contains histogram vectors of ρ consecutive key-frames (see Figure 43). Then, starting with the first partition, adjust each partition boundary between two adjacent partitions so as to minimize the l_2 norm for the two adjacent partitions on either side of the partition boundary, as follows.

Assign the centroid histogram vector as the representative vector for each partition;

If H_{j-1} is the representative vector for the vectors in the partition $[T_{j-1}, T_j]$ and H_j is the representative vector of the adjacent partition $[T_j, T_{j+1}]$, adjust T_j such that the total sum of squared distances of vectors in each cluster to the corresponding representative vector is minimized (see Figure 43).

If $T_j = T_{j+1}$, then delete H_j from the representative set of vectors. If $T_{j-1} = T_j$, then delete H_{j-1} from the set of representative vectors.

Continue with the next pair of partitions, until all partition boundaries are processed.

Apply steps 1-4 for 10 iterations (or until the decrease in total distortion is insignificant). After stopping, the frame in the first cluster whose histogram vector is closest to the representative vector is selected as the first key-frame. Key-frames for subsequent clusters are determined according to the "largest successive difference" criterion expressed in terms of the action measure. Coarser level summaries can be obtained by recursive application of the above procedure.

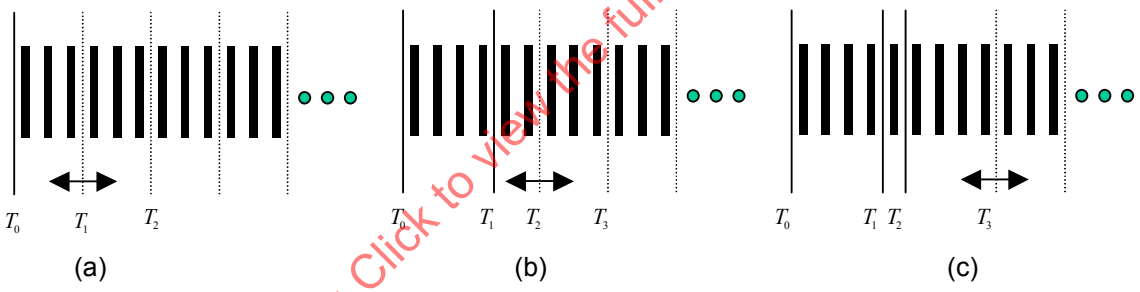


Figure 43 - Pairwise clustering for hierarchical key-frames summarization. In this example, the compaction ratio is 3. First T_1 is adjusted in (a) considering only the two consecutive partitions at either side of T_1. Then T_2 and T_3 are adjusted as depicted in (b) and (c), respectively.

Fidelity

The following algorithm describes computation of fidelity values associated with key-frames in a hierarchical key-frame summary. Assume that a feature descriptor such as a color histogram is available for each key-frame. Define a distance metric on the color histograms such as the l_1 norm. Consider a hierarchical summary with key-frames as shown in Figure 44. The key-frame in each node is identified by A, B, etc., while fidelity values are denoted by e1, e2, etc. Consider, for example, the fidelity value e1, which indicates how well the key-frames in the subtree with root at node B is represented by the key-frame at node A. The fidelity value e1 can be obtained as follows.

Compute the maximum distance between the histogram of A and those of its children B, E, F and G;

Take the reciprocal of this maximum distance.

After all fidelity values in the hierarchy are computed, normalize them so that the values lie between 0.0 and 1.0.

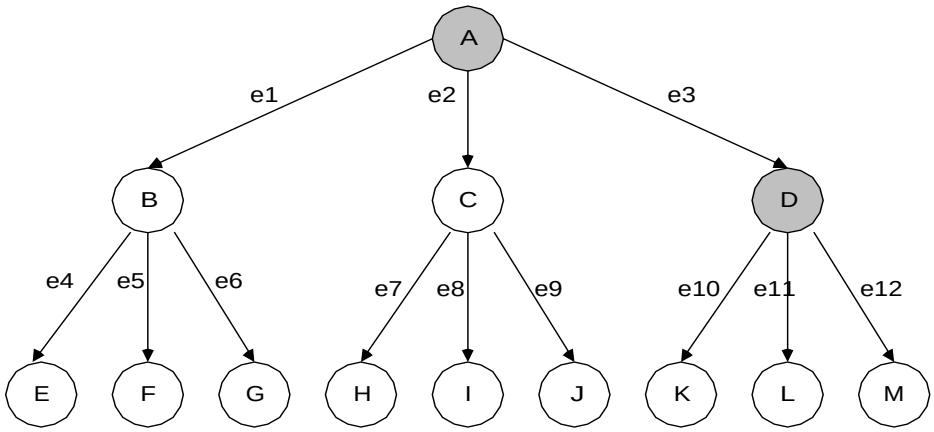


Figure 44 - An example of a key-frame hierarchy.

3.11.2.3.3 HierarchicalSummary DS use

In general, HierarchicalSummary descriptions can be used for navigation and browsing (e.g. visual table of contents or visual index of events), for viewing summarized content (e.g. visual highlights), and for scalable content viewing (e.g. adaptive to client or terminal capabilities and user preferences).

In the following, a method is described for utilizing the fidelity attribute of a HierarchicalSummary description. The notion of fidelity allows a variety of practically useful functionalities such as fidelity-based summary, scalable hierarchical summary and quick search. For example, if a user specifies a preferred number of key-frames to preview the whole video, then the system utilizes the fidelity attributes in the summary to select a given number of key-frames which best represent the original video in a sense defined by the encoder used to automatically generate the key-frame hierarchy. A set of key-frames are then sent to the terminal device for display.

Consider a key-frame hierarchy in Figure 44. In this example, key-frame *B* has three fidelity values e4, e5 and e6 associated with each of its three subtrees. The value e4 indicates the degree of representativeness of key-frame *B* over its subtree rooted at *E*. Thus, key-frame *B* represents its children contained in the subtree rooted at *E* with fidelity e4. As one goes down to finer levels, the fidelity values generally become larger, indicating that a key-frame at a finer level represents its subtree better than those at coarse levels. The following algorithm automatically selects a given number of key-frames from a key-frame hierarchy, based on the fidelity values. Denote the desired number of key-frames to be selected by N. Denote the set of key-frames with maximum fidelity by K.

initialize K to the empty set;

add the root node to K;

WHILE (*card*(K) < *N*) {
  consider nodes β with a parent node α such that $\alpha \in$ K and $\beta \notin$ K;
  let β^* be the node among these nodes with lowest fidelity value;
  add β^* to K;
}

The algorithm above yields the set K that contains the N key frames selected. For example, Figure 44, assume that *N*=2. If e3 is the minimum among e1, e2 and e3, the key frames A and D are selected. This decomposes the original tree in Figure 44 into the two subtrees shown in Figure 45.

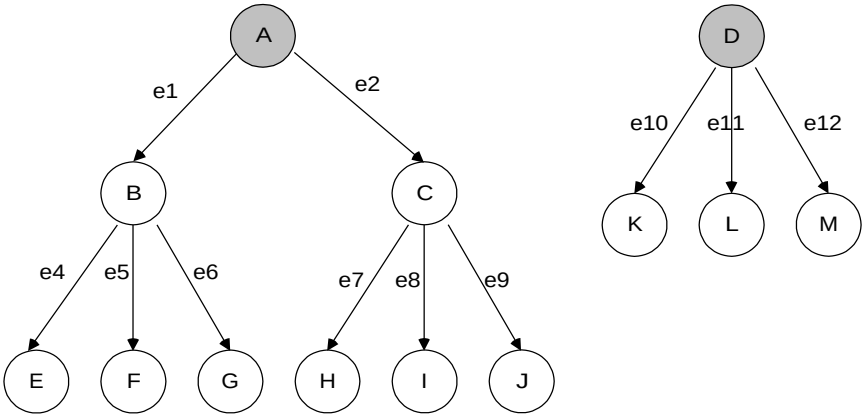


Figure 45 - An example of the key-frame selection algorithm based on fidelity values.

3.11.2.4 SummaryThemeList DS

3.11.2.4.1 SummaryThemeList DS examples

The following is an example of a `SummaryThemeList`, which contains a set of themes (e.g., certain kinds of events) for a sports news program. Note that this example describes a tree-structured representation of summary themes, as indicated by the parentID attributes. This structure is similar to an index and captures the themes in the multimedia content, allowing users to navigate the content accordingly. As shown in the last theme of the example ("John's favorite scenes"), a theme can be user-specific.

```
<SummaryThemeList>
    <SummaryTheme xml:lang="en" id="item0"> baseball </SummaryTheme>
    <SummaryTheme xml:lang="en" id="item01" parentID="item0">
                                            home run </SummaryTheme>
    <SummaryTheme xml:lang="en" id="item1"> basketball </SummaryTheme>
    <SummaryTheme xml:lang="en" id="item11" parentID="item1">
                                            three-pointer </SummaryTheme>
    <SummaryTheme xml:lang="en" id="item12" parentID="item1">
                                            slam dunk </SummaryTheme>
    <SummaryTheme xml:lang="en" id="item2"> soccer </SummaryTheme>
    <SummaryTheme xml:lang="en" id="item3"> John's favorite scenes
</SummaryTheme>
</SummaryThemeList>
```

3.11.2.5 SummarySegmentGroup DS

3.11.2.5.1 SummarySegmentGroup DS examples

The following description represents the same two example summaries encoded by the second description in 3.11.2.3.1. Note that, in the example description in 3.11.2.3.1, the segments in the short summary are also part of the segments in the longer summary. Therefore, a number of segments are described twice. The following description illustrates how to remove this redundancy. Space can be saved by assigning identifiers to the segments in the longer summary (using `id` attributes) and referring to these segments in the shorter summary (using `SummarySegmentRef` instead of `SummarySegment` and using the `idref` attribute). This defines the same summary as if the segments were actually part of the description of the short summary.

```
<Mpeg7>
    <Description xsi:type="SummaryDescriptionType">
        <Summarization mediaTimeUnit="PT1N25F"
            mediaTimeBase="Summary/SourceLocator/MediaUri">
            <Summary xsi:type="HierarchicalSummaryType"
                components="keyAudioVisualClips keyFrames"
                hierarchy="independent">
                <SourceID>urn:mycontent:av:av02</SourceID>
                <SourceLocator>
                    <MediaUri>http://www.mycontent.com/av/av02.mpg</MediaUri>
                </SourceLocator>
                <!-- This SummarySegmentGroup is the 1st summary -->
```

```
<SummarySegmentGroup duration="PT2M30S">
    <Name>150 Second Highlight Summary</Name>
    <SummarySegmentRef idref="seg02"/>
    <SummarySegmentRef idref="seg04"/>
    <SummarySegmentRef idref="seg06"/>
</SummarySegmentGroup>

<!-- This SummarySegmentGroup is the 2nd summary -->
<SummarySegmentGroup duration="PT3M54S">
    <Name>234 Second Highlight Summary</Name>
    <SummarySegment id="seg01">
        <KeyAudioVisualClip>
            <MediaTime>
                <MediaRelIncrTimePoint>10474
                </MediaRelIncrTimePoint>
                <MediaIncrDuration>474</MediaIncrDuration>
            </MediaTime>
        </KeyAudioVisualClip>
    </SummarySegment>
    <SummarySegment id="seg02">
        <KeyAudioVisualClip>
            <MediaTime>
                <MediaRelIncrTimePoint>10948
                </MediaRelIncrTimePoint>
                <MediaIncrDuration>1040</MediaIncrDuration>
            </MediaTime>
        </KeyAudioVisualClip>
    </SummarySegment>
    <SummarySegment id="seg03">
        <KeyAudioVisualClip>
            <MediaTime>
                <MediaRelIncrTimePoint>11948
                </MediaRelIncrTimePoint>
                <MediaIncrDuration>1353</MediaIncrDuration>
            </MediaTime>
        </KeyAudioVisualClip>
    </SummarySegment>
    <SummarySegment id="seg04">
        <KeyAudioVisualClip>
            <MediaTime>
                <MediaRelIncrTimePoint>13301
                </MediaRelIncrTimePoint>
                <MediaIncrDuration>1790</MediaIncrDuration>
            </MediaTime>
        </KeyAudioVisualClip>
    </SummarySegment>
    <SummarySegment id="seg05">
        <KeyAudioVisualClip>
            <MediaTime>
                <MediaRelIncrTimePoint>15091
                </MediaRelIncrTimePoint>
                <MediaIncrDuration>273</MediaIncrDuration>
            </MediaTime>
        </KeyAudioVisualClip>
    </SummarySegment>
    <SummarySegment id="seg06">
        <KeyAudioVisualClip>
            <MediaTime>
                <MediaRelIncrTimePoint>15364
                </MediaRelIncrTimePoint>
                <MediaIncrDuration>920</MediaIncrDuration>
            </MediaTime>
        </KeyAudioVisualClip>
    </SummarySegment>
```

```
            </SummarySegmentGroup>
         </Summary>
      </Summarization>
   </Description>
</Mpeg7>
```

3.11.2.6 SummarySegment DS

3.11.2.6.1 SummarySegment DS examples

The `HierarchicalSummary` DS structures information in multimedia content into groups of video clips, audio clips, key frames and key sounds, possibly using a hierarchical set of levels. The resulting description allows navigating content by "zooming in" and "zooming out" to various levels of detail.

The following is another description example of the summaries discussed in 3.11.2.3.1 and 3.11.2.5.1. The following description is a hierarchical summary that exploits the relation among summary segments in the two summaries to remove redundancy in the description. The summary segments are structured in multi-level fashion, i.e., the structure of `SummarySegmentGroup` elements is nested (level 0 and 1). In this case, segments in the `SummarySegmentGroup` element at level 0 (root level) form the short duration summary. Furthermore, these segments are implicitly also part of the long duration summary, although they are not explicitly encoded in the `SummarySegmentGroup` element at level 1. This implicit inclusion of `SummarySegment` elements from "coarser" levels of the hierarchy into "detailed" levels of the hierarchy is signalled by the `hierarchy` attribute of this `HierarchicalSummary` (its value is "dependent" instead of "independent"). This avoids the necessity to duplicate the segments at multiple levels of a hierarchical summary. Also note the use of the `order` attribute in `SummarySegment` elements to indicate the order in which these segments should be presented or navigated. The use of this attribute is necessary in this case, because the order of elements in the description no longer corresponds to the desired presentation or navigation order.

```
<Mpeg7>
   <Description xsi:type="SummaryDescriptionType">
      <Summarization mediaTimeUnit="PT1N25F"
         mediaTimeBase="Summary/SourceLocator/MediaUri">
         <Summary xsi:type="HierarchicalSummaryType"
            components="keyAudioVisualClips keyFrames"
            hierarchy="dependent">
            <SourceID>urn:mycontent:av:av02</SourceID>
            <SourceLocator>
               <MediaUri>http://www.mycontent.com/av/av02.mpg</MediaUri>
            </SourceLocator>
            <!-- This SummarySegmentGroup is the 1st summary -->
            <SummarySegmentGroup duration="PT2M30S" level="0">
               <Name>150 Second Highlight Summary</Name>
               <SummarySegment order="2">
                  <KeyAudioVisualClip>
                     <MediaTime>
                        <MediaRelIncrTimePoint>10948
                        </MediaRelIncrTimePoint>
                        <MediaIncrDuration>1040</MediaIncrDuration>
                     </MediaTime>
                  </KeyAudioVisualClip>
               </SummarySegment>
               <SummarySegment order="4">
                  <KeyAudioVisualClip>
                     <MediaTime>
                        <MediaRelIncrTimePoint>13301
                        </MediaRelIncrTimePoint>
                        <MediaIncrDuration>1790</MediaIncrDuration>
                     </MediaTime>
                  </KeyAudioVisualClip>
               </SummarySegment>
               <SummarySegment order="6">
                  <KeyAudioVisualClip>
                     <MediaTime>
```

```
                        <MediaRelIncrTimePoint>15364
                        </MediaRelIncrTimePoint>
                        <MediaIncrDuration>920</MediaIncrDuration>
                    </MediaTime>
                </KeyAudioVisualClip>
            </SummarySegment>

            <!-- This SummarySegmentGroup contains additional -->
            <!-- detail for the 2nd summary -->
            <SummarySegmentGroup duration="PT1M24S" level="1">
                <Name>234 Second Highlight Summary</Name>
                <SummarySegment order="1">
                    <KeyAudioVisualClip>
                        <MediaTime>
                            <MediaRelIncrTimePoint>10474
                            </MediaRelIncrTimePoint>
                            <MediaIncrDuration>474</MediaIncrDuration>
                        </MediaTime>
                    </KeyAudioVisualClip>
                </SummarySegment>
                <SummarySegment order="3">
                    <KeyAudioVisualClip>
                        <MediaTime>
                            <MediaRelIncrTimePoint>11948
                            </MediaRelIncrTimePoint>
                            <MediaIncrDuration>1353</MediaIncrDuration>
                        </MediaTime>
                    </KeyAudioVisualClip>
                </SummarySegment>
                <SummarySegment order="5">
                    <KeyAudioVisualClip>
                        <MediaTime>
                            <MediaRelIncrTimePoint>15091
                            </MediaRelIncrTimePoint>
                            <MediaIncrDuration>273</MediaIncrDuration>
                        </MediaTime>
                    </KeyAudioVisualClip>
                </SummarySegment>
            </SummarySegmentGroup>
        </SummarySegmentGroup>
    </Summary>
  </Summarization>
 </Description>
</Mpeg7>
```

Figure 44 shows an example of a hierarchical key frame summary containing three levels (the root is at level 0, while the leafs are at level 2).

The following is a description of the key-frame hierarchy in Figure 44 using the `HierarchicalSummary` DS. Note that children `SummarySegmentGroup` elements are specified after `SummarySegment` elements at each node in the hierarchy. The `fidelity` values refer to Figure 44 and should be understood as example values. Note that a summary consisting of key frames at a particular level of detail shall be constructed by combining information from all `SummarySegmentGroup` nodes at the same depth in a single tree. In this example, the most detailed summary is constructed by combining the key frames from all leaf (level 2) `SummarySegmentGroup` nodes.

```
<Mpeg7>
    <Description xsi:type="SummaryDescriptionType">
        <Summarization>
            <Summary xsi:type="HierarchicalSummaryType"
                components="keyFrames" hierarchy="independent">
                <SummarySegmentGroup level="0" numOfKeyFrames="1">
                    <SummarySegment id="key_frame_A">
                        <KeyFrame>
```

```
                <MediaTimePoint>T00:06:45</MediaTimePoint>
            </KeyFrame>
        </SummarySegment>

        <SummarySegmentGroup level="1"
            numOfKeyFrames="1" fidelity="0.4"> <!-- e1 -->
            <SummarySegment id="key_frame_B">
                <KeyFrame>
                    <MediaTimePoint>T00:03:45</MediaTimePoint>
                </KeyFrame>
            </SummarySegment>
            <SummarySegmentGroup level="2"
                numOfKeyFrames="1" fidelity="0.4"> <!-- e4 -->
                <SummarySegment id="key_frame_E">
                    <KeyFrame>
                        <MediaTimePoint>T00:02:00</MediaTimePoint>
                    </KeyFrame>
                </SummarySegment>
            </SummarySegmentGroup>
            <SummarySegmentGroup level="2"
                numOfKeyFrames="1" fidelity="0.2"> <!-- e5 -->
                <SummarySegment id="key_frame_F">
                    <KeyFrame>
                        <MediaTimePoint>T00:03:00</MediaTimePoint>
                    </KeyFrame>
                </SummarySegment>
            </SummarySegmentGroup>
            <SummarySegmentGroup level="2"
                numOfKeyFrames="1" fidelity="0.6"> <!-- e6 -->
                <SummarySegment id="key_frame_G">
                    <KeyFrame>
                        <MediaTimePoint>T00:04:00</MediaTimePoint>
                    </KeyFrame>
                </SummarySegment>
            </SummarySegmentGroup>
        </SummarySegmentGroup>

        <SummarySegmentGroup level="1"
            numOfKeyFrames="1" fidelity="0.5"> <!-- e2 -->
            <SummarySegment id="key_frame_C">
                <KeyFrame>
                    <MediaTimePoint>T00:07:15</MediaTimePoint>
                </KeyFrame>
            </SummarySegment>
            <SummarySegmentGroup level="2"
                numOfKeyFrames="1" fidelity="0.3"> <!-- e7 -->
                <SummarySegment id="key_frame_H">
                    <KeyFrame>
                        <MediaTimePoint>T00:06:00</MediaTimePoint>
                    </KeyFrame>
                </SummarySegment>
            </SummarySegmentGroup>
            <SummarySegmentGroup level="2"
                numOfKeyFrames="1" fidelity="0.3"> <!-- e8 -->
                <SummarySegment id="key_frame_I">
                    <KeyFrame>
                        <MediaTimePoint>T00:07:00</MediaTimePoint>
                    </KeyFrame>
                </SummarySegment>
            </SummarySegmentGroup>
            <SummarySegmentGroup level="2"
                numOfKeyFrames="1" fidelity="0.8"> <!-- e9 -->
                <SummarySegment id="key_frame_J">
                    <KeyFrame>
```

```
                        <MediaTimePoint>T00:08:00</MediaTimePoint>
                     </KeyFrame>
                  </SummarySegment>
               </SummarySegmentGroup>
            </SummarySegmentGroup>

            <SummarySegmentGroup level="1"
               numOfKeyFrames="1" fidelity="0.2"> <!-- e3 -->
               <SummarySegment id="key_frame_D">
                  <KeyFrame>
                     <MediaTimePoint>T00:10:40</MediaTimePoint>
                  </KeyFrame>
               </SummarySegment>
               <SummarySegmentGroup level="2"
                  numOfKeyFrames="1" fidelity="0.3"> <!-- e10 -->
                  <SummarySegment id="key_frame_K">
                     <KeyFrame>
                        <MediaTimePoint>T00:10:00</MediaTimePoint>
                     </KeyFrame>
                  </SummarySegment>
               </SummarySegmentGroup>
               <SummarySegmentGroup level="2"
                  numOfKeyFrames="1" fidelity="0.4"> <!-- e11 -->
                  <SummarySegment id="key_frame_L">
                     <KeyFrame>
                        <MediaTimePoint>T00:11:00</MediaTimePoint>
                     </KeyFrame>
                  </SummarySegment>
               </SummarySegmentGroup>
               <SummarySegmentGroup level="2"
                  numOfKeyFrames="1" fidelity="0.1"> <!-- e12 -->
                  <SummarySegment id="key_frame_M">
                     <KeyFrame>
                        <MediaTimePoint>T00:12:00</MediaTimePoint>
                     </KeyFrame>
                  </SummarySegment>
               </SummarySegmentGroup>
            </SummarySegmentGroup>
         </SummarySegmentGroup>
      </Summary>
   </Summarization>
</Description>
</Mpeg7>
```

The `fidelity` values of the `SummarySegmentGroup` elements in a hierarchical summary may be used by an application to adaptively select `SummarySegmentGroup` elements. For instance, a variable number of key frames can be extracted from the `HierarchicalSummary` in a scalable manner, given `fidelity` values for all elements with key frames in the hierarchy.

3.11.2.7 SequentialSummary DS

3.11.2.7.1 SequentialSummary DS examples

Using the `SequentialSummary` DS, a sequence of images, or frames from a video program can be shown sequentially in time - for example, as an animated slide show. The `SequentialSummary` DS also supports fast playback of parts of a video program, by referring to a separately stored composite summary of video frames. The following example of a video summary illustrates the `SequentialSummary` DS. The first locator specifies the location of the original (source) video, while the second locator specifies the location of a composite video summary. Then, each `VisualSummaryComponent` element describes the properties of a particular frame in the original video.

```
<SequentialSummary id="SoccerSummary001" components="visual">
   <SourceLocator>     <!-- source video -->
      <MediaUri>file://disk/soccer/source/soccer001.mpg</MediaUri>
```

```
    </SourceLocator>
    <VideoSummaryLocator>      <!-- summary video -->
       <MediaUri>file://disk/soccer/summary/soccer001-summary.mpg
       </MediaUri>
    </VideoSummaryLocator>
    <VisualSummaryComponent>      <!-- video frame #1 -->
    </VisualSummaryComponent>
    <VisualSummaryComponent>      <!-- video frame #2 -->
    </VisualSummaryComponent>
    <VisualSummaryComponent>      <!-- video frame #3 -->
    </VisualSummaryComponent>
    <VisualSummaryComponent>      <!-- video frame #4 -->
    </VisualSummaryComponent>
</SequentialSummary>
```

Another example is illustrated in Figure 46, containing three tracks of elements associated with the multimedia content: image frames, textual annotation and audio clips. Each image frame is described by the `VisualSummaryComponent` D, each annotation is described by the `TextualSummaryComponent` D and each audio clip is described by the `AudioSummaryComponent` D.

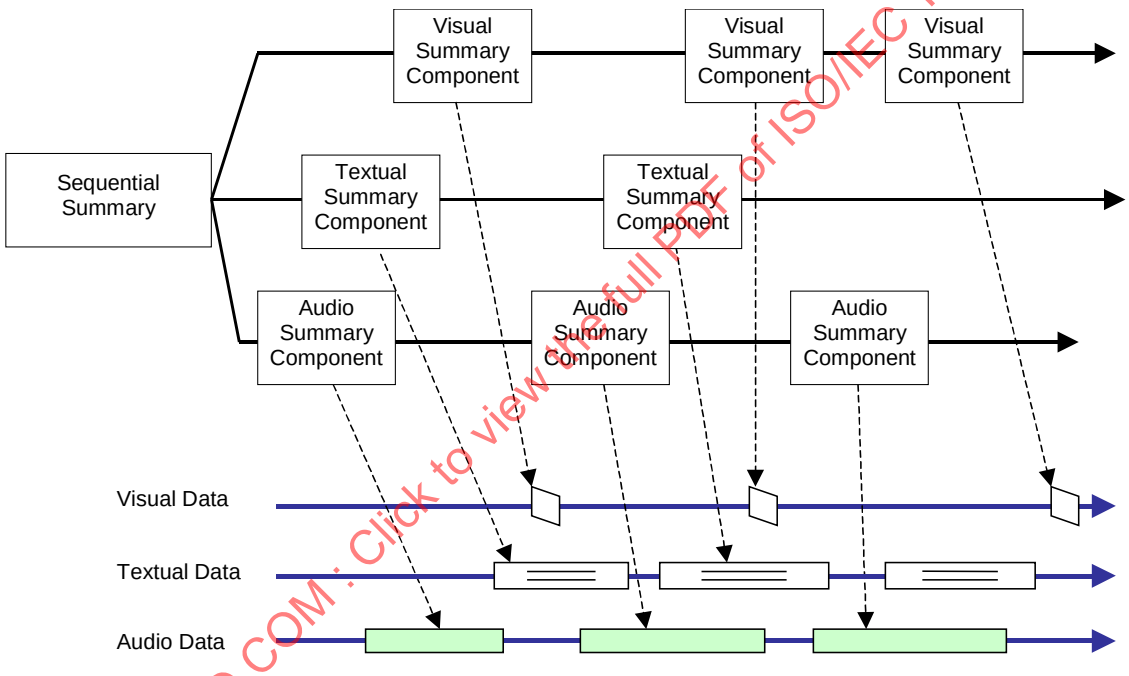


Figure 46 - Illustration of SequentialSummary DS.

The following description corresponds to the diagram shown in Figure 46. Note that the `components` attribute enables applications to quickly identify the type of summary and the data contained therein.

```
<SequentialSummary id="SoccerSummary005" components="visual audio textual">
    <SourceLocator>     <!-- source video -->
       <MediaUri>file://disk/soccer/source/soccer001.mpg</MediaUri>
    </SourceLocator>
    <VisualSummaryComponent>      <!-- video frame #1 -->
    </VisualSummaryComponent>
    <VisualSummaryComponent>      <!-- video frame #2 -->
    </VisualSummaryComponent>
    <VisualSummaryComponent>      <!-- video frame #3 -->
    </VisualSummaryComponent>
    <AudioSummaryComponent>    <!-- video frame #4 -->
    </AudioSummaryComponent>
    <AudioSummaryComponent>    <!-- audio clip #1 -->
    </AudioSummaryComponent>
    <AudioSummaryComponent>    <!-- audio clip #2 -->
    </AudioSummaryComponent>
```

```
    <TextualSummaryComponent>     <!-- text annotation #1 -->
    </TextualSummaryComponent>
    <TextualSummaryComponent>     <!-- text annotation #2 -->
    </TextualSummaryComponent>
</SequentialSummary>
```

3.11.2.7.2 SequentialSummary DS extraction

In general, SequentialSummary descriptions can be constructed manually or automatically. To construct a SequentialSummary description, key-frames and sound-clips are extracted, selected and composed into a summary. In addition, textual annotation may be added to the SequentialSummary description.

Key-frames

In the following, an algorithm is described for automatic key-frame extraction. Note that parts of this algorithm may also be used to create other types of summary descriptions. This algorithm consists of the following steps, illustrated in Figure 47 (see also Abdeljaoued et al., 2000 and Perkis et al, 2000).

Feature points are extracted from each frame and then Kalman filtering is used to track the feature points in the next frame. Feature points correspond to points which contain a significant amount of texture, such as corner points. Such points are good candidates for tracking. The algorithm used for the feature points extraction step has been developed by Kanade et al. The *KLT* software library, which is publicly available at http://vision.stanford.edu/~birch/klt/index.html, can be used to implement the feature points extraction step. Other feature point extraction algorithms can be used also. Since many feature points have to be tracked, a data association filter is required. The nearest neighbor filter is used within this algorithm. In order to validate the association, a texture descriptor, characterizing the neighborhood of the feature point, is used. A track at time *k* is defined as a sequence of feature points up to time *k* which have been associated with the same target. See Figure 48 for an illustration.

Shot boundaries are detected using an activity measure based on the rate of change in tracks. This activity measure depends on the number of terminated or initiated tracks, and is defined as the maximum between terminated and initiated tracks calculated as a percentage. The percentage of initiated tracks is the number of new tracks divided by the total number of tracks in the current frame, while the percentage of terminated tracks is the number of removed tracks divided by the total number of tracks in the previous frame.

For shot boundary detection, a video sequence is modeled as a set of successive stationary and nonstationary states of the activity measure. Significant events correspond to the stationary states, which are characterized by a constant or slowly time-varying activity change. On the other hand, shot boundaries correspond to an abrupt change (cut) or fast change (dissolve). Accordingly, the temporal segmentation algorithm should fulfill the following requirements: a) detection of abrupt changes or fast changes; b) detection of stationary segments.

For this purpose, a recursive temporal segmentation algorithm is used, which models the data as a succession of states represented as a Gaussian process. A change in the state corresponds to a change in the parameters of the process (mean μ and variance σ^2). The following equations are used in order to update the process parameters:

$$\mu_i = (1-\alpha)\,\mu_{i-1} + \alpha\, a_i$$
$$\sigma_i^2 = (1-\alpha)\,\sigma_{i-1}^2 + \alpha\,(a_i - \mu_i)^2$$

where a_i is the current activity change and α is a coefficient acting as an attenuation factor. If $|a_i - \mu_{i-1}| \geq \sigma_{i-1}$ then a new Gaussian process is initialized, with mean equal to the current activity change and standard deviation set as a large value. Figure 49 shows the activity change and its representation as a model of succession of Gaussian processes. Short impulses correspond to short processes with high activity change (shot boundaries), while longer segments correspond to Gaussian processes representing significant events.

A representative key-frame is extracted from the stationary or weakly non-stationary states (flat or oblique parts of the activity measure). The frame in the middle of the flat or oblique part is selected as a key-frame. Such a choice would allow representing the state in a compact way. For instance, in the case of a state that is part of a zooming camera operation, the frame in the middle of this state is a good compromise between the wide and focused view.

A significant state corresponds to a state with a long duration or a high activity change value. The introduction of a significance value, computed as the product of the activity change value (activity change mean) and the duration of the corresponding state, allows us to have a scalable summary. The significance value, which is assigned to each key frame, could be interpreted as the surface of the rectangle built by the duration of the state and the activity change mean.

Once the key frames have been ordered according to their significance value, the number of key frames can be adapted according to the user's preferences or the client device capabilities.

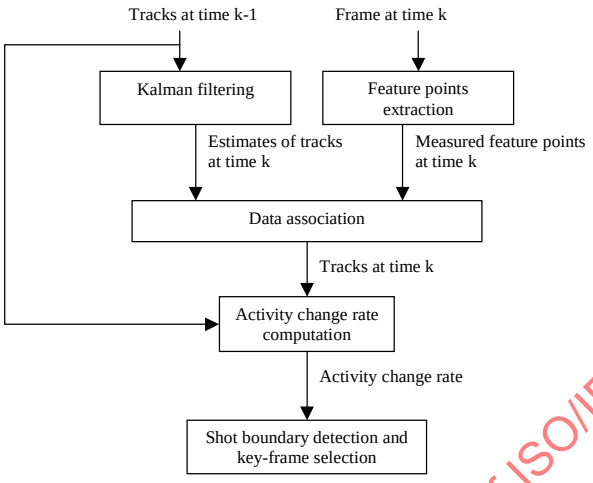


Figure 47 - Shot boundary detection and key-frame selection.

Figure 48 - Example tracking result (frame numbers 620, 621, 625). Note that many feature points disappear during the dissolve, while new feature points appear.

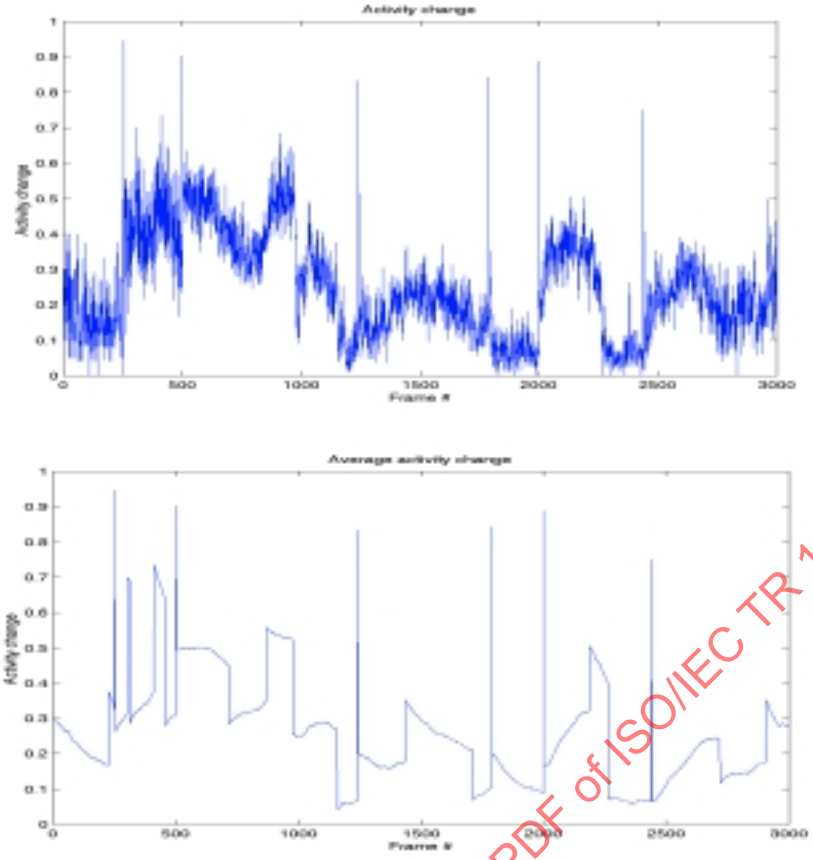


Figure 49 - Activity change (top). Segmented signal (bottom).

Frame-activity

In the following, a method is described for computing frame-activity values (`FrameActivity` element of `VisualSummaryComponentType`). Frame activity values are easily calculated from MPEG video streams because P-frames include information of motion vectors in macroblocks, from which frame-change-values can be computed, as follows.

Extract motion vectors from the inter coded macroblocks in a P-frame and sum up their absolute values.

Normalize the values with respect to the image size, by dividing the sum by the number of macroblocks in the frame.

Normalize the values based with respect to the time interval, by dividing the result of Step 2 by the duration between the P-frame and its reference picture.

The following are two special cases: the first is the case of intra coded macroblocks, and the second is the case of field predicted macroblocks. If a macroblock is intra coded, it is ignored. For the field-predicted macroblocks, multiply the absolute values of the motion vectors by 1/2 (because there are two motion vectors in the macroblock).

Note that a frame-change-value cannot be calculated from I- and B-frames. In order to calculate a frame-change-value for each frame, a linear approximation is used to interpolate missing values temporally. This procedure can be performed in a viewer application to decrease the size of the description. On the other hand, it is possible to calculate frame-change-values for all frames and include them in the description. In this case, viewer applications need no interpolation operation.

If the source video is not coded in MPEG-format, e.g. block-based template matching can be used to extract motion vectors. Another method for calculating frame-change-values is by applying pixel-wise subtraction of color values between one frame and the next frame. Using this method, almost the same effect can be obtained to implement smart quick view.

Thumbnails

Note that the video skim or smart quick view may consist of thumbnail-sizes images, to save data size. Thumbnails can be extracted from I-frames in an MPEG bitstream, by decoding only the DC DCT-

coefficients of macroblocks. The size of the extracted images is 1/64th of the original. Each frame can be coded individually (such as a sequence of bitmaps, JPEG-images, etc.) or packed into one composite file (such as a Motion-JPEG file, QuickTime movie-file, etc.). When the thumbnails are saved in separate files, each `ImageLocator` element will contain a URL. On the other hand, when the thumbnails are packed into a single file, the location of the file is described by a URL in the `VideoSummaryLocator` element and `ImageLocator` elements in each `VisualSummaryComponent` element contains only frame-numbers or time-stamps.

Thumbnail-sized images can also be obtained by selecting and decoding (if necessary) frames at some regular interval in a video stream, and down-sampling them into small size images. Note that smart quick view may require high-speed playback (without audio), in which case ready-made thumbnail-sized images are useful. However, in the case that frames from the original video stream are used, ready-made thumbnails are not required.

Regions-of-interest

In some applications, it is useful to indicate regions-of-interest in video images with varying sizes and from varying locations. For instance, the video content may contain frames with text or faces, which should be visualized at a higher resolution to highlight such areas or to improve readability of the video text, while other video data may be visualized at a lower resolution. In this case, the Region element of `VisualSummaryComponent` elements may be used to specify such regions-of-interest in the original video frames. Also, the images in the video skim can be clipped from the corresponding original frames and stored separately as still images, which can be referred to using the ImageLocator element in the `VisualSummaryComponent` D. The selection of such regions can be done manually, and should generally be adapted to the content. For instance, region-of-interests can be image regions with text, such as the score in a sports game, or regions with faces of persons that the user may be interested in. Note that there may be multiple regions-of-interest corresponding to the same video frame; this can be specified using multiple `VisualSummaryComponent` elements referring to the same frame (using the MediaTime element).

Audio-clips

In order to extract audio summary clips such as the main theme of popular song, the spectral characteristics of audio streams are analyzed. Analysis of time samples in the frequency domain is accompanied by time to frequency mapping, and many algorithms for this mapping exist. One of the flexible methods is that the input PCM samples are converted into subband samples by a filterbank, which is, for example, the method used in MPEG-1/-2 audio compression (Layers I and II). In case that the input audio format is MPEG audio, time to frequency mapping is not necessary, and the audio summary extraction algorithm described here can be directly applied to the subband data of the MPEG audio stream.

The audio clips corresponding to the main themes or clips including title phrases of popular songs can be regarded as audio summary clips. In general, these clips are emphasized and include relatively high level of music and/or vocal. This results in large subband energies for both music and vocal bands, or either. Consequently, a certain audio clip, which includes the maximum of sum of subband energy for music band and that for vocal band, can be extracted as the audio summary clip.

Then, the following steps are adopted in order to extract the audio summary.

Convert time samples into subband samples using the filterbank.

After the subband filtering, calculate the subband energy of each subband which is summed up for each second.

Calculate the summed subband energy for music band SE^T_{music} and that for vocal band SE^T_{vocal} at time T [second], according to the predefined band partition.

Determine the start time of audio summary clip $T_{summary}$ according to the following criterion.

$$T_{summary} = \max_T(\alpha \times SE^T_{music} + \beta \times SE^T_{vocal} + \gamma \times SE^T_{base})$$

In this expression, SE^T_{base} denotes subband energy of base subband (subband zero), which greatly relates to both music and vocal. α, β, and γ denote weighting factors for subband energies of music, vocal, and base respectively.

Once the start time of audio summary $T_{summary}$ is determined, assign the fixed time duration (according to the given duration constraint) or the time duration determined by another criterion, to each clip in order to compose audio summaries.

Composition of summaries with key-frames, audio-clips and textual annotation

To compose "slide-show" or "moving storyboard" summaries with key-frames, audio-clips and textual annotation, the following algorithms may be used.

Shot boundary and key-frame detection. Shot boundary detection is applied to the original video track, and the duration of every shot is recorded. Extract one key-frame per shot and use a `VisualSummaryComponent` element to describe each key-frame. Use the SyncTime element of each `VisualSummaryComponent` element to specify that the duration (intended display time) of the key-frame is that of the corresponding shot.

Time scale modification. A time scale modification algorithm can be used to speed up or slow down the audio by a factor, say N, preserving pitch and timbre. Hence the duration of the modified audio is N*d0, where d0 = duration of original audio. Modify the display time of each key-frame accordingly.

Speech recognition and information retrieval. Speech recognition can be used to detect terms. Key terms can be matched to a speech transcript for automatic labeling of the summary with key topics. Use `TextualSummaryComponent` elements to specify and synchronize this textual annotation with the key-frames and audio-clips.

3.11.2.7.3 SequentialSummary DS use

In general, SequentialSummary descriptions can be used for rendering audio skims, video skims, or audio-visual slideshows.

In the following, a method is described for utilizing the FrameActivity element of `VisualSummaryComponent` elements in a SequentialSummary description. The SequentialSummary DS can be used to specify a video skim, similar to a fast forward video playback. The SequentialSummary DS also allows video playback with variable speed, also called "smart quick view". In conventional fast forward mode, video is played back at constant speed, independent of the amount of activity in the scene or scene motion, which can make it difficult to understand the video content. In smart quick view mode, video playback speed is adjusted so as to stabilize the amount of scene change. This requires computation of the amount of scene change for frames of the video. In this case, one of the frame-properties consists of the "frame-change-value", which is a measure of change from one frame to the next. Consequently, a viewer can dynamically adjust the playback frame rate. That is, playback speed is decreased if the frame-change-value is high and increased if it is low.

The following notation is used to describe normal quick view and smart quick view.

Frame rate of the original video: *R* frames/sec

Frame number of original video: *i (0, 1, 2, …, K)*

Frame-change-value for frame *i*: *f*(*i*)

Playback speed factor with respect to the original video frame rate: *m*

Display frame rate (playback frame rate): *r* frames/sec

Display cycle number: *j (0, 1, 2, …, N)*

In the case of normal quick view, for each display cycle *j (j=0,1,2,…,N)*, the frame number in the original video *i* is given by: *(m*R/r)*j*. The total number of displayed frames *N* is calculated by *K/(m*R/r)*. Frame *i* can be extracted from the original video or a thumbnail-sized image may be used. In the case where a viewer application can only use I-frames of the original video, the I-frame nearest to the computed frame *i* can be used for display.

In the case of smart quick view, the frame-change-values are used to adjust playback speed automatically. Assume that frame-change-values *f*(*i*) are available for each frame *i* of the original video. If *f*(*i*) is not available for each frame, linear interpolation should be applied to compute the missing values. The frame-change-values *f*(*i*) are normalized such that their summation equals 1. Denote the normalized values by *w*(*i*), (*i=0,…, K-1*). In order to stabilize playback in smart quick view mode and achieve the display frame rate *r* on average at the same time, the frame *i* to be displayed is controlled by the viewer based on *w*(*i*). Figure 50 shows a plot of the normalized frame-change-values *w*(*i*). The temporal axis can be partitioned into *N* segments, such that the sum of the frame-change-values *w*(*i*) inside each segment (approximately the area under the curve) equals 1/*N*. The boundaries between these segments are used as decision points to calculate the frame number *i* of the original video to be displayed, as follows. For display cycle *j* (the display frame rate is *r*), find the first i for which $\sum_{n=1}^{i} w(n) \geq \frac{j}{N}$. That is, accumulate the values of *w*(*i*) until their sum exceeds *j*/*N*. This determines the frame number *i* of the original video to be displayed at time *j*. Again, the nearest I-frame can be used if other frames are not available.

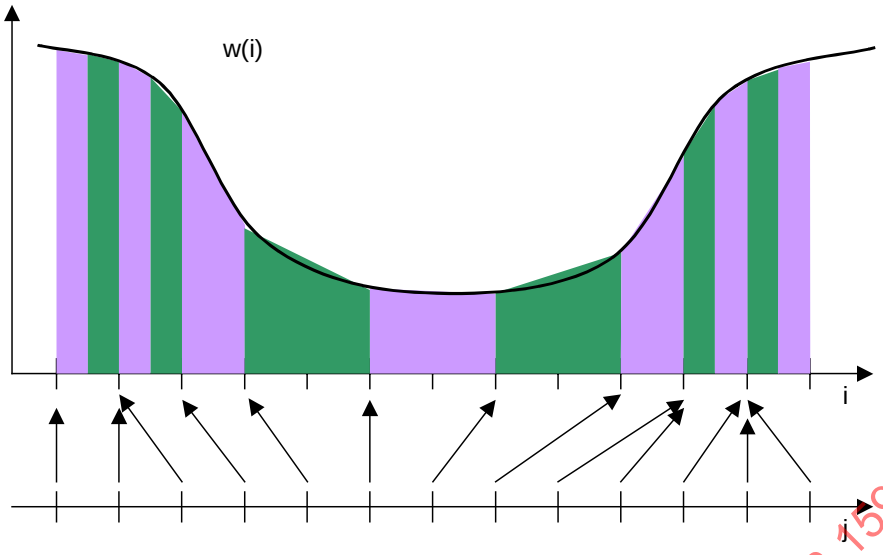


Figure 50 - Illustration of smart quick view.

Another functionality of the SequentialSummary DS is to visualize a video containing various regions-of-interest. Such regions-of-interest may be zoomed into or highlighted by the viewer application. Or, such regions-of-interest may be used to synthesize images composed of thumbnails with different resolutions. In the latter case, the thumbnail images are given by a sequence of still images with arbitrary size. The size of the thumbnail image and its location in the original frame is chosen according to the video content. Note that more than one thumbnail image can correspond to the same original video frame. Thumbnail images corresponding to different regions in the same frame are layered to synthesize a single frame for visualization (see Figure 51).

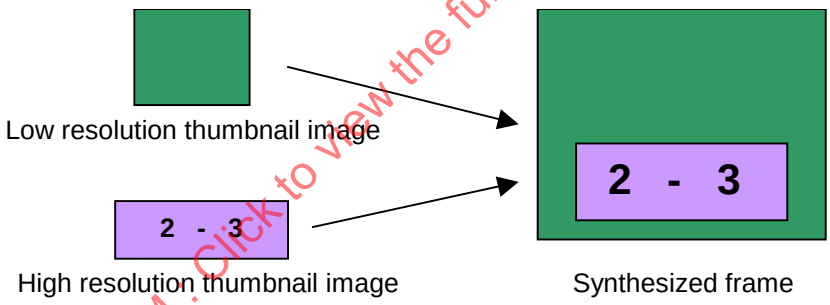


Figure 51 - Synthesizing frames in a video skim from multiple regions-of-interest.

3.11.2.8 VisualSummaryComponent D

3.11.2.8.1 VisualSummaryComponent D examples

The following is an example of a `SequentialSummary`, enabling a smart quick view, which is a variable speed presentation of the video content that uses the scene activity within parts of the original content to control the speed of summary presentation. In this instance, I-frames from the source video are included in the summary. However, scene activity is computed for P-frames from the source video. Each `VisualSummaryComponent` element in this summary contains a `ComponentSourceTime` element that refers to a frame in the original video with a number expressed in units of 1/30th of a second. Some `VisualSummaryComponent` elements also refer to the corresponding frame in the composite video summary using an `ImageLocator` element. Finally, some frames have a `FrameActivity` value associated with it, indicating the relative amount of activity in the original video. In this example, a single piece of original (source) data is being summarized; therefore, a single `SourceLocator` element in the `SequentialSummary` is sufficient.

```
<SequentialSummary id="SoccerSummary006" components="visual">
   <SourceLocator>          <!-- Location of the source content -->
      <MediaUri>file://disk/soccer/source/soccer001.mpg</MediaUri>
   </SourceLocator>
```

```
<VideoSummaryLocator>     <!-- Location of a composite video skim -->
   <MediaUri>file://disk/soccer/summary/soccer01-summary.mpg</MediaUri>
</VideoSummaryLocator>

<VisualSummaryComponent>    <!-- Properties of video I-frame-->
   <ComponentSourceTime>    <!-- Frame number in the original video -->
      <MediaRelIncrTimePoint mediaTimeUnit="PT1N30F"
         mediaTimeBase="../../../SourceLocator[1]">2
      </MediaRelIncrTimePoint>
   </ComponentSourceTime>
   <ImageLocator>        <!-- Locates summary frame (in video skim) -->
      <MediaRelIncrTimePoint mediaTimeUnit="PT1N30F"
         mediaTimeBase="../../../VideoSummaryLocator[1]">0
      </MediaRelIncrTimePoint>
   </ImageLocator>
</VisualSummaryComponent>

<VisualSummaryComponent>    <!-- Properties of video P-frame-->
   <ComponentSourceTime>    <!-- Frame number in the original video -->
      <MediaRelIncrTimePoint mediaTimeUnit="PT1N30F"
         mediaTimeBase="../../../SourceLocator[1]">5
      </MediaRelIncrTimePoint>
   </ComponentSourceTime>
   <FrameActivity>1.0</FrameActivity>     <!-- Frame activity value -->
</VisualSummaryComponent>

<VisualSummaryComponent>    <!-- Properties of video P-frame-->
   <ComponentSourceTime>    <!-- Frame number in the original video -->
      <MediaRelIncrTimePoint mediaTimeUnit="PT1N30F"
         mediaTimeBase="../../../SourceLocator[1]">8
      </MediaRelIncrTimePoint>
   </ComponentSourceTime>
   <FrameActivity>0.9</FrameActivity>     <!-- Frame activity value -->
</VisualSummaryComponent>

<VisualSummaryComponent>    <!-- Properties of video I-frame-->
   <ComponentSourceTime>    <!-- Frame number in the original video -->
      <MediaRelIncrTimePoint mediaTimeUnit="PT1N30F"
         mediaTimeBase="../../../SourceLocator[1]">11
      </MediaRelIncrTimePoint>
   </ComponentSourceTime>
   <ImageLocator>        <!-- Locates summary frame (in video skim) -->
      <MediaRelIncrTimePoint mediaTimeUnit="PT1N30F"
         mediaTimeBase="../../../VideoSummaryLocator[1]">1
      </MediaRelIncrTimePoint>
   </ImageLocator>
</VisualSummaryComponent>

<VisualSummaryComponent>    <!-- Properties of video P-frame-->
   <ComponentSourceTime>    <!-- Frame number in the original video -->
      <MediaRelIncrTimePoint mediaTimeUnit="PT1N30F"
         mediaTimeBase="../../../SourceLocator[1]">14
      </MediaRelIncrTimePoint>
   </ComponentSourceTime>
   <FrameActivity>0.8</FrameActivity>     <!-- Frame activity value -->
</VisualSummaryComponent>

<VisualSummaryComponent>    <!-- Properties of video P-frame-->
   <ComponentSourceTime>    <!-- Frame number in the original video -->
      <MediaRelIncrTimePoint mediaTimeUnit="PT1N30F"
         mediaTimeBase="../../../SourceLocator[1]">17
      </MediaRelIncrTimePoint>
   </ComponentSourceTime>
   <FrameActivity>0.5</FrameActivity>     <!-- Frame activity value -->
```

```
    </VisualSummaryComponent>

    <VisualSummaryComponent>    <!-- Properties of video I-frame-->
       <ComponentSourceTime>    <!-- Frame number in the original video -->
          <MediaRelIncrTimePoint mediaTimeUnit="PT1N30F"
             mediaTimeBase="../../../SourceLocator[1]">20
          </MediaRelIncrTimePoint>
       </ComponentSourceTime>
       <ImageLocator>        <!-- Locates summary frame (in video skim) -->
          <MediaRelIncrTimePoint mediaTimeUnit="PT1N30F"
             mediaTimeBase="../../../VideoSummaryLocator[1]">2
          </MediaRelIncrTimePoint>
       </ImageLocator>
    </VisualSummaryComponent>
</SequentialSummary>
```

3.11.2.9 AudioSummaryComponent D

3.11.2.9.1 AudioSummaryComponent D examples

The AudioSummaryComponent D can be used to provide an audio slide show (a succession of audio clips) and supports summarization of multiple pieces of content, such as a summary of multiple songs recorded on one CD album. In addition to playing audio slides (i.e., clips) one by one, applications can use the AudioSourceLocator element in order to switch playback between an audio slide component and its original. For example, one can listen to pieces of songs in the form of an audio slide show described by AudioSummaryComponent elements; and if one encounters some audio piece of his/her favorite song at a certain location in the song, one can listen to its original from that point forward.

There may be several types of audio summaries, depending on whether the original content is stored in a single stream of file, or in multiple streams or files. Also, each audio slide in the summary may be either: a) part of the original content, b) part of a composite summary, or c) in a separate stream or file.

The following figure illustrates the case when there is a single source, but each audio summary component (audio clip) is located in a separate audio clip file.

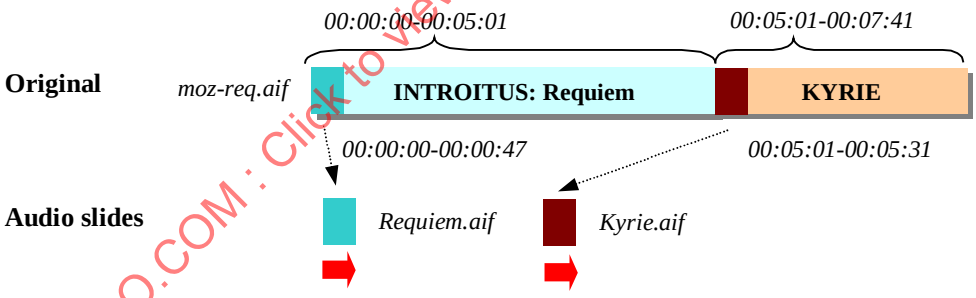


Figure 52 - Example of an audio summary with a single source.

In this case, the top-level SourceLocator associated with the entire summary indicates the location of a single source ("moz-req.aif"). AudioSourceLocator elements associated with each slide specify the location of audio clips (e.g. a song, a movement) using MediaTime elements (00m 00s to 05m 01s for the first part, and 05m 01s to 07m 41s for the second part). ComponentSourceTime elements indicate the start time and duration of audio summary components in the source, and SoundLocator elements each locate a separate audio clip using a MediaUri element ("Requiem.aif" and "Kyrie.aif" respectively).

```
<SequentialSummary id="classics004" components="audio">
    <Name>Mozart's Requiem KV 626</Name>          <!-- Summary name -->
    <SourceLocator>           <!-- Location of the source content -->
       <MediaUri>file://Mozart/moz-req.aif</MediaUri>
    </SourceLocator>

    <AudioSummaryComponent>   <!-- Component #1 -->
       <Title xml:lang="de">INTROITUS: Requiem</Title>
       <AudioSourceLocator>   <!-- Location of movement #1 within the source -->
          <MediaTime>
```

```
            <MediaRelTimePoint
               mediaTimeBase="../../../../SourceLocator[1]">PT0S
            </MediaRelTimePoint>
            <MediaDuration>PT05M01S</MediaDuration>
         </MediaTime>
      </AudioSourceLocator>
      <ComponentSourceTime>  <!-- Location of component #1 within the source --
>
         <MediaRelTimePoint
            mediaTimeBase="../../../SourceLocator[1]">PT0S
         </MediaRelTimePoint>
         <MediaDuration>PT47S</MediaDuration>
      </ComponentSourceTime>
      <SoundLocator>         <!-- File location of slide component #1 -->
         <MediaUri>file://Mozart/Requiem.aif</MediaUri>
      </SoundLocator>
   </AudioSummaryComponent>

   <AudioSummaryComponent>   <!-- Component #2 -->
      <Title xml:lang="de">KYRIE</Title>
      <AudioSourceLocator>   <!-- Location of movement #2 within the source -->
         <MediaTime>
            <MediaRelTimePoint
               mediaTimeBase="../../../../SourceLocator[1]">PT05M01S
            </MediaRelTimePoint>
            <MediaDuration>PT02M40S</MediaDuration>
         </MediaTime>
      </AudioSourceLocator>
      <ComponentSourceTime>  <!-- Location of component #2 within the source --
>
         <MediaRelTimePoint
            mediaTimeBase="../../../SourceLocator[1]">PT05M01S
         </MediaRelTimePoint>
         <MediaDuration>PT30S</MediaDuration>
      </ComponentSourceTime>
      <SoundLocator>         <!-- File location of slide component #2 -->
         <MediaUri>file://Mozart/Kyrie.aif</MediaUri>
      </SoundLocator>
   </AudioSummaryComponent>

   <!-- More AudioSummaryComponent elements ... -->
</SequentialSummary>
```


The following figure illustrates the case when there are multiple sources, and the audio summary components (audio clips) are all part of a composite audio summary.

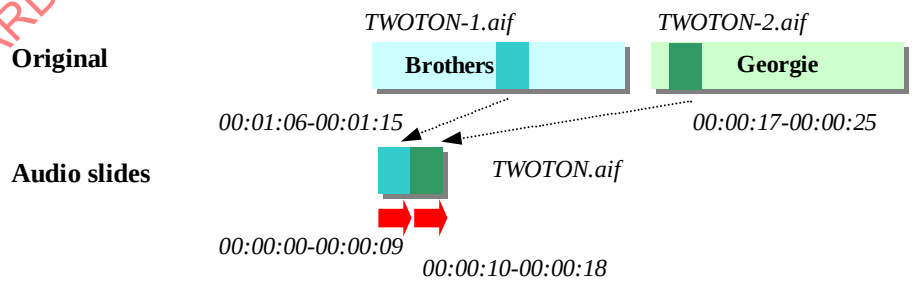


Figure 53 - Example of an audio summary with multiple sources.

In this case, the `AudioSummaryLocator` element locates the composite audio summary ("TWOTON.aif"). The `AudioSourceLocator` elements in each `AudioSummaryComponent` element specify the location of each source using `MediaUri` ("TWOTON-1.aif" and "TWOTON-2.aif", respectively). `ComponentSourceTime` elements refer to the location of the audio clips within the source, and `SoundLocator` elements indicate the start time and duration of the audio clips within the composite audio

summary using MediaTime (00s to 09s, and 10s to 18s, respectively). The Title element indicates the song title.

```
<SequentialSummary id="rock007" components="audio">
    <Name>Two Ton Shoe Rock Album</Name>          <!-- Summary name -->
    <AudioSummaryLocator>     <!-- Location of the composite audio summary -->
        <MediaUri>file://TwoTonShoe/Summary/TWOTON.aif</MediaUri>
    </AudioSummaryLocator>

    <AudioSummaryComponent>   <!-- Component #1 -->
        <Title xml:lang="en">Brothers</Title>
        <AudioSourceLocator>   <!-- Location of source #1 -->
            <MediaUri>file://TwoTonShoe/TWOTON-1.aif</MediaUri>
        </AudioSourceLocator>
        <ComponentSourceTime>  <!-- Location of component #1 within the source --
>
            <MediaRelTimePoint
               mediaTimeBase="../../AudioSourceLocator[1]">PT01M06S
            </MediaRelTimePoint>
            <MediaDuration>PT09S</MediaDuration>
        </ComponentSourceTime>
        <SoundLocator>         <!-- Location of component #1 within audio summary
-->
            <MediaTime>
               <MediaRelTimePoint
                  mediaTimeBase="../../../../AudioSummaryLocator[1]">PT0S
               </MediaRelTimePoint>
               <MediaDuration>PT09S</MediaDuration>
            </MediaTime>
        </SoundLocator>
    </AudioSummaryComponent>

    <AudioSummaryComponent>   <!-- Component #2 -->
        <Title xml:lang="en">Georgie</Title>
        <AudioSourceLocator>      <!-- Location of source #2 -->
            <MediaUri>file://TwoTonShoe/TWOTON-2.aif</MediaUri>
        </AudioSourceLocator>
        <ComponentSourceTime>  <!-- Location of component #2 within the source --
>
            <MediaRelTimePoint
               mediaTimeBase="../../AudioSourceLocator[1]">PT17S
            </MediaRelTimePoint>
            <MediaDuration>PT08S</MediaDuration>
        </ComponentSourceTime>
        <SoundLocator>         <!-- Location of component #2 within audio summary
-->
            <MediaTime>
               <MediaRelTimePoint
                  mediaTimeBase="../../../../AudioSummaryLocator[1]">PT10S
               </MediaRelTimePoint>
               <MediaDuration>PT08S</MediaDuration>
            </MediaTime>
        </SoundLocator>
    </AudioSummaryComponent>

    <!-- More AudioSummaryComponent elements ... -->
</SequentialSummary>
```


3.11.2.10 TextualSummaryComponent D

3.11.2.10.1 TextualSummaryComponent D examples

The TextualSummaryComponent D can be used to synchronize text data with audio, video or audiovisual summaries. The following example shows the use of text to describe a table of contents of a presentation.

The summary itself contains video frames, each associated with a particular video segment in the presentation, synchronized with a composite audio summary. Each video frame is stored in a separate (JPEG) file. For this example, start and end time of the video segments and their associated textual information in the summary video are as follows.

Topic	Start Time	End Time	Duration
"Introduction"	00:00:00	00:01:00	1 min
"Business Model"	00:01:01	00:03:00	2 min
"Stock Options"	00:03:01	00:05:00	2 min
"Get Rich Quick"	00:05:01	00:06:00	1 min

```
<SequentialSummary id="MSB4" components="visual audio textual">
   <AudioSummaryLocator>      <!-- Composite audio summary -->
      <MediaUri>http://www.mywebsite.com/CueVideo/as001.mp3</MediaUri>
      <MediaTime>
         <MediaTimePoint>T00:00:00</MediaTimePoint>
         <MediaDuration>PT6M</MediaDuration>
      </MediaTime>
   </AudioSummaryLocator>

   <VisualSummaryComponent>
      <ImageLocator>   <!-- Locates summary frame #1 -->
         <MediaUri>http://www.mywebsite.com/CueVideo/speaker1.jpg</MediaUri>
      </ImageLocator>  <!-- Duration of frame #1 in summary video: 1 min -->
      <SyncTime>
         <MediaTimePoint>T00:00:00</MediaTimePoint>
         <MediaDuration>PT01M</MediaDuration>
      </SyncTime>
   </VisualSummaryComponent>
   <VisualSummaryComponent>
      <ImageLocator>   <!-- Locates summary frame #2 -->
         <MediaUri>http://www.mywebsite.com/CueVideo/speaker2.jpg</MediaUri>
      </ImageLocator>  <!-- Duration of frame #2 in summary video: 4 min -->
      <SyncTime>
         <MediaTimePoint>T00:01:00</MediaTimePoint>
         <MediaDuration>PT04M</MediaDuration>
      </SyncTime>
   </VisualSummaryComponent>
   <VisualSummaryComponent>
      <ImageLocator>   <!-- Locates summary frame #3 -->
         <MediaUri>http://www.mywebsite.com/CueVideo/speaker3.jpg</MediaUri>
      </ImageLocator>  <!-- Duration of frame #3 in summary video: 1 min -->
      <SyncTime>
         <MediaTimePoint>T00:05:00</MediaTimePoint>
         <MediaDuration>PT01M</MediaDuration>
      </SyncTime>
   </VisualSummaryComponent>

   <TextualSummaryComponent>
      <FreeText xml:lang="en"> Introduction </FreeText>
      <SyncTime>       <!-- Synchronizes text information with summary -->
         <MediaTimePoint>T00:00:00</MediaTimePoint>
         <MediaDuration>PT01M</MediaDuration>
      </SyncTime>
   </TextualSummaryComponent>
   <TextualSummaryComponent>
      <FreeText xml:lang="en"> Business Model </FreeText>
      <SyncTime>       <!-- Synchronizes text information with summary -->
         <MediaTimePoint>T00:01:00</MediaTimePoint>
         <MediaDuration>PT02M</MediaDuration>
      </SyncTime>
```

```
    </TextualSummaryComponent>
    <TextualSummaryComponent>
        <FreeText xml:lang="en"> Stock Options </FreeText>
        <SyncTime>       <!-- Synchronizes text information with summary -->
            <MediaTimePoint>T00:03:00</MediaTimePoint>
            <MediaDuration>PT02M</MediaDuration>
        </SyncTime>
    </TextualSummaryComponent>
    <TextualSummaryComponent>
        <FreeText xml:lang="en"> Get Rich Quick </FreeText>
        <SyncTime>       <!-- Synchronizes text information with summary -->
            <MediaTimePoint>T00:05:00</MediaTimePoint>
            <MediaDuration>PT01M</MediaDuration>
        </SyncTime>
    </TextualSummaryComponent>
</SequentialSummary>
```

3.11.3 Views, partitions and decompositions

3.11.3.1 Partition datatype

3.11.3.1.1 Partition datatype examples

The following examples illustrate descriptions of two-dimensional `Partitions` measured in samples and fractions. The first example specifies a two-dimensional partition, such as a partition of an image, which starts at sample or pixel (20, 40) and ends at sample (100, 100). This gives the `Partition` a size of (80 x 60) samples or pixels. The second example specifies a two-dimensional partition, which starts at position (0.0, 0.0) and has size (0.5, 0.5) relative to the size of the space. For example, in describing a `Partition` of a (512 x 512) image, the `Partition` would start at pixel position (0, 0) and have size (256, 256) samples or pixels.

```
<Partition>
    <Origin xOrigin="left" yOrigin="top" />
    <Start xsi:type="SignalPlaneSampleType" x="20" y="40" />
    <End xsi:type="SignalPlaneSampleType" x="100" y="100" />
</Partition>

<Partition dim="2">
    <Origin xOrigin="left" yOrigin="bottom" />
    <Start xsi:type="SignalPlaneFractionType" x="0.0" y="0.0" />
    <Extent xsi:type="SignalPlaneFractionType" x="0.5" y="0.5" />
</Partition>
```

3.11.3.2 Filter datatype

3.11.3.2.1 Filter datatype examples

The following example describes a 1-D discrete filter. The terms of the filter have values 0.5 and 0.5. The example defines a two-tap averaging filter, which when applied to audio takes the average of neighboring samples.

```
<Filter1D>
    <Terms mpeg7:dim="2"> 0.5 0.5 </Terms>
</Filter1D>
```

The following example describes a 2-D discrete filter. The filter corresponds to a 3 x 3 Laplacian filter, which when applied to an image takes the difference of pixel values vertically and horizontally in the neighborhood around each pixel. The Laplacian filter is commonly used for edge detection.

```
<Filter2D>
    <Terms mpeg7:dim="3 3">
         0.0 -1.0  0.0
        -1.0  4.0 -1.0
         0.0 -1.0  0.0
```

```
    </Terms>
</Filter2D>
```

The following example describes a discrete multi-dimensional separable filter. The individual filters that make up the separable filter are specified as two three-tap one-dimensional filters. The terms of the 2-D separable filter are derived from the direct product of the 1-D filters to produce the 2-D separable filter. The derived terms of the 2-D separable filter (top) are equivalent to those of the 2-D filter specified below it (bottom). The example defines a low-pass filter, which when applied to an image takes the average of neighboring samples.

```
<FilterSeparable>
    <Filter1D><Terms mpeg7:dim="3"> 1.0 2.0 1.0 </Terms></Filter1D>
    <Filter1D><Terms mpeg7:dim="3"> 1.0 2.0 1.0 </Terms></Filter1D>
</FilterSeparable>

<Filter2D>
    <Terms mpeg7:dim="3 3">
        1.0 2.0 1.0
        2.0 4.0 2.0
        1.0 2.0 1.0
    </Terms>
</Filter2D>
```

3.11.3.3 Filtering datatype

3.11.3.3.1 Filtering datatype examples

The following example describes the filtering of an image using a discrete 2-D filter. The description specifies the padding of the image by one pixel on each dimension using symmetric extension. The description also specifies the shifting of the filter kernel by one sample or pixel in both the horizontal and vertical direction before taking the convolution sum. The description also specifies the output image should be cropped by one pixel at all borders (left, top, right and bottom). The example uses a 2-D filter of size 3 x 3.

```
<Filtering xPad="symmetric" yPad="symmetric" >
    <Filter xsi:type="Filter2DType">
        <Terms mpeg7:dim="3 3">
            1.0 2.0 1.0
            2.0 4.0 2.0
            1.0 2.0 1.0
        </Terms>
    </Filter>
    <PadSize x="1" y="1" />
    <Shift x="1" y="1" />
    <CropStart x="1" y="1" />
    <CropEnd x="1" y="1" />
</Filtering>
```

3.11.3.4 View DS

3.11.3.4.1 View DS Use

Space and frequency views can be used in applications that involve the access and navigation of large images and video at multiple resolutions. For example, browsing applications of large aerial images and maps involve the interactive zooming-in, zooming-out and panning around the 2-D image data. Typically, each operation requires the extraction, delivery and/or synthesis, and display of a space and frequency view of the large image. A similar framework applies to the progressive delivery of video at multiple spatial and temporal resolutions.

3.11.3.5 SpaceView DS

3.11.3.5.1 SpaceView DS examples

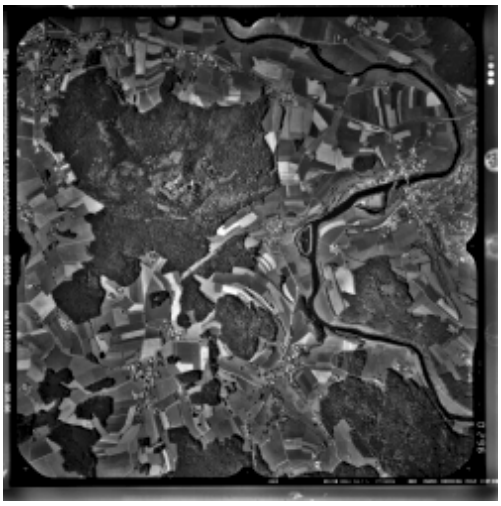
The following examples describe different `SpaceViews`. The first example describes a `SpaceView` which corresponds to the upper-left quadrant of an image.

```
<Mpeg7>
   <Description xsi:type="ViewDescriptionType">
      <View xsi:type="SpaceViewType">
         <Target>
            <ImageSignal>
               <MediaLocator>
                  <MediaUri>file://Aerial-upperleft.jpg</MediaUri>
               </MediaLocator>
            </ImageSignal>
         </Target>
         <Source>
            <ImageSignal>
               <MediaLocator>
                  <MediaUri>file://Aerial.jpg</MediaUri>
               </MediaLocator>
            </ImageSignal>
         </Source>
         <SpacePartition>
            <Origin xOrigin="left" yOrigin="top"/>
            <Start xsi:type="SignalPlaneFractionType" x="0" y="0"/>
            <End xsi:type="SignalPlaneFractionType" x="0.5" y="0.5"/>
         </SpacePartition>
      </View>
   </Description>
</Mpeg7>
```

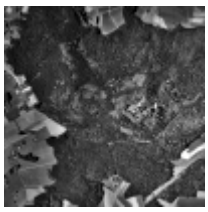
The second example describes a SpaceView which corresponds to the first 16384 samples of an audio signal.

```
<Mpeg7>
   <Description xsi:type="ViewDescriptionType">
      <View xsi:type="SpaceViewType">
         <Target>
            <AudioSignal>
               <MediaLocator>
                  <MediaUri>music-intro.mp3</MediaUri>
               </MediaLocator>
            </AudioSignal>
         </Target>
         <Source>
            <AudioSignal>
               <MediaLocator>
                  <MediaUri>music.mp3</MediaUri>
               </MediaLocator>
            </AudioSignal>
         </Source>
         <SpacePartition>
            <Start xsi:type="SignalPlaneSampleType" t="0"/>
            <Extent xsi:type="SignalPlaneSampleType" t="16384"/>
         </SpacePartition>
      </View>
   </Description>
</Mpeg7>
```

Examples of Space Views include regions of still images, temporal segments of video and temporal segments of audio. Figure 54.a) shows a large aerial image of which only a small subset depicting a rocky area is of interest to the user, see Figure 54.b). The Space View DS is used to describe this spatial view of the large 2-D image.



(a)



(b)

Figure 54 - Aerial image (a) source: Aerial image LB_120.tif, and (b) a part of image a) based on a spatial view DS.

3.11.3.6 FrequencyView DS

3.11.3.6.1 FrequencyView DS examples

The following example describes a `FrequencyView` that corresponds to a twice-iterated, low-pass, low-pass wavelet subband of an audio signal. The `FrequencyView` corresponds to the first one-quarter of the frequency plane. Furthermore, the filtered signal is down-sampled by a factor of four to produce a `Target FrequencyView` audio signal that has one-quarter the number of samples as the `Source` audio signal. In practice, the example below specifies a coarse version of the audio signal.

```
<Mpeg7>
   <Description xsi:type="ViewDescriptionType">
      <View xsi:type="FrequencyViewType">
         <Target>
            <AudioSignal>
               <MediaLocator>
                  <MediaUri>file://audio-ll.mp3</MediaUri>
               </MediaLocator>
            </AudioSignal>
         </Target>
         <Source>
            <AudioSignal>
               <MediaLocator>
                  <MediaUri>file://audio.mp3</MediaUri>
               </MediaLocator>
            </AudioSignal>
         </Source>
         <FrequencyPartition>
            <Start xsi:type="SignalPlaneFractionType" t="0"/>
            <End xsi:type="SignalPlaneFractionType" t="0.25"/>
         </FrequencyPartition>
         <DownSamplingFactor t="4"/>
      </View>
   </Description>
</Mpeg7>
```

In general, examples of Frequency Views include spatial-frequency subbands of still images, 3-D wavelet subbands of video and temporal-frequency subbands of audio. The sample below illustrates a frequency view of an aerial image, which corresponds to a spatial-frequency subband of the image.

Figure 55 - Frequency View of an Aerial image – spatial-frequency subband.

3.11.3.7 SpaceFrequencyView DS

3.11.3.7.1 SpaceFrequencyView DS examples

The following example describes a `SpaceFrequencyView` that corresponds to a wavelet subband of a region of an image. The `SpaceFrequencyView` corresponds to the lower one-quarter of the spatial-frequency plane of the upper-left corner region of the image. Furthermore, the filtered region is down-sampled by a factor of two on each dimension to produce a `Target SpaceFrequencyView` image that has one-sixteenth the number of samples as the `Source` image. In this example, the order of the space and frequency analysis operations to extract the view is specified as space first then frequency. In practice, the example below specifies a coarse version of the upper-left region of the image.

```
<Mpeg7>
   <Description xsi:type="ViewDescriptionType">
      <View xsi:type="SpaceFrequencyViewType" order="spaceFrequency">
         <Target>
            <ImageSignal>
               <MediaLocator>
                  <MediaUri>file://soccer-ul-ll.jpg</MediaUri>
               </MediaLocator>
            </ImageSignal>
         </Target>
         <Source>
            <ImageSignal>
               <MediaLocator>
                  <MediaUri>file://soccer.jpg</MediaUri>
               </MediaLocator>
            </ImageSignal>
         </Source>
         <SpacePartition>
            <Start xsi:type="SignalPlaneFractionType" x="0" y="0"/>
            <End xsi:type="SignalPlaneFractionType" x="0.5" y="0.5"/>
         </SpacePartition>
         <FrequencyPartition>
            <Start xsi:type="SignalPlaneFractionType" x="0" y="0"/>
            <End xsi:type="SignalPlaneFractionType" x="0.5" y="0.5"/>
         </FrequencyPartition>
         <DownSamplingFactor x="2" y="2"/>
      </View>
   </Description>
</Mpeg7>
```


3.11.3.7.1.1 SpaceFrequencyView DS Examples

Examples of Space Frequency Views include spatial-frequency subbands of regions of still images, 3-D wavelet subbands of temporal segments of video and temporal-frequency subbands of temporal segments of audio. An example of a Space Frequency View is given in Figure 56. The data of an aerial image is shown in some spatial region with all frequency components, in others only the lowband components are transmitted to provide some context information.

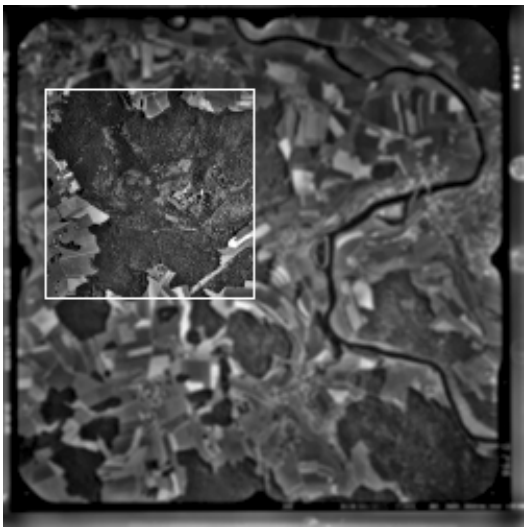


Figure 56 - Example SpaceFrequency view of Figure 54 using a high resolution for the region of interest and a reduced resolution for the context.

3.11.3.8 ResolutionView DS

3.11.3.8.1 ResolutionView DS examples

The following example describes a `ResolutionView` that corresponds a one-sixteenth size thumbnail view of an image (downsampled by a factor of four along both dimensions).

```
<Mpeg7>
    <Description xsi:type="ViewDescriptionType">
        <View xsi:type="ResolutionViewType">
            <Target>
                <ImageSignal>
                    <MediaLocator>
                        <MediaUri>file://soccer-coarse.jpg</MediaUri>
                    </MediaLocator>
                </ImageSignal>
            </Target>
            <Source>
                <ImageSignal>
                    <MediaLocator>
                        <MediaUri>file://soccer.jpg</MediaUri>
                    </MediaLocator>
                </ImageSignal>
            </Source>
            <DownSamplingFactor x="4" y="4"/>
        </View>
    </Description>
</Mpeg7>
```

Examples of Space Resolution Views include subsampled spatial-frequency subbands of regions of still images, 3-D wavelet subbands of temporal segments of video and temporal-frequency subbands of temporal segments of audio. Often it is only necessary to access an overview or low-resolution version of a large image. In this case, it is sufficient to look at the representation of an image generated by the low frequency components of the image. For this purpose the view can be described by a ResolutionView DS or, more generally by a FrequencyView DS. The ResolutionView DS describes the reduction of the image using low pass filtering. For example, Figure 57shows a low-resolution view of a large aerial image.

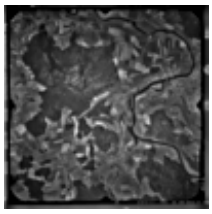


Figure 57 - Example view of image with reduced resolution.

3.11.3.8.2 ResolutionView DS extraction

A Resolution View can be extracted from an image, video, or audio signal by sub-setting the data and by using a low-pass filter that in the Fourier domain corresponds to a low-frequency partition of the sub-set in the frequency plane.

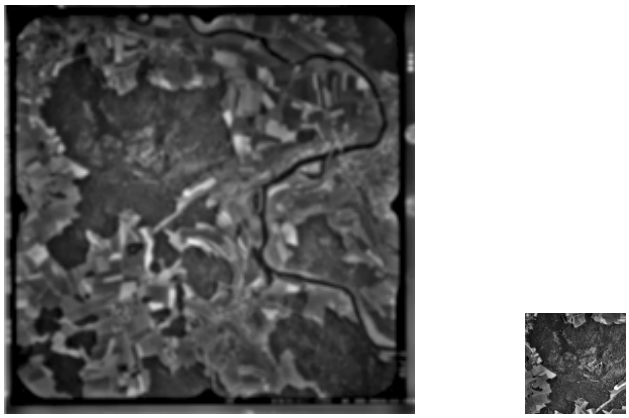
3.11.3.9 SpaceResolutionView DS

3.11.3.9.1 SpaceResolutionView DS examples

The following example describes a `SpaceResolutionView` that corresponds to a coarse or thumbnail view of a region of an image. The `SpaceResolutionView` corresponds to the lower one-quarter resolution view of the upper-left corner region of the image. In this example, the order of the space and frequency (resolution) analysis operations to extract the view is specified as space first then frequency (resolution).

```
<Mpeg7>
   <Description xsi:type="ViewDescriptionType">
      <View xsi:type="SpaceResolutionViewType" order="spaceFrequency">
         <Target>
            <ImageSignal>
               <MediaLocator>
                  <MediaUri>file://soccer-ul-ll.jpg</MediaUri>
               </MediaLocator>
            </ImageSignal>
         </Target>
         <Source>
            <ImageSignal>
               <MediaLocator>
                  <MediaUri>file://soccer.jpg</MediaUri>
               </MediaLocator>
            </ImageSignal>
         </Source>
         <SpacePartition>
            <Start xsi:type="SignalPlaneFractionType" x="0" y="0"/>
            <End xsi:type="SignalPlaneFractionType" x="0.5" y="0.5"/>
         </SpacePartition>
         <DownSamplingFactor x="2" y="2"/>
      </View>
   </Description>
</Mpeg7>
```

Figure 58.a) shows a large aerial image of which only a small subset depicting a rocky area is of interest to the user, see Figure 58.b). The SpaceResolution View DS is used to describe this view of the large 2-D image.



(a) (b)

Figure 58 - Aerial image (a) source: Aerial image LB_120.tif, and (b) a part of image a) based on a spatial view DS.

3.11.3.10 ViewDecomposition DS

3.11.3.11 ViewSet DS

3.11.3.11.1 ViewSet DS examples

The following example describes a `ViewSet` that contains two `SpaceViews`. The `ViewSet` is specified to be nonredundant and not complete. In this example, the two views correspond to the upper-left and upper-right quadrants, respectively, of the source image specified as the source of the view set. In both cases, the specification of the `SpacePartition` is given in relation to the source image of the view set.

```
<Mpeg7>
   <Description xsi:type="ViewDescriptionType">
      <ViewSet complete="false" nonRedundant="true" setProperty="space">
         <Source>
            <ImageSignal>
               <MediaLocator>
                  <MediaUri>file:\\soccer.jpg</MediaUri>
               </MediaLocator>
            </ImageSignal>
         </Source>
         <View xsi:type="SpaceViewType">
            <Target>
               <ImageSignal>
                  <MediaLocator>
                     <MediaUri>file://soccer-upper-left.jpg</MediaUri>
                  </MediaLocator>
               </ImageSignal>
            </Target>
            <SpacePartition>
               <Start xsi:type="SignalPlaneFractionType" x="0" y="0"/>
               <End xsi:type="SignalPlaneFractionType" x="0.5" y="0.5"/>
            </SpacePartition>
         </View>
         <View xsi:type="SpaceViewType">
            <Target>
               <ImageSignal>
                  <MediaLocator>
                     <MediaUri>file://soccer-upper-right.jpg </MediaUri>
                  </MediaLocator>
               </ImageSignal>
            </Target>
            <SpacePartition>
               <Start xsi:type="SignalPlaneFractionType" x="0.5" y="0"/>
               <End xsi:type="SignalPlaneFractionType" x="1.0" y="0.5"/>
            </SpacePartition>
```

```
          </View>
       </ViewSet>
   </Description>
</Mpeg7>
```

Examples of View Sets include a set of spatial-frequency subbands of an image and a set of layers of scalable video data.

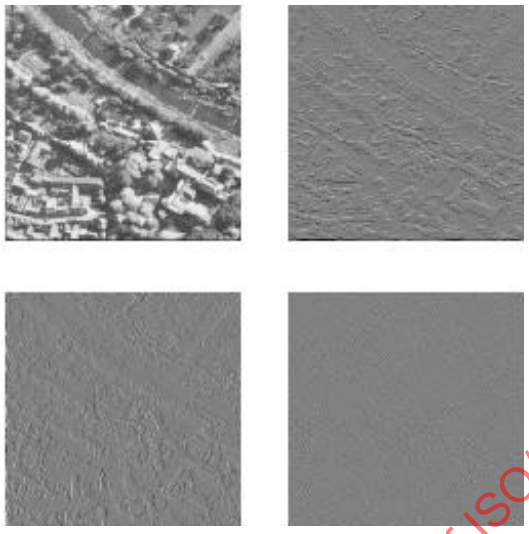


Figure 59 - Example View Set with a set of Frequency Views that are image subbands. This View Set is complete and nonredundant.

3.11.3.12 SpaceTree DS

3.11.3.12.1 SpaceTree DS examples

The following example describes a `SpaceTree` with branching factor of two at the root node, which corresponds to the splitting of the source image into two child space views. The specification of the `SpacePartitions` of the `Child` views is given in relation to the `Source` image of the `SpaceTree`.

```
<Mpeg7>
   <Description xsi:type="ViewDescriptionType">
      <ViewDecomposition xsi:type="SpaceTreeType" complete="false"
         nonRedundant="true" branching="2">
         <Source>
            <ImageSignal>
               <MediaLocator>
                  <MediaUri>soccer.jpg</MediaUri>
               </MediaLocator>
            </ImageSignal>
         </Source>
         <Child branching="0">
            <View>
               <Target>
                  <ImageSignal>
                     <MediaLocator>
                        <MediaUri>soccer-00.jpg</MediaUri>
                     </MediaLocator>
                  </ImageSignal>
               </Target>
               <SpacePartition>
                  <Start xsi:type="SignalPlaneFractionType" x="0.0" y="0"/>
                  <End xsi:type="SignalPlaneFractionType" x="0.5" y="0.5"/>
               </SpacePartition>
            </View>
         </Child>
         <Child branching="0">
            <View>
```

```
                <Target>
                    <ImageSignal>
                        <MediaLocator>
                            <MediaUri>soccer-01.jpg</MediaUri>
                        </MediaLocator>
                    </ImageSignal>
                </Target>
                <SpacePartition>
                    <Start xsi:type="SignalPlaneFractionType" x="0.5" y="0"/>
                    <End xsi:type="SignalPlaneFractionType" x="1.0" y="0.5"/>
                </SpacePartition>
            </View>
        </Child>
    </ViewDecomposition>
</Description>
</Mpeg7>
```

3.11.3.13 FrequencyTree DS

3.11.3.13.1 FrequencyTree DS examples

The following example describes a FrequencyTree with branching factor of two at the root node. The FrequencyTree specifies one FrequencyView at the first level of the tree and two FrequencyView at the second level of the tree.

```
<Mpeg7>
    <Description xsi:type="ViewDescriptionType">
        <ViewDecomposition xsi:type="FrequencyTreeType" complete="false"
            nonRedundant="true" branching="2">
            <Source>
                <ImageSignal>
                    <MediaLocator>
                        <MediaUri>soccer.jpg</MediaUri>
                    </MediaLocator>
                </ImageSignal>
            </Source>
            <Child branching="0">
                <View>
                    <Target>
                        <ImageSignal>
                            <MediaLocator>
                                <MediaUri>soccer-ll.jpg</MediaUri>
                            </MediaLocator>
                        </ImageSignal>
                    </Target>
                    <FrequencyPartition>
                        <Start xsi:type="SignalPlaneFractionType" x="0" y="0"/>
                        <End xsi:type="SignalPlaneFractionType" x="0.5" y="0.5"/>
                    </FrequencyPartition>
                </View>
            </Child>
            <Child branching="0">
                <View>
                    <Target>
                        <ImageSignal>
                            <MediaLocator>
                                <MediaUri>soccer-lh.jpg</MediaUri>
                            </MediaLocator>
                        </ImageSignal>
                    </Target>
                    <FrequencyPartition>
                        <Start xsi:type="SignalPlaneFractionType" x="0" y="0.5"/>
                        <End xsi:type="SignalPlaneFractionType" x="0.5" y="1"/>
                    </FrequencyPartition>
```

```
            </View>
         </Child>
      </ViewDecomposition>
   </Description>
</Mpeg7>
```

3.11.3.14 SpaceFrequencyGraph DS

3.11.3.14.1 SpaceFrequencyGraph DS examples

The following example describes a SpaceFrequencyGraph with branching factor of two on each space and frequency dimension at the root node. The SpaceFrequencyGraph specifies one SpaceFrequencyView at the first level of the directed acyclic graph and four SpaceFrequencyViews at the second level of the graph.

```
<Mpeg7>
   <Description xsi:type="ViewDescriptionType">
      <ViewDecomposition xsi:type="SpaceFrequencyGraphType" complete="false"
         nonRedundant="false" branching="2">
         <Source>
            <ImageSignal>
               <MediaLocator>
                  <MediaUri>soccer.jpg</MediaUri>
               </MediaLocator>
            </ImageSignal>
         </Source>
         <SpaceChild branching="0">
            <View>
               <Target>
                  <ImageSignal>
                     <MediaLocator>
                        <MediaUri>soccer-0.jpg</MediaUri>
                     </MediaLocator>
                  </ImageSignal>
               </Target>
               <SpacePartition>
                  <Start xsi:type="SignalPlaneFractionType" x="0" y="0"/>
                  <End xsi:type="SignalPlaneFractionType" x="0.5" y="1"/>
               </SpacePartition>
               <FrequencyPartition>
                  <Start xsi:type="SignalPlaneFractionType" x="0" y="0"/>
                  <End xsi:type="SignalPlaneFractionType" x="1" y="1"/>
               </FrequencyPartition>
            </View>
         </SpaceChild>
         <SpaceChild branching="0">
            <View>
               <Target>
                  <ImageSignal>
                     <MediaLocator>
                        <MediaUri>soccer-1.jpg</MediaUri>
                     </MediaLocator>
                  </ImageSignal>
               </Target>
               <SpacePartition>
                  <Start xsi:type="SignalPlaneFractionType" x="0" y="0"/>
                  <End xsi:type="SignalPlaneFractionType" x="1" y="0.5"/>
               </SpacePartition>
               <FrequencyPartition>
                  <Start xsi:type="SignalPlaneFractionType" x="0" y="0"/>
                  <End xsi:type="SignalPlaneFractionType" x="1" y="1"/>
               </FrequencyPartition>
            </View>
         </SpaceChild>
```

```
          <FrequencyChild branching="0">
             <View>
                <Target>
                   <ImageSignal>
                      <MediaLocator>
                         <MediaUri>soccer-ll.jpg</MediaUri>
                      </MediaLocator>
                   </ImageSignal>
                </Target>
                <SpacePartition>
                   <Start xsi:type="SignalPlaneFractionType" x="0" y="0"/>
                   <End xsi:type="SignalPlaneFractionType" x="1" y="1"/>
                </SpacePartition>
                <FrequencyPartition>
                   <Start xsi:type="SignalPlaneFractionType" x="0" y="0"/>
                   <End xsi:type="SignalPlaneFractionType" x="0.5" y="0.5"/>
                </FrequencyPartition>
             </View>
          </FrequencyChild>
          <FrequencyChild branching="0">
             <View>
                <Target>
                   <ImageSignal>
                      <MediaLocator>
                         <MediaUri>soccer-lh.jpg</MediaUri>
                      </MediaLocator>
                   </ImageSignal>
                </Target>
                <SpacePartition>
                   <Start xsi:type="SignalPlaneFractionType" x="0" y="0"/>
                   <End xsi:type="SignalPlaneFractionType" x="1" y="1"/>
                </SpacePartition>
                <FrequencyPartition>
                   <Start xsi:type="SignalPlaneFractionType" x="0" y="0.5"/>
                   <End xsi:type="SignalPlaneFractionType" x="0.5" y="1"/>
                </FrequencyPartition>
             </View>
          </FrequencyChild>
       </ViewDecomposition>
    </Description>
</Mpeg7>
```

Examples of Space Frequency Graphs include graph structures that combine wavelet-packet and spatial-tree decompositions of image, video and audio data. The Space and Frequency Graph decomposes images or audio signals in space (time) and frequency. The decomposition of images using the Space and Frequency Graph illustrated above enables efficient multi-resolution access and progressive retrieval of the image data.

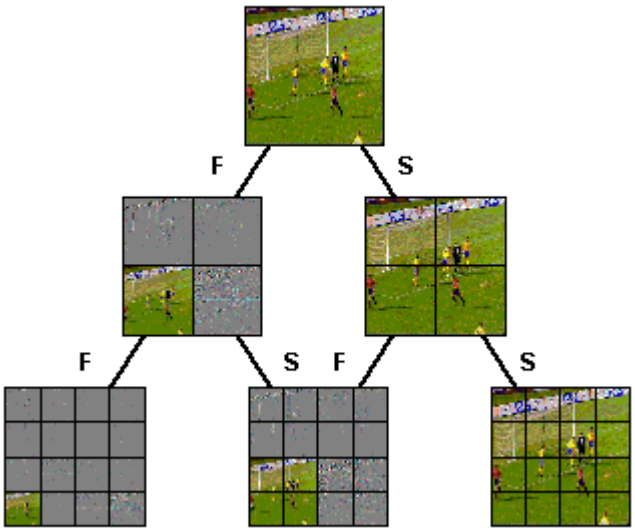


Figure 60 - shows an example Space and Frequency Graph decomposition of an image. The Space and Frequency Graph structure includes node elements that correspond to the different space and frequency views of the image, which consist of views in space (spatial segments), frequency (wavelet subbands), and space and frequency (wavelet subbands of spatial segments). The Space and Frequency Graph structure includes also transition elements that indicate the analysis and synthesis dependencies among the views. For example, in the figure, the "S" transitions indicate spatial decomposition while the "F" transitions indicate frequency or subband decomposition.

3.11.3.15 VideoViewGraph DS

3.11.3.15.1 VideoViewGraph DS examples

The following example describes a `VideoViewGraph` with branching factor of two on each spatial- and/or temporal-frequency dimension at the root node. The `VideoViewGraph` specifies one `FrequencyView` at the first level of the directed acyclic graph and four `FrequencyViews` at the second level of the graph.

```
<Mpeg7>
    <Description xsi:type="ViewDescriptionType">
        <ViewDecomposition xsi:type="VideoViewGraphType" complete="true"
            nonRedundant="false" branching="2">
            <Source>
                <VideoSignal>
                    <MediaLocator>
                        <MediaUri>file://soccer.mpg</MediaUri>
                    </MediaLocator>
                </VideoSignal>
            </Source>
            <SpaceFrequencyChild complete="false" nonRedundant="true"
branching="0">
                <View>
                    <Target>
                        <VideoSignal>
                            <MediaLocator>
                                <MediaUri>soccer-s0.mpg</MediaUri>
                            </MediaLocator>
                        </VideoSignal>
                    </Target>
                    <FrequencyPartition>
                        <Start xsi:type="SignalPlaneFractionType" x="0" y="0"
t="0"/>
                        <End xsi:type="SignalPlaneFractionType" x="0.5" y="0.5"
t="0.5"/>
                    </FrequencyPartition>
                </View>
            </SpaceFrequencyChild>
```

```
          <SpaceFrequencyChild complete="false" nonRedundant="true"
branching="0">
              <View>
                  <Target>
                      <VideoSignal>
                          <MediaLocator>
                              <MediaUri>soccer-s1.mpg</MediaUri>
                          </MediaLocator>
                      </VideoSignal>
                  </Target>
                  <FrequencyPartition>
                      <Start xsi:type="SignalPlaneFractionType" x="0.5" y="0.5"
t="0"/>
                      <End xsi:type="SignalPlaneFractionType" x="1" y="1" t="1"/>
                  </FrequencyPartition>
              </View>
          </SpaceFrequencyChild>
          <TimeFrequencyChild complete="false" nonRedundant="true"
branching="0">
              <View>
                  <Target>
                      <VideoSignal>
                          <MediaLocator>
                              <MediaUri>soccer-t0.mpg</MediaUri>
                          </MediaLocator>
                      </VideoSignal>
                  </Target>
                  <FrequencyPartition>
                      <Start xsi:type="SignalPlaneFractionType" x="0" y="0"
t="0"/>
                      <End xsi:type="SignalPlaneFractionType" x="1" y="1"
t="0.5"/>
                  </FrequencyPartition>
              </View>
          </TimeFrequencyChild>
          <TimeFrequencyChild complete="false" nonRedundant="true"
branching="0">
              <View>
                  <Target>
                      <VideoSignal>
                          <MediaLocator>
                              <MediaUri>soccer-t1.mpg</MediaUri>
                          </MediaLocator>
                      </VideoSignal>
                  </Target>
                  <FrequencyPartition>
                      <Start xsi:type="SignalPlaneFractionType" x="0" y="0"
t="0.5"/>
                      <End xsi:type="SignalPlaneFractionType" x="1" y="1" t="1"/>
                  </FrequencyPartition>
              </View>
          </TimeFrequencyChild>
      </ViewDecomposition>
   </Description>
</Mpeg7>
```


An example of a Video View Graph includes the set of views generated using a 3-D wavelet decomposition of video.

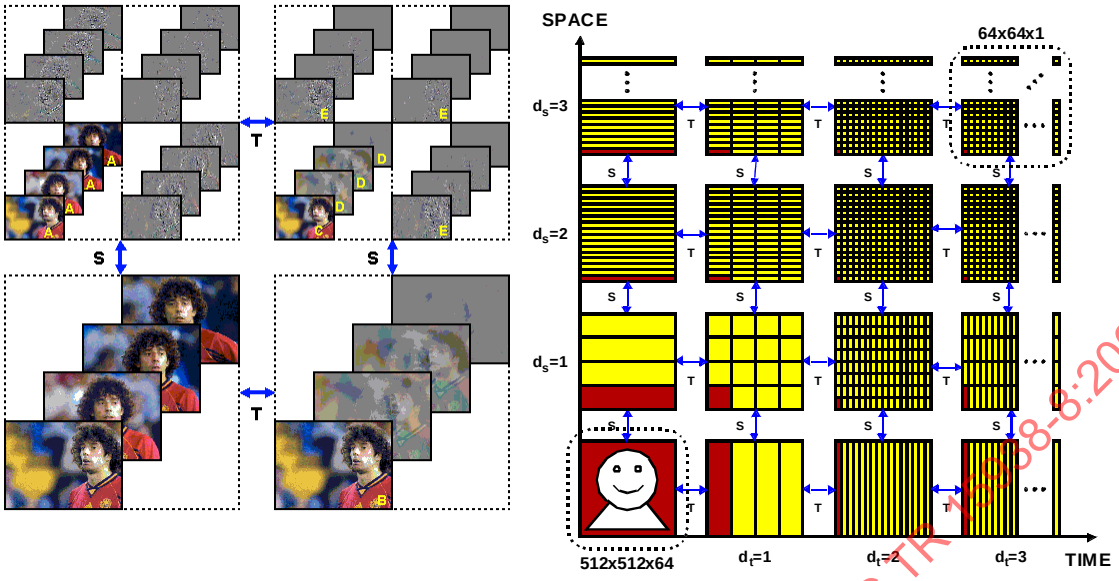


Figure 61 - Example of Video View Graph. (a) Basic spatial- and temporal-frequency decomposition building block, (b) Example video view graph of depth three in spatial- and temporal-frequency.

3.11.3.16 MultiResolutionPyramid DS

3.11.3.16.1 MultiResolutionPyramid DS examples

The following example describes a two-level `MultiResolutionPyramid` consisting of a Gaussian pyramid of image views.

```
<Mpeg7>
    <Description xsi:type="ViewDescriptionType">
        <ViewDecomposition xsi:type="MultiResolutionPyramidType" level="1">
            <Source>
                <ImageSignal>
                    <MediaLocator>
                        <MediaUri>soccer.jpg</MediaUri>
                    </MediaLocator>
                </ImageSignal>
            </Source>
            <Child level="1">
                <View>
                    <Target>
                        <ImageSignal>
                            <MediaLocator>
                                <MediaUri>soccer-1.jpg</MediaUri>
                            </MediaLocator>
                        </ImageSignal>
                    </Target>
                    <DownSamplingFactor x="2" y="2"/>
                </View>
                <Child level="2">
                    <View>
                        <Target>
                            <ImageSignal>
                                <MediaLocator>
                                    <MediaUri>soccer-2.jpg</MediaUri>
                                </MediaLocator>
                            </ImageSignal>
                        </Target>
                        <DownSamplingFactor x="4" y="4"/>
                    </View>
                </Child>
```

```
          </Child>
       </ViewDecomposition>
   </Description>
</Mpeg7>
```

3.11.4 Variations of the content

3.11.4.1 VariationSet DS

3.11.4.1.1 VariationSet DS examples

Figure 62 illustrates a set of variations of multimedia content. The example shows the source video content in the lower left corner and shows eight variations: two variations are video content, three variations are images, two variations are text, and one variation is audio. Each variation has a fidelity value that indicates how close or faithful the variation content is to the source content.

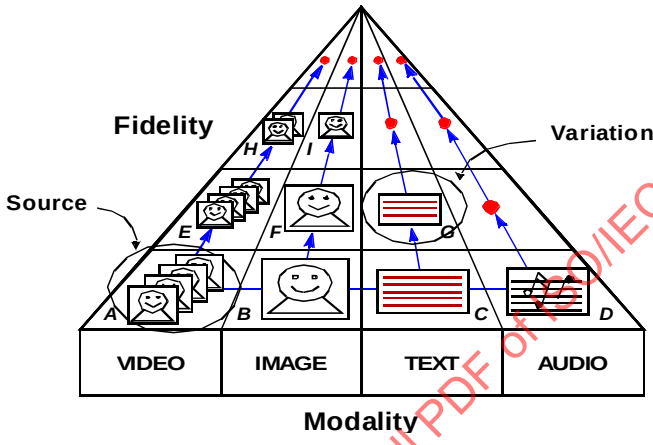


Figure 62 - Illustration of different variations of a source content. The eight variation contents have different modalities (video, image, text, audio) and fidelities with respect to the source content.

The following example of the `VariationSet` DS describes a subset of the variation contents illustrated above,namely B, C and E. The source content is described first, using a `Video` element and a `MediaLocator` element. Following in the description is a set of three variations, described using an `Image`, `Audio` and `Video` element, respectively. Each `Variation` contains the `fidelity`, `priority` and `VariationRelationship`. The example shows that in some cases multiple `VariationRelationships` can be specified, such as the fact that variation E is derived from the source content via both SpatialReduction and Compression. Also, the `timeOffset` and `timeScale` attributes in the last `Variation` element relate the time-line of this variation content to the time-line of the source content.

```
<Mpeg7>
   <Description xsi:type="VariationDescriptionType">
      <VariationSet>
         <Source xsi:type="mpeg7:VideoType">
            <Video>
               <MediaLocator>
                  <MediaUri>file://soccer-A.mpg</MediaUri>
               </MediaLocator>
            </Video>
         </Source>
         <Variation fidelity="0.85" priority="1">
            <Content xsi:type="ImageType">
               <Image>
                  <MediaLocator>
                     <MediaUri>file://soccer-B.jpg</MediaUri>
                  </MediaLocator>
               </Image>
            </Content>
            <VariationRelationship>extraction</VariationRelationship>
         </Variation>
         <Variation fidelity="0.75" priority="3">
            <Content xsi:type="AudioType">
```

```
                <Audio>
                    <MediaLocator>
                        <MediaUri>file://soccer-C.mp3</MediaUri>
                    </MediaLocator>
                </Audio>
            </Content>
            <VariationRelationship>extraction</VariationRelationship>
            <VariationRelationship>languageTranslation</VariationRelationship>
        </Variation>
        <Variation fidelity="0.5" priority="2" timeOffset="PT10S"
timeScale="0.5">
            <Content xsi:type="VideoType">
                <Video>
                    <MediaLocator>
                        <MediaUri>file://soccer-E.mpg</MediaUri>
                    </MediaLocator>
                </Video>
            </Content>
            <VariationRelationship>spatialReduction</VariationRelationship>
            <VariationRelationship>compression</VariationRelationship>

   <VariationRelationship>alternativeMediaProfile</VariationRelationship>
        </Variation>
      </VariationSet>
   </Description>
</Mpeg7>
```

3.11.4.1.2 VariationSet DS Extraction

In some cases the variations are derived from the original multimedia content by processing. For example, in the cases of the variation type of "summary", the variation may be computed from the source multimedia program. The variation fidelity attribute gives the quality of the variation for replacing the original for purposes of delivery under different network condition, user or publisher preferences, or capabilities of the client devices.

One procedure for computing the fidelity is based on the media attributes of the variation and source multimedia content, as follows: consider *A* = original data, and *B* = variation of data, then

$$Fidelity(A,B) = \frac{1}{7}\left(\frac{B.hasVideo}{A.hasVideo} + \frac{B.hasAudio}{A.hasAudio} + \frac{B.DataSize}{A.DataSize} + \frac{B.FrameRate}{A.FrameRate} + \frac{B.SampleRate}{A.SampleRate} + \frac{B.SpatialSize}{A.SpatialSize} + \frac{B.Colors}{A.Colors}\right)$$

A second procedure for computing fidelity when the variation of a video uses only images, such as for a storyboard is based on the number of key-frames from video used in the summary of the video.

$$Fidelity(A,B) = \left(\frac{B.Number-of-Selected-Keyframes}{A.Number-of-TotalKeyframes}\right).$$

3.11.4.1.3 VariationSet DS Use

The Variation DS represents the associations or relationships between different variations of multimedia programs. The Variation DS serves important content management functionalities by tracking the variations of multimedia content that result from various types of multimedia processing such as summarization, translation, reduction, revision and so forth. As illustrated in Figure 63, the Variation DS also serves an important role in applications such as Universal Multimedia Access by allowing the selection among the different variations of the multimedia programs in order to select the most appropriate one in adapting to the specific capabilities of the terminal devices, network conditions or user preferences.

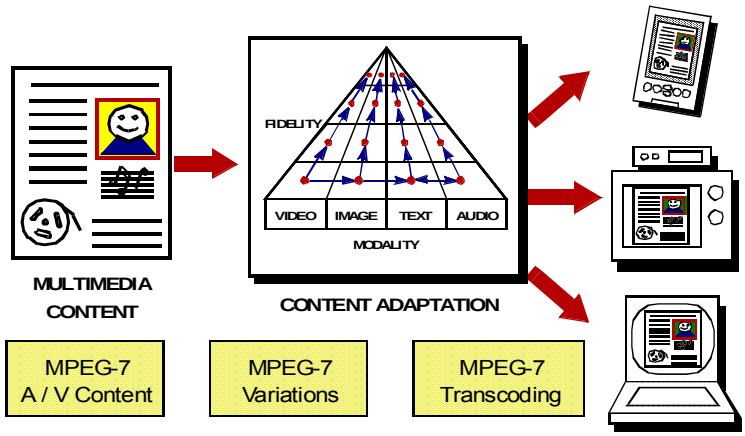


Figure 63 - Illustration of an example application of Universal Multimedia Access (UMA) in which the appropriate variations of the multimedia programs are selected according to the capabilities of the terminal devices. The MPEG-7 transcoding hints may be used in addition to further adapt the programs to the devices.

The Variation DS can be used applications such as Universal Multimedia Access (UMA). In UMA, the variations of a source multimedia program can replace the source, if necessary, to adapt to the capabilities of the client terminals, network conditions or user preferences. Figure 64 illustrates an example use of the Variation DS in which two different variations of an multimedia program are selected under different terminal device and network conditions. Figure 65 shows how the selection of different combinations of variations of programs within a multimedia presentation can be made together to trade-off the total content value and data size.

Figure 64 - Shows a selection screen (left) which allows the user to specify the terminal device and network characteristics in terms of screen size, screen color, supported frame rate, bandwidth and supported modalities (image, video, audio). Center and right show the selection of Variations of a video news program under different terminal and network conditions. The high-rate color variation program is selected for high-end terminals (center). The low-resolution grayscale variation program is selected for low-end terminals (right).

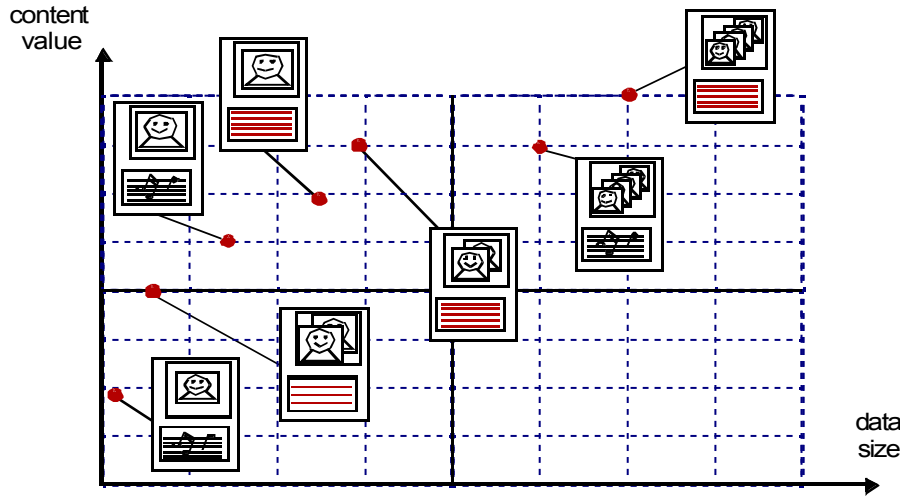


Figure 65 - Shows the trade-off in content value (summed fidelity) *vs.* data size when different combinations of variations of programs are selected within a multimedia presentation.

3.12 Content organization tools

3.12.1 Introduction

This clause specifies tools for describing the organization and modeling of multimedia content. The tools are used for describing collections and models as follows:

Table 14 - Overview of Content Organization Tools.

Tools	*Functionality*
Collection	Tools for describing unordered collections. Examples include collections of multimedia content, segments, descriptors, concepts, or mixed collections.
Model	Tools for describing parameterized models of multimedia content, descriptors, or collections (abstract).
ProbabilityModel	Tools for describing the association of statistics or probabilities with the attributes of multimedia content, descriptors or collections.
AnalyticModel	Tools for describing the association of labels or semantics with multimedia content or collections.
Cluster Model	Tools for describing the association of labels or semantics, and statistics or probabilities with multimedia content collections.
Classification Model	Tools for describing collections of multimedia content in terms of labels, semantics, and models, which allows classification of unknown multimedia content.

3.12.2 Collections

3.12.2.1 Collection DS

Information on extraction and use is not provided.

3.12.2.2 ContentCollection DS

3.12.2.2.1 ContentCollection DS examples

The following example shows the use of the `ContentCollection DS` to describe a collection of two images.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="MultimediaCollectionType">
         <Collection xsi:type="ContentCollectionType">
            <Content xsi:type="ImageType">
               <Image>
```

```
                    <MediaLocator xsi:type="ImageLocatorType">
                        <MediaUri>soccer1.jpg</MediaUri>
                    </MediaLocator>
                </Image>
            </Content>
            <Content xsi:type="ImageType">
                <Image>
                    <MediaLocator xsi:type="ImageLocatorType">
                        <MediaUri>soccer2.jpg</MediaUri>
                    </MediaLocator>
                </Image>
            </Content>
        </Collection>
    </MultimediaContent>
</Description>
</Mpeg7>
```

The following example shows the use of the `ContentCollection` DS to describe a collection or album of musical songs. The title of the collection is called "Live from Pisa." The collection consists of six songs, which are organized into two individual collections or album sides (side "A" and side "B"). The creation information for the collection describes the name of the artist. The creation information for each individual song describes the title of the song.

```
<Mpeg7>
    <Description xsi:type="ContentEntityType">
        <MultimediaContent xsi:type="MultimediaCollectionType">
            <Collection xsi:type="ContentCollectionType" name="Album - Live from
Pisa">
            <CreationInformation>
                <Creation>
                    <Title type="popular"> Live from Pisa </Title>
                    <Creator>
                        <Role href="RoleCS">
                            <Name> Artist </Name>
                        </Role>
                        <Agent xsi:type="PersonType">
                            <Name>
                                <GivenName> John </GivenName>
                                <FamilyName> Smith </FamilyName>
                            </Name>
                        </Agent>
                    </Creator>
                    <CopyrightString> Copyright 1997, All rights reserved.
                    </CopyrightString>
                </Creation>
            </CreationInformation>
            <TextAnnotation>
                <FreeTextAnnotation> Collection of musical songs.
                </FreeTextAnnotation>
            </TextAnnotation>
            <ContentCollection name="Side A">
                <Content xsi:type="AudioType">
                    <Audio>
                        <MediaLocator>
                            <MediaUri>pompodor.mid</MediaUri>
                        </MediaLocator>
                        <CreationInformation>
                            <Creation>
                                <Title> Pompodor </Title>
                            </Creation>
                        </CreationInformation>
                    </Audio>
                </Content>
```

```
                <Content xsi:type="AudioType">
                    <Audio>
                        <MediaLocator>
                            <MediaUri>wheel.mid</MediaUri>
                        </MediaLocator>
                        <CreationInformation>
                            <Creation>
                                <Title> Wheel of Misfortune</Title>
                            </Creation>
                        </CreationInformation>
                    </Audio>
                </Content>
                <Content xsi:type="AudioType">
                    <Audio>
                        <MediaLocator>
                            <MediaUri>berreta.mid</MediaUri>
                        </MediaLocator>
                        <CreationInformation>
                            <Creation>
                                <Title> Red Berreta </Title>
                            </Creation>
                        </CreationInformation>
                    </Audio>
                </Content>
            </ContentCollection>
            <ContentCollection name="Side B">
                <Content xsi:type="AudioType">
                    <Audio>
                        <MediaLocator>
                            <MediaUri>brow.mid</MediaUri>
                        </MediaLocator>
                        <CreationInformation>
                            <Creation>
                                <Title> Browbeater </Title>
                            </Creation>
                        </CreationInformation>
                    </Audio>
                </Content>
                <Content xsi:type="AudioType">
                    <Audio>
                        <MediaLocator>
                            <MediaUri>sunshine.mid</MediaUri>
                        </MediaLocator>
                        <CreationInformation>
                            <Creation>
                                <Title> Sunshine </Title>
                            </Creation>
                        </CreationInformation>
                    </Audio>
                </Content>
                <Content xsi:type="AudioType">
                    <Audio>
                        <MediaLocator>
                            <MediaUri>corner.mid</MediaUri>
                        </MediaLocator>
                        <CreationInformation>
                            <Creation>
                                <Title> Down on the Corner </Title>
                            </Creation>
                        </CreationInformation>
                    </Audio>
                </Content>
            </ContentCollection>
        </Collection>
```

```
        </MultimediaContent>
    </Description>
</Mpeg7>
```

3.12.2.3 SegmentCollection DS

3.12.2.3.1 SegmentCollection DS examples

The following example illustrates the use of the SegmentCollection DS for describing a collection of two still regions. Each still region from an image corresponds to a region whose boundaries are identified using a spatial mask.

```
<Mpeg7>
    <Description xsi:type="ContentEntityType">
        <MultimediaContent xsi:type="MultimediaCollectionType">
            <Collection xsi:type="SegmentCollectionType">
                <Segment xsi:type="StillRegionType">
                    <MediaLocator xsi:type="ImageLocatorType">
                        <MediaUri>soccer-upper-left.jpg</MediaUri>
                    </MediaLocator>
                    <TextAnnotation>
                        <FreeTextAnnotation> Soccer image (upper left region)
                        </FreeTextAnnotation>
                    </TextAnnotation>
                    <VisualDescriptor xsi:type="ScalableColorType" numOfCoeff="16"
                        numOfBitplanesDiscarded="0">
                        <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                    </VisualDescriptor>
                </Segment>
                <Segment xsi:type="StillRegionType">
                    <MediaLocator xsi:type="ImageLocatorType">
                        <MediaUri>soccer-lower-right.jpg</MediaUri>
                    </MediaLocator>
                    <TextAnnotation>
                        <FreeTextAnnotation> Soccer image (lower right region)
                        </FreeTextAnnotation>
                    </TextAnnotation>
                    <VisualDescriptor xsi:type="ScalableColorType" numOfCoeff="16"
                        numOfBitplanesDiscarded="0">
                        <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                    </VisualDescriptor>
                </Segment>
            </Collection>
        </MultimediaContent>
    </Description>
</Mpeg7>
```

3.12.2.4 DescriptorCollection DS

3.12.2.4.1 DescriptorCollection DS examples

The following example shows the use of DescriptorCollection DS for describing a collection of instances of color descriptors. In this example, the color descriptors are ScalableColor D (defined in ISO/IEC 15938-3).

```
<Mpeg7>
    <Description xsi:type="ContentEntityType">
        <MultimediaContent xsi:type="MultimediaCollectionType">
            <Collection xsi:type="DescriptorCollectionType">
                <Descriptor xsi:type="ScalableColorType" numOfCoeff="16"
                    numOfBitplanesDiscarded="0">
                    <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                </Descriptor>
                <Descriptor xsi:type="ScalableColorType" numOfCoeff="16"
```

```
                numOfBitplanesDiscarded="0">
                <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
            </Descriptor>
            <Descriptor xsi:type="ScalableColorType" numOfCoeff="16"
                numOfBitplanesDiscarded="0">
                <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
            </Descriptor>
            <Descriptor xsi:type="ScalableColorType" numOfCoeff="16"
                numOfBitplanesDiscarded="0">
                <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
            </Descriptor>
        </Collection>
    </MultimediaContent>
</Description>
</Mpeg7>
```

3.12.2.5 ConceptCollection DS

3.12.2.5.1 Introduction

3.12.2.5.2 ConceptCollection DS examples

The following example shows the use of the `ConceptCollection DS` for describing a collection of four semantic objects ("car", "house", "boat", and "tree").

```
<Mpeg7>
    <Description xsi:type="ContentEntityType">
        <MultimediaContent xsi:type="MultimediaCollectionType">
            <Collection xsi:type="ConceptCollectionType">
                <Concept xsi:type="ObjectType">
                    <Label>
                        <Name> Car </Name>
                    </Label>
                </Concept>
                <Concept xsi:type="ObjectType">
                    <Label>
                        <Name> House </Name>
                    </Label>
                </Concept>
                <Concept xsi:type="ObjectType">
                    <Label>
                        <Name> Boat </Name>
                    </Label>
                </Concept>
                <Concept xsi:type="ObjectType">
                    <Label>
                        <Name> Tree </Name>
                    </Label>
                </Concept>
            </Collection>
        </MultimediaContent>
    </Description>
</Mpeg7>
```

3.12.2.6 Mixed Collection DS

3.12.2.6.1 MixedCollection DS examples

The following example shows the use of the `MixedCollection DS` for describing a collection of two images ("baseball01.jpg" and "baseball02.jpg") and two objects ("ball" and "glove").

```
<Mpeg7>
    <Description xsi:type="ContentEntityType">
        <MultimediaContent xsi:type="MultimediaCollectionType">
            <Collection xsi:type="MixedCollectionType">
```

```
            <Content xsi:type="ImageType">
               <Image>
                  <MediaLocator xsi:type="ImageLocatorType">
                     <MediaUri>baseball01.jpg</MediaUri>
                  </MediaLocator>
               </Image>
            </Content>
            <Content xsi:type="ImageType">
               <Image>
                  <MediaLocator xsi:type="ImageLocatorType">
                     <MediaUri>baseball02.jpg</MediaUri>
                  </MediaLocator>
               </Image>
            </Content>
            <Concept xsi:type="ObjectType">
               <Label>
                  <Name> Ball </Name>
               </Label>
            </Concept>
            <Concept xsi:type="ObjectType">
               <Label>
                  <Name> Glove </Name>
               </Label>
            </Concept>
         </Collection>
      </MultimediaContent>
   </Description>
</Mpeg7>
```

3.12.2.7 StructuredCollection DS

3.12.2.7.1 StructuredCollection DS examples

The following example shows the use of the `StructuredCollection DS` for desribing a structured collection consisting of two collections of images, each containing two images. The following relationships are described between the two collections of images using a relationship graph: `similarTo` and `overlaps`, which gives that the two collections are similar, and they overlap in some sense.

```
<Mpeg7>
   <Description xsi:type="ContentEntityType">
      <MultimediaContent xsi:type="MultimediaCollectionType">
         <StructuredCollection>
            <!-- Describes a Collection of two images -->
            <Collection id="collection1" xsi:type="ContentCollectionType">
               <Content xsi:type="ImageType">
                  <Image>
                     <MediaLocator xsi:type="ImageLocatorType">
                        <MediaUri>soccer1.jpg</MediaUri>
                     </MediaLocator>
                  </Image>
               </Content>
               <Content xsi:type="ImageType">
                  <Image>
                     <MediaLocator xsi:type="ImageLocatorType">
                        <MediaUri>soccer2.jpg</MediaUri>
                     </MediaLocator>
                  </Image>
               </Content>
            </Collection>
            <!-- Describes a Collection of two images -->
            <Collection id="collection2" xsi:type="ContentCollectionType">
               <Content xsi:type="ImageType">
                  <Image>
                     <MediaLocator xsi:type="ImageLocatorType">
```

```
                        <MediaUri>soccer3.jpg</MediaUri>
                    </MediaLocator>
                </Image>
            </Content>
            <Content xsi:type="ImageType">
                <Image>
                    <MediaLocator xsi:type="ImageLocatorType">
                        <MediaUri>soccer4.jpg</MediaUri>
                    </MediaLocator>
                </Image>
            </Content>
        </Collection>
        <!-- Describes the relationships among the collections -->
        <Relationships>
            <Node id="source" href="#collection1"/>
            <Node id="target1" href="#collection2"/>
            <Relation
type="urn:mpeg:mpeg7:cs:SemanticRelationCS:2001:similarTo"
                source="#source" target="#target1"/>
            <Relation
                type="urn:mpeg:mpeg7:cs:BaseRelationCS:2001:overlaps"
                source="#source" target="#target1"/>
        </Relationships>
    </StructuredCollection>
  </MultimediaContent>
 </Description>
</Mpeg7>
```

3.12.2.7.2 StructuredCollection DS use

Based on an image collection description, an image collection browsing and searching application could be developed providing the following functionality:

- Browse the images in the collection
- Browse the classes in the collection
- Browse the images belonging to a class
- Browse the classes assigned to each image
- Retrieve classes to a query one in terms of mean color histogram

In the class browsing system, the user could view the classes as a simple flat list even though these include classes from two independent classifications of the images in the collection. Another way to show the classes to users would be in a hierarchical fashion. For each class, a semantic label could be displayed together with the representative icon of the class. Users could view the images that belong to each class by clicking with the mouse on the name or the representative icon of the class.

In the image browsing system, users could view the classes to which an image belongs by clicking with the mouse on the icon of the image. Again, by selecting a class, users could browse the images that belong to that class.

When browsing though the collection classes, a text "ch" right below the class representative icon could start a class query based on mean color histogram. Similar classes to the selected one based on the mean color histogram would be returned. Euclidean distance or any other similarity matching functions could be used to compare the mean color histograms of two classes (see Visual XM document).

3.12.3 Models

3.12.3.1 Model DS

Information on extraction and use is not provided.

3.12.4 Probability models

3.12.4.1 ProbabilityModel DS

Information on extraction and use is not provided.

3.12.4.2 ProbabilityDistribution DS

3.12.4.2.1 ProbabilityDistribution DS examples

The following example shows the use of the `ProbabilityDistribution DS` for describing a probability distribution in terms of its statistics such as mean, variance, min, max, mode, median, and moment.

```
<Mpeg7>
    <DescriptionUnit xsi:type="ProbabilityDistributionType" confidence="1.0"
dim="2">
        <Mean mpeg7:dim="2"> 0.25 0.5 </Mean>
        <Variance mpeg7:dim="2"> 0.1 0.9 </Variance>
        <Min mpeg7:dim="2"> 0.0 0.0 </Min>
        <Max mpeg7:dim="2"> 1.0 1.0 </Max>
        <Mode mpeg7:dim="2"> 0.5 0.5 </Mode>
        <Median mpeg7:dim="2"> 0.5 0.5 </Median>
        <Moment>
            <Value mpeg7:dim="2" order="3"> 0.2 0.3 </Value>
        </Moment>
    </DescriptionUnit>
</Mpeg7>
```

3.12.4.3 Discrete distribution description tools

3.12.4.3.1 Discrete distribution description tools examples

The following example illustrates the use of the `HistogramProbability DS` for describing an eight-dimensional histogram.

```
<Mpeg7>
    <DescriptionUnit xsi:type="HistogramProbabilityType" momentNormalized="1"
        dim="8">
        <Distribution mpeg7:dim="8"> 0.125 0.0 0.0 0.25 0.125 0.25 0.25 0.0
        </Distribution>
    </DescriptionUnit>
</Mpeg7>
```

The following example illustrates the use of the `BinomialDistribution DS` for describing a one-dimensional binomial distribution.

```
<Mpeg7>
    <DescriptionUnit xsi:type="BinomialDistributionType" dim="1">
        <SuccessProbability mpeg7:dim="1"> 0.5 </SuccessProbability>
        <NumOfTrials mpeg7:dim="1"> 16 </NumOfTrials>
    </DescriptionUnit>
</Mpeg7>
```

The following example illustrates the use of the `BinomialDistribution DS` for describing a two-dimensional hypergeometric distribution.

```
<Mpeg7>
    <DescriptionUnit xsi:type="HyperGeometricDistributionType" dim="2">
        <NumOfSuccesses mpeg7:dim="2"> 5 5 </NumOfSuccesses>
        <NumOfTrials mpeg7:dim="2"> 8 8 </NumOfTrials>
        <PopulationSize mpeg7:dim="2"> 16 16 </PopulationSize>
    </DescriptionUnit>
</Mpeg7>
```

The following example illustrates the use of the PoissonDistribution DS for describing a three-dimensional Poisson distribution.

```
<Mpeg7>
    <DescriptionUnit xsi:type="PoissonDistributionType" dim="3">
        <Lambda mpeg7:dim="3"> 0.4 0.3 0.75 </Lambda>
    </DescriptionUnit>
</Mpeg7>
```

The following example illustrates the use of the GeometricDistribution DS for describing a one-dimensional geometric distribution.

```
<Mpeg7>
    <DescriptionUnit xsi:type="GeometricDistributionType" dim="1">
        <SuccessProbability mpeg7:dim="1"> 0.75 </SuccessProbability>
    </DescriptionUnit>
</Mpeg7>
```

The following example illustrates the use of the DiscreteUniformDistribution DS for describing a one-dimensional discrete uniform distribution.

```
<Mpeg7>
    <DescriptionUnit xsi:type="DiscreteUniformDistributionType" dim="1">
        <Range mpeg7:dim="1"> 0.125 </Range>
        <Scale mpeg7:dim="1"> 2.0 </Scale>
        <Shift mpeg7:dim="1"> 8.0 </Shift>
    </DescriptionUnit>
</Mpeg7>
```

3.12.4.4 Continuous distribution description tools

3.12.4.4.1 Continuous distribution description tools examples

The following example illustrates the use of the GaussianDistribution DS for describing a one-dimensional Gaussian distribution.

```
<Mpeg7>
    <DescriptionUnit xsi:type="GaussianDistributionType" dim="1">
        <Mean mpeg7:dim="1"> 0.5 </Mean>
        <Variance mpeg7:dim="1"> 0.25 </Variance>
    </DescriptionUnit>
</Mpeg7>
```

The following example illustrates the use of the ExponentialDistribution DS for describing a two-dimensional generalized Gaussian distribution.

```
<Mpeg7>
    <DescriptionUnit xsi:type="GeneralizedGaussianDistributionType" dim="2">
        <Mean mpeg7:dim="2"> 0.5 0.35 </Mean>
        <Variance mpeg7:dim="2"> 0.25 0.75 </Variance>
        <Shape mpeg7:dim="2"> 2 2 </Shape>
    </DescriptionUnit>
</Mpeg7>
```

The following example illustrates the use of the ExponentialDistribution DS for describing a two-dimensional exponential distribution.

```
<Mpeg7>
    <DescriptionUnit xsi:type="ExponentialDistributionType" dim="2">
        <Theta mpeg7:dim="2"> 0.5 0.25 </Theta>
    </DescriptionUnit>
</Mpeg7>
```

The following example illustrates the use of the GammaDistribution DS for describing a three-dimensional Gamma distribution.

```
<Mpeg7>
    <DescriptionUnit xsi:type="GammaDistributionType" dim="3">
        <Theta mpeg7:dim="3"> 0.4 0.3 0.75 </Theta>
        <Shape mpeg7:dim="3"> 8 4 16 </Shape>
    </DescriptionUnit>
</Mpeg7>
```

The following example illustrates the use of the ContinuousUniformDistribution DS for describing a one-dimensional continuous uniform distribution.

```
<Mpeg7>
    <DescriptionUnit xsi:type="ContinuousUniformDistributionType" dim="1">
        <MaxRange mpeg7:dim="1"> 1.0 </MaxRange>
        <MinRange mpeg7:dim="1"> 0.0 </MinRange>
    </DescriptionUnit>
</Mpeg7>
```

The following example illustrates the use of the LognormalDistribution DS for describing a one-dimensional lognormal distribution.

```
<Mpeg7>
    <DescriptionUnit xsi:type="LognormalDistributionType" dim="1">
        <NormalMean mpeg7:dim="1"> 0.5 </NormalMean>
        <NormalVariance mpeg7:dim="1"> 0.35 </NormalVariance>
    </DescriptionUnit>
</Mpeg7>
```

3.12.4.5 Finite state model description tools

3.12.4.5.1 Finite state model description tools examples

The following example shows the use of the StateTransitionModel DS for describing a state-transition model that has three states. In this example, assume that the observed weather has one of the following states: "precipitation", "cloudy", or "sunny". Furthermore, the state-transition probabilities indicate the probability of moving from one state to another. The initial probabilities specify the initial probability of each state. The state-transition model allows questions to be answered such as, what is the probability that the weather for eight consecutive days is "sun-sun-sun-rain-rain-sun-cloudy-sun", or given that the system is in a known state, i.e., "sunny", what is the expected number of consecutive days the system will remain in that state.

```
<Mpeg7>
    <Description xsi:type="ModelDescriptionType">
        <Model xsi:type="StateTransitionModelType" numOfStates="3">
            <Initial mpeg7:dim="3"> 0.5 0.25 0.25 </Initial>
            <Transitions mpeg7:dim="3 3"> 0.4 0.3 0.3 0.2 0.6 0.2 0.1 0.1 0.8
        </Transitions>
            <State>
                <Label>
                    <Name>Precipitation </Name>
                </Label>
            </State>
            <State>
                <Label>
                    <Name>Cloudy </Name>
                </Label>
            </State>
            <State>
                <Label>
                    <Name>Sunny </Name>
                </Label>
            </State>
```

```
        </Model>
    </Description>
</Mpeg7>
```

The following example shows the use of the StateTransitionModel DS for describing a state-transition model of the events depicted a video of a soccer game. The model describes three states: "Pass", "Shot on goal" and "Goal score". The StateTransitionModel DS describes the states, the initial state probabilities, and the transition probabilities between the states.

```
<Mpeg7>
    <Description xsi:type="ModelDescriptionType">
        <Model xsi:type="StateTransitionModelType" numOfStates="3">
            <Initial mpeg7:dim="3"> 0.25 0.5 0.25 </Initial>
            <Transitions mpeg7:dim="3 3"> 0.2 0.2 0.6 0.1 0.8 0.1 0.3 0.3 0.4
        </Transitions>
            <State>
                <Label>
                    <Name> Pass </Name>
                </Label>
            </State>
            <State>
                <Label>
                    <Name>Shot on goal </Name>
                </Label>
            </State>
            <State>
                <Label>
                    <Name>Goal score </Name>
                </Label>
            </State>
        </Model>
    </Description>
</Mpeg7>
```

The following example shows the use of DiscreteHiddenMarkovModelType for describing a discrete hidden markov model of events in a soccer game, such as "passes" and "goal scores".

```
<Mpeg7>
    <Description xsi:type="ModelDescriptionType">
        <Model xsi:type="DiscreteHiddenMarkovModelType" numOfStates="2">
            <Initial mpeg7:dim="2"> 0.5 0.5 </Initial>
            <Transitions mpeg7:dim="2 2"> 0.4 0.6 0.3 0.7 </Transitions>
            <State>
                <Label>
                    <Name>Pass</Name>
                </Label>
            </State>
            <State>
                <Label>
                    <Name>Goal score</Name>
                </Label>
            </State>
            <NumOfObservationsPerState>2</NumOfObservationsPerState>
            <Observation>Team A pass</Observation>
            <Observation>Team B pass</Observation>
            <ObservationDistribution xsi:type="HistogramProbabilityType"
                momentNormalized="1" dim="2">
                <Distribution mpeg7:dim="2">0.2 0.8</Distribution>
            </ObservationDistribution>
            <NumOfObservationsPerState>2</NumOfObservationsPerState>
            <Observation>Team A goal</Observation>
            <Observation>Team B goal</Observation>
            <ObservationDistribution xsi:type="HistogramProbabilityType"
```

```
            momentNormalized="1" dim="2">
            <Distribution mpeg7:dim="2">0.4 0.6</Distribution>
         </ObservationDistribution>
      </Model>
   </Description>
</Mpeg7>
```

The following example shows the use of the `ContinuousHiddenMarkovModel` DS for describing a continuous hidden Markov model of audio sound effects. Each continuous hidden Markov model has 5 states and represents a sound effect class. The parameters of the continuous density state model can be estimated via training, for example, using the Baum-Welch algorithm. After training, the continuous HMM model consists of a 5x5 state transition matrix, a 5x1 initial state density matrix, and 5 multi-dimensional Gaussian distributions defined in terms of the mean and variance parameters. Each multi-dimensional Gaussian distribution has six dimensions corresponding to audio features comprised of 5 channels of Independent Component Analysis (ICA) data and 1 channel of spectral envelope data.

```
<Mpeg7>
   <Description xsi:type="ModelDescriptionType">
      <Model xsi:type="ContinuousHiddenMarkovModelType" numOfStates="5">
         <Initial mpeg7:dim="5"> 0.1 0.2 0.1 0.4 0.2 </Initial>
         <Transitions mpeg7:dim="5 5">
            0.2 0.2 0.6 0.0 0.0
            0.1 0.2 0.1 0.3 0.3
            0.4 0.2 0.1 0.1 0.2
            0.2 0.1 0.4 0.2 0.1
            0.0 0.2 0.1 0.3 0.4
         </Transitions>
         <State>
            <Label>
               <Name> State 1 </Name>
            </Label>
         </State>
         <State>
            <Label>
               <Name> State 2 </Name>
            </Label>
         </State>
         <State>
            <Label>
               <Name> State 3 </Name>
            </Label>
         </State>
         <State>
            <Label>
               <Name> State 4 </Name>
            </Label>
         </State>
         <State>
            <Label>
               <Name> State 5 </Name>
            </Label>
         </State>
         <DescriptorModel>
            <Descriptor xsi:type="BeatType">
               <BeatData> 1 2 3 4 5 6 </BeatData>
            </Descriptor>
            <Field xsi:type="xPathFieldType">BeatData</Field>
         </DescriptorModel>
         <ObservationDistribution xsi:type="GaussianDistributionType" dim="6">
            <Mean mpeg7:dim="6"> 0.5 0.5 0.25 0.3 0.5 0.3 </Mean>
            <Variance mpeg7:dim="6"> 0.25 0.75 0.5 0.45 0.75 0.3</Variance>
         </ObservationDistribution>
         <ObservationDistribution xsi:type="GaussianDistributionType" dim="6">
```

```
            <Mean mpeg7:dim="6"> 0.25 0.4 0.25 0.3 0.2 0.1 </Mean>
            <Variance mpeg7:dim="6"> 0.5 0.25 0.5 0.45 0.5 0.2</Variance>
         </ObservationDistribution>
         <ObservationDistribution xsi:type="GaussianDistributionType" dim="6">
            <Mean mpeg7:dim="6"> 0.2 0.5 0.35 0.3 0.5 0.5 </Mean>
            <Variance mpeg7:dim="6"> 0.5 0.5 0.5 0.5 0.75 0.5</Variance>
         </ObservationDistribution>
         <ObservationDistribution xsi:type="GaussianDistributionType" dim="6">
            <Mean mpeg7:dim="6"> 0.5 0.3 0.25 0.2 0.5 0.6 </Mean>
            <Variance mpeg7:dim="6"> 0.5 0.1 0.5 0.25 0.75 0.4</Variance>
         </ObservationDistribution>
         <ObservationDistribution xsi:type="GaussianDistributionType" dim="6">
            <Mean mpeg7:dim="6"> 0.5 0.15 0.25 0.3 0.5 0.35 </Mean>
            <Variance mpeg7:dim="6"> 0.5 0.75 0.5 0.5 0.75 0.35</Variance>
         </ObservationDistribution>
      </Model>
   </Description>
</Mpeg7>
```

3.12.4.5.2 FiniteStateModel DS use

State-transition models can be extracted from the events along the temporal dimension of a video sequence. For example, a temporal sequence of scenes in video can be characterized by a state-transition model that describes the probabilities of transitions between scenes.

The state-transition models can be matched using the following matching metrics to determine the similarity of the underlying multimedia content being modeled:

Euclidean distance: calculates the sum of squared differences between transition probabilities.

$$dissimilar\ score = \sum_i \sum_j \left(A_{ij} - B_{ij}\right)^2$$

Quadratic distance: calculates the sum of weighted quadratic distance between transition probabilities.

$$dissimilar\ score = \sum_i \sum_j \sum_k \sum_l \frac{\left(A_{ij} - B_{ij}\right)\left(A_{kl} - B_{kl}\right)}{\left(1 + abs(i-k) + abc(j-l)\right)}$$

Weighted transition frequency: calculates the weighted sum of ratios of transition probabilities.

$$fA_{ij} = A_{ij} + A_{ji} \quad rA_{ij} = A_{ij} \Big/ A_{ji}$$

$$match\ score = \sum_i \sum_{j>i} \sqrt{fA_{ij} \cdot fB_{ij}} \cdot \min\left(\frac{fA_{ij}}{fB_{ij}}, \frac{fB_{ij}}{fA_{ij}}\right) \cdot \min\left(\frac{rA_{ij}}{rB_{ij}}, \frac{rB_{ij}}{rA_{ij}}\right)$$

Euclidean distance of aggregated state transitions: calculates the sum of the squared differences of aggregated transitions.

$$dissimilar\ score = \sum_i \left(\sum_j A_{ij} - \sum_j B_{ij}\right)^2 - \sum_j \left(\sum_i A_{ij} - \sum_i B_{ij}\right)^2$$

3.12.5 Analytic models

3.12.5.1.1 AnalyticModel DS examples

The example below illustrates the use of the `ModelState DS` to describe a an analytic model that represents a state in a finite state model. The description gives three labels for the state and gives information about the confidence and reliability of the state analytic model.

```
<Mpeg7>
   <Description xsi:type="ModelDescriptionType">
```

```
        <Model xsi:type="ModelStateType" confidence="0.9" reliability="0.75">
            <Label relevance="0.5" confidence="0.9" reliability="0.75">
                <Name> Shot on goal </Name>
            </Label>
            <Label relevance="1.0" confidence="0.75" reliability="0.75">
                <Name> Ball block </Name>
            </Label>
            <Label relevance="0.25" confidence="0.5" reliability="0.75">
                <Name> Shot wide </Name>
            </Label>
        </Model>
    </Description>
</Mpeg7>
```

3.12.5.2 CollectionModel DS

3.12.5.2.1 CollectionModel DS examples

The following example illustrates the use of the `CollectionModel DS` for describing a collection model consisting of a content collection of four images. In this example, the semantic concept is being described by the collection of images. For example, the collection of images describe the concept of "soccer shots on goal". In this example, the description gives a confidence of 0.75 and a reliability of 0.5.

```
<Mpeg7>
    <Description xsi:type="ModelDescriptionType">
        <Model xsi:type="CollectionModelType" confidence="0.75" reliability="0.5"
            function="described">
            <Label>
                <Name>Soccer shots on goal</Name>
            </Label>
            <Collection xsi:type="ContentCollectionType">
                <Content xsi:type="ImageType">
                    <Image>
                        <MediaLocator xsi:type="ImageLocatorType">
                            <MediaUri>soccer1.jpg</MediaUri>
                        </MediaLocator>
                    </Image>
                </Content>
                <Content xsi:type="ImageType">
                    <Image>
                        <MediaLocator xsi:type="ImageLocatorType">
                            <MediaUri>soccer2.jpg</MediaUri>
                        </MediaLocator>
                    </Image>
                </Content>
                <Content xsi:type="ImageType">
                    <Image>
                        <MediaLocator xsi:type="ImageLocatorType">
                            <MediaUri>soccer3.jpg</MediaUri>
                        </MediaLocator>
                    </Image>
                </Content>
                <Content xsi:type="ImageType">
                    <Image>
                        <MediaLocator xsi:type="ImageLocatorType">
                            <MediaUri>soccer4.jpg</MediaUri>
                        </MediaLocator>
                    </Image>
                </Content>
            </Collection>
        </Model>
    </Description>
</Mpeg7>
```

The following example illustrates the use of the `CollectionModel DS` for describing a model of a collection of two color descriptions. In this example, the semantic concept "Sunsets" has the function of describing the collection of descriptors.

```
<Mpeg7>
    <Description xsi:type="ModelDescriptionType">
        <Model xsi:type="CollectionModelType" confidence="0.75" reliability="0.5"
            function="describing">
            <Label>
                <Name> Sunsets </Name>
            </Label>
            <Collection xsi:type="DescriptorCollectionType">
                <Descriptor xsi:type="ScalableColorType" numOfCoeff="16"
                    numOfBitplanesDiscarded="0">
                    <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                </Descriptor>
                <Descriptor xsi:type="ScalableColorType" numOfCoeff="16"
                    numOfBitplanesDiscarded="0">
                    <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                </Descriptor>
            </Collection>
        </Model>
    </Description>
</Mpeg7>
```

The following example illustrates the use of the `CollectionModel DS` for describing a collection of of four concepts. The concept collection has a semantic label: "soccer stadium objects", that is, the semantic concept has the function of describing the collection of concepts. In this example, the confidence is 0.75 and reliability is 0.5.

```
<Mpeg7>
    <Description xsi:type="ModelDescriptionType">
        <Model xsi:type="CollectionModelType" confidence="0.75" reliability="0.5"
            function="describing">
            <Label>
                <Name>Soccer stadium objects</Name>
            </Label>
            <Collection xsi:type="ConceptCollectionType">
                <Concept xsi:type="ObjectType">
                    <Label>
                        <Name> Ball </Name>
                    </Label>
                </Concept>
                <Concept xsi:type="ObjectType">
                    <Label>
                        <Name> Goal </Name>
                    </Label>
                </Concept>
                <Concept xsi:type="ObjectType">
                    <Label>
                        <Name> Seats </Name>
                    </Label>
                </Concept>
                <Concept xsi:type="ObjectType">
                    <Label>
                        <Name> Water </Name>
                    </Label>
                </Concept>
            </Collection>
        </Model>
    </Description>
</Mpeg7>
```

3.12.5.3 DescriptorModel DS

3.12.5.3.1 DescriptorModel DS examples

The following example illustrates the use of the DescriptorModel DS for describing a descriptor model of the ScalableColor descriptor. The DescriptorModel DS specifies that the descriptor model is formed from the Coefficients element of the ScalableColor D (defined in ISO/IEC 15938-3). For example, in the DescriptorModel for ScalableColorType, the value of numOfCoefficients="16" is constant in the descriptor model.

```
<mpeg7>
   <Description xsi:type="ModelDescriptionType">
      <Model xsi:type="DescriptorModelType">
         <Descriptor xsi:type="ScalableColorType" numOfCoeff="16"
            numOfBitplanesDiscarded="0">
            <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
         </Descriptor>
         <Field>Coeff</Field>
      </Model>
   </Description>
</Mpeg7>
```

The following example illustrates the use of the DescriptorModel DS for describing a descriptor model of the ContourShape descriptor. The DescriptorModel DS specifies that the descriptor model is formed from the concatenation of six elements of the ContourShape D (defined in ISO/IEC 15938-3). All other elements and attributes not mentioned in the field statements are assumed to be constant in the descriptor models, taking the values specified in the example Descriptors.

```
<Mpeg7>
   <Description xsi:type="ModelDescriptionType">
      <Model xsi:type="DescriptorModelType">
         <Descriptor xsi:type="ContourShapeType">
            <GlobalCurvature> 3 5 </GlobalCurvature>
            <PrototypeCurvature> 4 7 </PrototypeCurvature>
            <HighestPeakY>2</HighestPeakY>
            <Peak peakX="4" peakY="2"/>
            <Peak peakX="3" peakY="5"/>
            <Peak peakX="7" peakY="1"/>
         </Descriptor>
         <Field>GlobalCurvature</Field>
         <Field>PrototypeCurvature</Field>
         <Field>HighestPeakY</Field>
         <Field>Peak</Field>
      </Model>
   </Description>
</Mpeg7>
```

3.12.5.4 ProbabilityModelClass DS

3.12.5.4.1 ProbabilityModelClass DS examples

The following example illustrates the use of the ProbabilityModelClass DS for describing a probability model class that characterizes a class of "Nature scene" images by representing the statistics associated with the color features of the images of that class. For example, the specification below indicates that the Coefficients element of the ScalableColor D (defined in ISO/IEC 15938-3) for the Nature scene images has a centroid or mean value of (0.5, 0.5, …) and a variance of (0.25, 0.75, …).

```
<mpeg7>
   <Description xsi:type="ModelDescriptionType">
      <Model xsi:type="ProbabilityModelClassType" confidence="0.75"
         reliability="0.5">
         <Label>
            <Name>Nature scenes</Name>
         </Label>
```

```
          <DescriptorModel>
             <Descriptor xsi:type="ScalableColorType" numOfCoeff="16"
                numOfBitplanesDiscarded="0">
                <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
             </Descriptor>
             <Field>Coeff</Field>
          </DescriptorModel>
          <ProbabilityModel xsi:type="ProbabilityDistributionType"
confidence="1.0"
             dim="16">
             <Mean mpeg7:dim="16"> 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 </Mean>
             <Variance mpeg7:dim="16"> 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 5
</Variance>
          </ProbabilityModel>
       </Model>
   </Description>
</Mpeg7>
```

The following example illustrates the use of the `ProbabilityModelClass DS` for describing a probability model that characterizes checker patterns using a probability model of `EdgeHistogram D` (see ISO/IEC 15938-3).

```
<Mpeg7>
   <Description xsi:type="ModelDescriptionType">
      <Model xsi:type="ProbabilityModelClassType" confidence="0.75"
         reliability="0.5">
         <Label relevance="0.75">
            <Name>Checker patterns</Name>
         </Label>
         <DescriptorModel>
            <Descriptor xsi:type="EdgeHistogramType">
               <BinCounts> 3 5 2 5 . . . 6 </BinCounts>
            </Descriptor>
            <Field>BinCounts</Field>
         </DescriptorModel>
         <ProbabilityModel xsi:type="ProbabilityDistributionType"
confidence="0.75"
            dim="80">
            <Mean mpeg7:dim="80"> 5 3 9 4 . . . 5 </Mean>
            <Variance mpeg7:dim="80"> 4.5 5.0 8.0 7.5 . . . 5.2 </Variance>
         </ProbabilityModel>
      </Model>
   </Description>
</Mpeg7>
```

The following example illustrates the use of the `ProbabilityModelClass DS` for describing a probability model that characterizes oval shapes using a probability model of `RegionShape D` (see ISO/IEC 15938-3).

```
<Mpeg7>
   <Description xsi:type="ModelDescriptionType">
      <Model xsi:type="ProbabilityModelClassType" confidence="0.75"
         reliability="0.5">
         <Label relevance="0.75">
            <Name> Ovals </Name>
         </Label>
         <DescriptorModel>
            <Descriptor xsi:type="RegionShapeType">
               <MagnitudeOfART> 3 5 2 5 . . . 6 </MagnitudeOfART>
            </Descriptor>
            <Field>MagnitudeOfART</Field>
         </DescriptorModel>
         <ProbabilityModel xsi:type="ProbabilityDistributionType"
confidence="1.0"
```

```
            dim="35">
            <Mean dim="35"> 4 8 6 9 . . . 5 </Mean>
            <Variance dim="35"> 1.3 2.5 5.0 4.5 . . . 3.2 </Variance>
         </ProbabilityModel>
      </Model>
   </Description>
</Mpeg7>
```

The following example illustrates the use of the `ProbabilityModelClass DS` for describing a probability model that characterizes silhouettes using a probability model of `ContourShape D` (see ISO/IEC 15938-3).

```
<Mpeg7>
   <Description xsi:type="ModelDescriptionType">
      <Model xsi:type="ProbabilityModelClassType" confidence="0.75"
         reliability="0.5">
         <Label relevance="0.75">
            <Name> Silhouettes </Name>
         </Label>
         <DescriptorModel>
            <Descriptor xsi:type="ContourShapeType">
               <GlobalCurvature> 3 5 </GlobalCurvature>
               <PrototypeCurvature> 4 7 </PrototypeCurvature>
               <HighestPeakY>2</HighestPeakY>
               <Peak peakX="4" peakY="2"/>
               <Peak peakX="3" peakY="5"/>
               <Peak peakX="7" peakY="1"/>
            </Descriptor>
            <Field>GlobalCurvature</Field>
            <Field>PrototypeCurvature</Field>
            <Field>HighestPeakY</Field>
            <Field>Peak</Field>
         </DescriptorModel>
         <ProbabilityModel xsi:type="ProbabilityDistributionType"
confidence="1.0"
            dim="11">
            <Mean mpeg7:dim="11"> 3 9 7 4 6 9 1 2 6 8 9</Mean>
            <Variance mpeg7:dim="11"> 3.4 5.4 9.1 1.8 2.3 6.5 7.9 1.2 3.4 3.3
1.0
            </Variance>
         </ProbabilityModel>
      </Model>
   </Description>
</Mpeg7>
```


3.12.6 Cluster models

3.12.6.1.1 ClusterModel DS examples

The following example illustrates the use of the `ClusterModel DS` for describing a cluster model consisting of a set of examples of two scalable color descriptions. The cluster models have a semantic label: "Nature scenes". The example describes also the probability model of the `ScalableColor D` (see ISO/IEC 15938-3).

```
<Mpeg7>
   <Description xsi:type="ModelDescriptionType">
      <Model xsi:type="ClusterModelType" confidence="0.75" reliability="0.5">
         <Label>
            <Name> Nature scenes </Name>
         </Label>
         <Collection xsi:type="DescriptorCollectionType">
            <Descriptor xsi:type="ScalableColorType" numOfCoeff="16"
               numOfBitplanesDiscarded="0">
               <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
```

```
            </Descriptor>
            <Descriptor xsi:type="ScalableColorType" numOfCoeff="16"
               numOfBitplanesDiscarded="0">
               <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
            </Descriptor>
         </Collection>
         <DescriptorModel>
            <Descriptor xsi:type="ScalableColorType" numOfCoeff="16"
               numOfBitplanesDiscarded="0">
               <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
            </Descriptor>
            <Field>Coeff</Field>
         </DescriptorModel>
         <ProbabilityModel xsi:type="ProbabilityDistributionType"
confidence="1.0"
            dim="16">
            <Mean mpeg7:dim="16"> 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 </Mean>
            <Variance mpeg7:dim="16"> 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 5
</Variance>
         </ProbabilityModel>
      </Model>
   </Description>
</Mpeg7>
```

3.12.7 Classification models

Information on extraction and use is not provided.

3.12.7.1 ClusterClassificationModel DS

3.12.7.1.1 ClusterClassificationModel examples

The following example illustrates the use of the `ClusterClassificationModel` DS for describing a cluster classification model related to scenes from a soccer game. In this example, the `ClusterClassificationModel` is comprised of two `ClusterModels`. The first `ClusterModel` describes a cluster of two images that form the class with label "Soccer shots on goal". The second `ClusterModel` describes a cluster of two images that form the class with label "Goal scores".

```
<Mpeg7>
   <Description xsi:type="ModelDescriptionType">
      <Model xsi:type="ClusterClassificationModelType" confidence="0.9"
         reliability="0.8" complete="true" redundant="false">
         <ClusterModel confidence="0.75" reliability="0.5">
            <Label>
               <Name> Soccer shots on goal </Name>
            </Label>
            <Collection xsi:type="ContentCollectionType">
               <Content xsi:type="ImageType">
                  <Image>
                     <MediaLocator xsi:type="ImageLocatorType">
                        <MediaUri>soccer1.jpg</MediaUri>
                     </MediaLocator>
                  </Image>
               </Content>
               <Content xsi:type="ImageType">
                  <Image>
                     <MediaLocator xsi:type="ImageLocatorType">
                        <MediaUri>soccer2.jpg</MediaUri>
                     </MediaLocator>
                  </Image>
               </Content>
            </Collection>
         </ClusterModel>
         <ClusterModel confidence="0.9" reliability="0.75">
            <Label>
```

```
                <Name> Goal scores </Name>
            </Label>
            <Collection xsi:type="ContentCollectionType">
                <Content xsi:type="ImageType">
                    <Image>
                        <MediaLocator xsi:type="ImageLocatorType">
                            <MediaUri>soccer3.jpg</MediaUri>
                        </MediaLocator>
                    </Image>
                </Content>
                <Content xsi:type="ImageType">
                    <Image>
                        <MediaLocator xsi:type="ImageLocatorType">
                            <MediaUri>soccer4.jpg</MediaUri>
                        </MediaLocator>
                    </Image>
                </Content>
            </Collection>
        </ClusterModel>
    </Model>
</Description>
</Mpeg7>
```

The following example illustrates the use of the `ClusterClassificationModel` DS for describing a cluster classification model related to images depicting nature scenes. The `ClusterClassificationModel` is comprised of two `ClusterModels`. The first `ClusterModel` describes a collection of two scalable color descriptions that forms the class with label "Sunsets". The second `ClusterModel` describes a collection of two scalable color descriptions that forms the class with label "Nature scenes".

```
<Mpeg7>
    <Description xsi:type="ModelDescriptionType">
        <Model xsi:type="ClusterClassificationModelType" confidence="0.95"
            reliability="0.75" complete="true" redundant="false">
            <ClusterModel confidence="0.8" reliability="0.75">
                <Label relevance="0.75">
                    <Name>Sunsets</Name>
                </Label>
                <Collection xsi:type="DescriptorCollectionType">
                    <Descriptor xsi:type="ScalableColorType" numOfCoeff="16"
                        numOfBitplanesDiscarded="0">
                        <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                    </Descriptor>
                    <Descriptor xsi:type="ScalableColorType" numOfCoeff="16"
                        numOfBitplanesDiscarded="0">
                        <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                    </Descriptor>
                </Collection>
            </ClusterModel>
            <ClusterModel confidence="0.75" reliability="0.5">
                <Label>
                    <Name>Nature scenes</Name>
                </Label>
                <Collection xsi:type="DescriptorCollectionType">
                    <Descriptor xsi:type="ScalableColorType" numOfCoeff="16"
                        numOfBitplanesDiscarded="0">
                        <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                    </Descriptor>
                    <Descriptor xsi:type="ScalableColorType" numOfCoeff="16"
                        numOfBitplanesDiscarded="0">
                        <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
                    </Descriptor>
                </Collection>
```

```
          </ClusterModel>
       </Model>
   </Description>
</Mpeg7>
```

3.12.7.2 ProbabilityClassificationModel DS

3.12.7.2.1 ProbabilityClassificationModel DS examples

The following example illustrates the use of the ProbabilityClassificationModel DS for describing a probability classification model for sunset and nature images. The ProbabilityClassificationModel DS is comprised of two instances of ProbabilityModelClass DS. The first ProbabilityModelClass DS instance specifies a class of scalable color descriptors that forms with label "Sunsets". The second ProbabilityModelClass DS instance specifies a class scalable color descriptors with label "Nature scenes".

```
<Mpeg7>
   <Description xsi:type="ModelDescriptionType">
      <Model xsi:type="ProbabilityClassificationModelType" confidence="0.95"
         reliability="0.75" complete="true" redundant="false">
         <ProbabilityModelClass confidence="0.9" reliability="0.5">
            <Label>
               <Name>Sunsets</Name>
            </Label>
            <DescriptorModel>
               <Descriptor xsi:type="ScalableColorType" numOfCoeff="16"
                  numOfBitplanesDiscarded="0">
                  <Coeff> 4 5 6 7 8 9 0 1 2 3 4 5 6 1 2 3</Coeff>
               </Descriptor>
               <Field>Coeff</Field>
            </DescriptorModel>
            <ProbabilityModel xsi:type="ProbabilityDistributionType"
               confidence="1.0" dim="16">
               <Mean mpeg7:dim="16"> 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 </Mean>
               <Variance mpeg7:dim="16"> 5 6 7 8 9 0 1 2 3 4 5 6 5 2 3 4
               </Variance>
            </ProbabilityModel>
         </ProbabilityModelClass>
         <ProbabilityModelClass confidence="0.9" reliability="0.8">
            <Label>
               <Name>Nature scenes</Name>
            </Label>
            <DescriptorModel>
               <Descriptor xsi:type="ScalableColorType" numOfCoeff="16"
                  numOfBitplanesDiscarded="0">
                  <Coeff> 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 </Coeff>
               </Descriptor>
               <Field>Coeff</Field>
            </DescriptorModel>
            <ProbabilityModel xsi:type="ProbabilityDistributionType"
               confidence="1.0" dim="16">
               <Mean mpeg7:dim="16"> 3 4 5 0 1 2 3 4 5 6 7 8 9 0 1 2 </Mean>
               <Variance mpeg7:dim="16"> 5 6 5 2 3 4 5 6 7 8 9 0 1 2 3 4
               </Variance>
            </ProbabilityModel>
         </ProbabilityModelClass>
      </Model>
   </Description>
</Mpeg7>
```

3.13 User interaction tools

3.13.1 Introduction

This clause specifies the following description tools related to user interaction with multimedia content.

Table 15 - Overview of User Interaction Tools.

Tool	*Functionality*
User Preferences	Tools for describing user preferences pertaining to multimedia content, enabling effective user interaction and personalization of content access and consumption. See clause 3.13.2.
Usage History	Tools for describing usage history of users of multimedia content, enabling effective user interaction and personalization of content access and consumption. See clause 3.13.3.

3.13.2 User preferences

The User Preferences tools are used to specify user's preferences pertaining to filtering, searching and browsing of multimedia content and can be used for personalized viewing and listening. Filtering and search preferences describe, for example, favorite titles, genres, actors and sources of content. This information can be used to find preferred multimedia content by matching it with information in multimedia content descriptions. Browsing preferences, for example, describe preferred views of favorite content, where preferences may be dependent on usage conditions such as available bandwidth or the time the user has to consume the information. This allows the user to navigate and access different views of the content in a personalized manner.

3.13.2.1 UserPreferences DS

3.13.2.1.1 UserPreferences DS examples

An example `UserPreferences` description containing several preferences pertaining to filtering and searching of content is as follows. Note that XML comments indicate description elements that are discussed in more detail in later subclauses.

```
<Mpeg7>
   <Description xsi:type="UserDescriptionType">
      <UserPreferences>
         <UserIdentifier>
            <!-- User preferences identification elements -->
         </UserIdentifier>
         <FilteringAndSearchPreferences>
            <CreationPreferences>
               <Creator>
                  <Role href="urn:mpeg:mpeg7:cs:RoleCS:2001:ACTOR"/>
                  <Agent xsi:type="PersonType">
                     <Name>
                        <GivenName>Harrison</GivenName>
                        <FamilyName>Ford</FamilyName>
                     </Name>
                  </Agent>
               </Creator>
               <DatePeriod>
                  <TimePoint>1995-01-01</TimePoint>
                  <Duration>P1825D</Duration>
               </DatePeriod>
            </CreationPreferences>
            <ClassificationPreferences>
               <Genre><Name>News</Name></Genre>
               <Genre><Name>Sports</Name></Genre>
               <Genre><Name>Documentary</Name></Genre>
            </ClassificationPreferences>
         </FilteringAndSearchPreferences>
         <BrowsingPreferences>
```

```
            <!-- Browsing preference elements -->
         </BrowsingPreferences>
      </UserPreferences>
   </Description>
</Mpeg7>
```

3.13.2.1.2 UserPreferences DS extraction

In general, `UserPreferences` descriptions can be constructed manually or automatically. A `UserPreferences` description may be constructed based on explicit input from the multimedia content user. Alternatively, a `UserPreferences` description may be constructed automatically based on the user's content usage history.

3.13.2.1.3 UserPreferences DS use

In general, the descriptions of the user's preferences can be used to automatically find preferred multimedia content and to present preferred views of the content to the user.

In the following, a method is described for automatic filtering of multimedia content using content descriptions and user preference descriptions. Each individual component of the FilteringAndSearchPreferences DS in the UserPreferences DS corresponds to a test or matching operation against components of descriptions of multimedia content. Examples of individual components are the Role, GivenName, FamilyName, DatePeriod elements and the Genre elements in the example user preference description shown in subclause 3.13.2.1.1.

For example, the name values of each Genre element in this user preference description can be matched against the name values of the Genre element in the following partial content description. Likewise, the date values of the DatePeriod element can be matched against the date value of the Release element of the content description below.

```
<MultiMediaContent>
   <AudioVisual>
      <CreationInformation>
         <Creation>
            <Title xml:lang="en">Afternoon news</Title>
         </Creation>
         <Classification>
            <Genre><Name xml:lang="en">News</Name></Genre>
            <Release date="1998-06-16T21:30+01:00">
               <Country>es</Country>
            </Release>
         </Classification>
      </CreationInformation>
   </AudioVisual>
</MultiMediaContent>
```

After individual preference components are tested, the results of these tests must be combined into a single test result that reflects the user's overall preferences. The individual test results can be combined according to the hierarchy of the UserPreferences description. Each parent test becomes a combination of its children tests, and this continues up the hierarchy, yielding one composite test result. The combination of children tests within a single parent may depend on the types of the elements being tested. For example, the partial user preferences description above specifies a preference for content with an actor having first name "Harrison" and having last name "Ford". Therefore, in this case, an intersection operator can be used to combine the individual test results. As another example, the user preferences description above specifies preferences for multiple genres: "News", "Sports" and "Documentaries". Different multimedia programs, each with a different genre, may each satisfy the individual tests against these genre preferences. Therefore, in this case, a union operator can be used to combine the individual test results.

The combination of the user's preferences and the overall matching result against multimedia content descriptions can be used to rank-order the corresponding multimedia content items and/or to automatically filter the content items.

In general, individual preference components are the elements and attributes of the `CreationPreferences` DS, the `ClassificationPreferences` DS, the `SourcePreferences` DS and the `SummaryPreferences` DS. The following tables provide a more complete mapping from individual

elements (and attributes) of a user preference description to individual elements (and attributes) of content descriptions. The first column of each table specifies the name of an element (or attribute) of a user preference description. The second column of each table specifies the name(s) of one or more elements (or attributes) of a content description that the preference element (or attribute) maps to. Note that elements in both the first and second columns of each table may contain further children elements (or attributes) that may be including in the mapping implicitly.

Note: This mapping is an example mapping and is not normative.

Table 16 - Informative mapping of elements (and attributes) from UserPreferences/FilteringAndSearchPreferences/CreationPreferences to elements (and attributes) of a content description.

Element/attribute Name	*Mapping*
Title	CreationInformation/Creation/Title
Creator	CreationInformation/Creation/Creator
Keyword	CreationInformation/Creation/Title CreationInformation/Creation/Abstract
Location	CreationInformation/Creation/CreationCoordinates/Location
DatePeriod	CreationInformation/Creation/CreationCoordinates/Date
Tool	CreationInformation/Creation/CreationTool/Tool

Table 17 - Informative mapping of elements (and attributes) from UserPreferences/FilteringAndSearchPreferences/ClassificationPreferences to elements (and attributes) of a content description.

Element/attribute Name	*Mapping*
Country	CreationInformation/Classification/Release/Region
DatePeriod	CreationInformation/Classification/Release/date
LanguageFormat	CreationInformation/Classification/Language CreationInformation/Classification/CaptionLanguage CreationInformation/Classification/SignLanguage
Language	CreationInformation/Classification/Language
CaptionLanguage	CreationInformation/Classification/CaptionLanguage
Form	CreationInformation/Classification/Form
Genre	CreationInformation/Classification/Genre
Subject	CreationInformation/Classification/Subject
Review	CreationInformation/Classification/MediaReview
ParentalGuidance	CreationInformation/Classification/ParentalGuidance

Table 18 - Informative mapping of elements (and attributes) from UserPreferences/FilteringAndSearchPreferences/SourcePreferences to elements (and attributes) of a content description.

Element/attribute Name	*Mapping*
DisseminationFormat	UsageInformation/Availability/Dissemination/Format
DisseminationSource	UsageInformation/Availability/Dissemination/Source
DisseminationLocation	UsageInformation/Availability/Dissemination/Location
DisseminationDate	UsageInformation/Availability/AvailabilityPeriod

Element/attribute Name	*Mapping*
Disseminator	UsageInformation/Availability/Dissemination/Disseminator
MediaFormat	MediaInformation/MediaProfile/MediaFormat
noRepeat	UsageInformation/Availability/AvailabilityPeriod/type
noEncryption	UsageInformation/Availability/AvailabilityPeriod/type
noPayPerUse	UsageInformation/Availability/AvailabilityPeriod/type

Table 19 - Informative mapping of elements (and attributes) from UserPreferences/BrowsingPreferences/SummaryPreferences to elements (and attributes) of a content description.

Element/attribute Name	*Mapping*
SummaryType	HierarchicalSummary/components SequentialSummary/components
SummaryTheme	HierarchicalSummary/SummaryThemeList/SummaryTheme SequentialSummary/TextualSummaryComponent/FreeText
SummaryDuration	HierarchicalSummary/SummarySegmentGroup/duration
MinSummaryDuration	HierarchicalSummary/SummarySegmentGroup/duration
MaxSummaryDuration	HierarchicalSummary/SummarySegmentGroup/duration
NumOfKeyFrames	HierarchicalSummary/SummarySegmentGroup/numOfKeyFrames
MinNumOfKeyFrames	HierarchicalSummary/SummarySegmentGroup/numOfKeyFrames
MaxNumOfKeyFrames	HierarchicalSummary/SummarySegmentGroup/numOfKeyFrames
NumOfChars	CreationInformation/Creation/Abstract/FreeTextAnnotation
MinNumOfChars	CreationInformation/Creation/Abstract/FreeTextAnnotation
MaxNumOfChars	CreationInformation/Creation/Abstract/FreeTextAnnotation

3.13.2.2 UserIdentifier datatype

3.13.2.2.1 UserIdentifier datatype examples

The `UserIdentifier` datatype may be used to identify a particular user preference description and distinguish it from other user preference descriptions. The `Name` element may contain the user's actual name, a nickname, a user's account name or email address, or any other name. The same user may have multiple user preference descriptions, each identified by a different value of `Name`, for use under different usage conditions. Also, a group of persons can use a single set of user preferences, using a single identifier for the group. The following partial example illustrates a description owned by user "Jane", who desires to keep the identifier part of this description private.

```
<UserPreferences>
   <UserIdentifier protected="true">
      <Name xml:lang="en">Jane</Name>
   </UserIdentifier>
   <FilteringAndSearchPreferences protected="true">
      <!-- Filtering and search preference elements -->
   </FilteringAndSearchPreferences>
   <BrowsingPreferences protected="true">
      <!-- Browsing preference elements -->
   </BrowsingPreferences>
</UserPreferences>
```

3.13.2.3 FilteringAndSearchPreferences DS

3.13.2.3.1 FilteringAndSearchPreferences DS examples

The FilteringAndSearchPreferences DS and its main parts, the CreationPreferences DS, ClassificationPreferences DS and SourcePreferences DS, are container preference components that group individual preference components.

In general, the FilteringAndSearchPreferences DS may be used to search or filter multimedia content by matching the values of components of the filtering and search preferences to the values of parts of descriptions of multimedia content. For instance, the values of CreationPreferences may be matched to instances of the Creation DS as defined in subclause 9.1.2. The values of ClassificationPreferences may be matched to instances of the Classification DS as defined in subclause 9.1.3. The values of SourcePreferences may be matched to instances of the MediaInformation DS, CreationInformation DS or UsageInformation DS as defined in clauses 8, 9 and 10.

Each individual component of the FilteringAndSearchPreferences DS corresponds to a test or matching operation by a content filtering or search application against components of descriptions of multimedia content. The FilteringAndSearchPreferences DS by itself does not imply any specific normative behavior of such an application regarding the combination of individual preference components. The most basic behavior of an application would be consistent with viewing the structure of the FilteringAndSearchPreferences DS as a simple aggregation of individual preference components. However, the structure of the DS strongly suggests restrictions on the behavior expected from such an application by the user, with regard to combinations of preference components. A few examples are discussed in the following.

For example, when multiple sibling elements of the same type are present in a user preference description, such as the multiple Genre elements in the following description, an application may tend to favor multimedia content matching the first Genre ("Daily news") or the second Genre ("Sports"). Note that the exact behavior may also be made to depend on whether the particular element in the user preference description can be present only once in the content description or not.

```
<FilteringAndSearchPreferences>
   <ClassificationPreferences>
      <Genre href="urn:mpeg:mpeg7:cs:GenreCS:2001:1.3.1">
         <Name>Daily news</Name>
      </Genre>
      <Genre href="urn:mpeg:mpeg7:cs:GenreCS:2001:1.6">
         <Name>Sports</Name>
      </Genre>
   </ClassificationPreferences>
</FilteringAndSearchPreferences>
```

As another example, in the presence of a negative preferenceValue, such as for one Genre element among multiple sibling Genre preference elements, an application may tend to suppress multimedia content matching the first Genre ("Daily news") and favor multimedia content that matches the Genre with a positive preferenceValue ("Sports").

```
<FilteringAndSearchPreferences>
   <ClassificationPreferences>
      <Genre preferenceValue="-10" href="urn:mpeg:mpeg7:cs:GenreCS:2001:1.3.1">
         <Name>Daily news</Name>
      </Genre>
      <Genre preferenceValue="10" href="urn:mpeg:mpeg7:cs:GenreCS:2001:1.6">
         <Name>Sports</Name>
      </Genre>
   </ClassificationPreferences>
</FilteringAndSearchPreferences>
```

Furthermore, when multiple sibling elements of different types are present in a description, such as the Genre and Language elements in the following description, an application may tend to favor multimedia content matching the Genre ("Daily news") and with the correct Language ("en") over content that satisfies only one (or none) of the tests.

```
<FilteringAndSearchPreferences>
   <ClassificationPreferences>
      <Language>en</Language>
      <Genre href="urn:mpeg:mpeg7:cs:GenreCS:2001:1.3.1">
         <Name>Daily news </Name>
      </Genre>
   </ClassificationPreferences>
</FilteringAndSearchPreferences>
```

The following is an example using the hierarchical structure of the FilteringAndSearchPreferences DS and using multiple preferenceValue attributes. The preferenceValue attributes express the weight of a user preference component (and its content) relative to other components. This example contains three sibling FilteringAndSearchPreferences elements, each of which contains preferences on the genre of multimedia content, indicating that the user prefers content of genre "news" over content of genre "documentary" or "sports". However, within the "news" genre, the user has a preference for a particular presenter over another presenter, as indicated by the child FilteringAndSearchPreferences element and the preferenceValue attributes of sibling Creator elements. And within the "sports" genre, the user has a higher preference for "soccer" than for "baseball", as indicated by the child FilteringAndSearchPreferences element and the preferenceValue attributes of sibling Genre elements.

An application may attempt to match this example description against a description of multimedia content by using a bottom-up procedure. That is, the application may attempt to match the leaf Creator and leaf Genre elements first, resulting in individual matching scores. Then, matching scores among sibling children components may be weighed by the preference values, combined, and propagated to their parent component (in this case, CreationPreferences or ClassificationPreferences components). This procedure can be repeated across the hierarchy, finally resulting in a composite matching score for a content description.

```
<FilteringAndSearchPreferences preferenceValue="90">
   <SourcePreferences>
      <DisseminationSource>KBS1</DisseminationSource>
   </SourcePreferences>
   <FilteringAndSearchPreferences preferenceValue="80">
      <ClassificationPreferences>
         <Genre href="urn:mpeg:mpeg7:cs:GenreCS:2001:1.3.1">
            <Name>Daily news</Name>
         </Genre>
      </ClassificationPreferences>
      <FilteringAndSearchPreferences>
         <CreationPreferences>
            <Creator preferenceValue="70">
               <Role href="urn:mpeg:mpeg7:cs:RoleCS:2001:ANCHOR"/>
               <Agent xsi:type="PersonType">
                  <Name><GivenName>Tom Brokite</GivenName></Name>
               </Agent>
            </Creator>
            <Creator preferenceValue="90">
               <Role href="urn:mpeg:mpeg7:cs:RoleCS:2001:ANCHOR"/>
               <Agent xsi:type="PersonType">
                  <Name><GivenName>Jerry Pack</GivenName></Name>
               </Agent>
            </Creator>
         </CreationPreferences>
      </FilteringAndSearchPreferences>
   </FilteringAndSearchPreferences>
   <FilteringAndSearchPreferences preferenceValue="70">
      <ClassificationPreferences>
         <Genre href="urn:mpeg:mpeg7:cs:GenreCS:2001:1.13">
            <Name>Documentary</Name>
         </Genre>
      </ClassificationPreferences>
   </FilteringAndSearchPreferences>
```

```
    <FilteringAndSearchPreferences preferenceValue="60">
        <ClassificationPreferences>
            <Genre href="urn:mpeg:mpeg7:cs:GenreCS:2001:1.6">
                <Name>Sports</Name>
            </Genre>
        </ClassificationPreferences>
        <FilteringAndSearchPreferences>
            <ClassificationPreferences>
                <Genre preferenceValue="60"
                    href="urn:mpeg:mpeg7:cs:GenreCS:2001:1.6.65">
                    <Name>Soccer</Name>
                </Genre>
                <Genre preferenceValue="50"
                    href="urn:mpeg:mpeg7:cs:GenreCS:2001:1.6.8">
                    <Name>Baseball</Name>
                </Genre>
            </ClassificationPreferences>
        </FilteringAndSearchPreferences>
    </FilteringAndSearchPreferences>
</FilteringAndSearchPreferences>
```

It should be noted that the specific method for testing individual components is not normative and may involve (sub)string matching, numerical comparisons, counting and other operations. Here, it is the syntax and semantics of the individual components that strongly suggest restrictions on the set of useful test operators to be used by a search or filtering application. For example, if the `Genre` name is represented in textual form, an application may use some form of case-insensitive string matching of the user preference element against the value of the appropriate element of a program description. Matching date values, on the other hand, may require numerical comparison operations.

Note further that a filtering or search application may test a single component of the `UserPreferences` DS against one or more components of the content description. For example, a `Title` element of the `CreationPreferences` DS may naturally be tested against the `Title` value of the content description. On the other hand, a key phrase specified with the `Keyword` element in the same DS may be matched with multiple textual components of content descriptions, such as the title, abstract or others. The specific matching methodology is non-normative and depends on the user's search or filtering application; however, not all choices make sense.

The `PreferenceCondition` element of the `FilteringAndSearchPreferences` DS can be used to describe a time or place or a time and place combination that can be associated with a particular set of browsing, filtering and search preferences. For example, a user may have preferences for different broadcast sports programs during different seasons of the year. Similarly, a user may have preference for programs in English language when the user is traveling in Japan. The following example highlights the case where the user's stated genre preferences apply every day during primetime hours (8PM to 11PM).

```
<UserPreferences>
    <FilteringAndSearchPreferences>
        <ClassificationPreferences>
            <Genre href="urn:mpeg:mpeg7:cs:GenreCS:2001:2.1.2">
                <Name>Comedy</Name>
            </Genre>
        </ClassificationPreferences>
        <PreferenceCondition>
            <Time recurrence="daily">
                <TimePoint>T20:00+01:00</TimePoint>
                <Duration>PT3H</Duration>
            </Time>
        </PreferenceCondition>
    </FilteringAndSearchPreferences>
</UserPreferences>
```

In the next example, the preferences of a user who is interested in a yearly recurring basketball tournament (lasting one week) can be given by the following `PreferenceCondition` instance.

```
<UserPreferences>
    <FilteringAndSearchPreferences>
        <ClassificationPreferences>
            <Genre href="urn:mpeg:mpeg7:cs:GenreCS:2001:1.6.9">
                <Name>Basketball</Name>
            </Genre>
        </ClassificationPreferences>
        <PreferenceCondition>
            <Time recurrence="annually" numOfRecurrences="5">
                <TimePoint>2001-03-28T8:00</TimePoint>
                <Duration>P7D</Duration>
            </Time>
        </PreferenceCondition>
    </FilteringAndSearchPreferences>
</UserPreferences>
```

3.13.2.4 CreationPreferences DS

3.13.2.4.1 CreationPreferences DS examples

The `CreationPreferences` DS can be used to specify the user's preferred content titles, creators, creation dates and places, keywords or a creation tool. In the following example, the user is expressing preference for content that is created between the years 1995 and 2000 (1825 days) and describes preferred actors or actresses, each with a relative `preferenceValue` attribute. The keywords "internet" and "world wide web" indicate a preference for content dealing with those topics in particular.

```
<UserPreferences>
    <FilteringAndSearchPreferences>
        <CreationPreferences>
            <Creator preferenceValue="18">
                <Role href="urn:mpeg:mpeg7:cs:RoleCS:2001:ACTOR"/>
                <Agent xsi:type="PersonType">
                    <Name>
                        <GivenName>Meg</GivenName>
                        <FamilyName>Ryan</FamilyName>
                    </Name>
                </Agent>
            </Creator>
            <Creator preferenceValue="19">
                <Role href="urn:mpeg:mpeg7:cs:RoleCS:2001:ACTOR"/>
                <Agent xsi:type="PersonType">
                    <Name>
                        <GivenName>Cameron</GivenName>
                        <FamilyName>Diaz</FamilyName>
                    </Name>
                </Agent>
            </Creator>
            <Creator preferenceValue="20">
                <Role href="urn:mpeg:mpeg7:cs:RoleCS:2001:ACTOR"/>
                <Agent xsi:type="PersonType">
                    <Name>
                        <GivenName>Harrison</GivenName>
                        <FamilyName>Ford</FamilyName>
                    </Name>
                </Agent>
            </Creator>
            <Keyword>internet</Keyword>
            <Keyword>world wide web</Keyword>
            <DatePeriod>
                <TimePoint>1995-01-01</TimePoint>
                <Duration>P1825D</Duration>
            </DatePeriod>
        </CreationPreferences>
    </FilteringAndSearchPreferences>
</UserPreferences>
```

The following example indicates a preference for a particular actor, playing a particular character.

```
<UserPreferences>
    <FilteringAndSearchPreferences>
        <CreationPreferences>
            <Creator>
                <Role href="urn:mpeg:mpeg7:cs:RoleCS:ACTOR"/>
                <Agent xsi:type="PersonType">
                    <Name>
                        <GivenName>Clint</GivenName>
                        <FamilyName>Eastwood</FamilyName>
                    </Name>
                </Agent>
                <Character>
                    <GivenName>Dirty Harry</GivenName>
                </Character>
            </Creator>
        </CreationPreferences>
    </FilteringAndSearchPreferences>
</UserPreferences>
```

3.13.2.5 ClassificationPreferences DS

3.13.2.5.1 ClassificationPreferences DS examples

The `ClassificationPreferences` DS can be used to specify the user's preferred language or a favorite genre (e.g., "science-fiction movies", "business news" or "pop-music") or preferred country of origin (e.g. music from France). In the following example, the user prefers news programs with closed captions in English, when he/she is in Japan. In this example, the user also prefers movies that are spoken in English and have been reviewed by Roger Ebert and rated at 10 (where 10 is the best rating) and have a PG-13 parental rating label according to the MPAA (Motion Picture Association of America) rating scheme. Multiple instantiations of `ClassificationPreferences` can be ranked by the application according to the values of their individual `preferenceValue` attributes.

```
<UserPreferences allowAutomaticUpdate="false">
    <FilteringAndSearchPreferences>
        <ClassificationPreferences preferenceValue="10">
            <LanguageFormat>closedCaptions</LanguageFormat>
            <CaptionLanguage>en</CaptionLanguage>
            <Genre href="urn:mpeg:mpeg7:cs:GenreCS:2001:1.3.1">
                <Name>Daily news</Name>
            </Genre>
        </ClassificationPreferences>
        <ClassificationPreferences preferenceValue="12">
            <Language>en</Language>
            <Genre href="urn:mpeg:mpeg7:cs:GenreCS:2001:8">
                <Name>Movies</Name>
            </Genre>
            <Review>
                <Rating>
                    <RatingValue>10</RatingValue>
                    <RatingScheme best="10" worst="1" style="higherBetter"/>
                </Rating>
                <Reviewer xsi:type="PersonType">
                    <Name>
                        <FamilyName>Ebert</FamilyName>
                        <GivenName>Roger</GivenName>
                    </Name>
                </Reviewer>
            </Review>
            <ParentalGuidance>
                <ParentalRating
                    href="urn:mpeg:mpeg7:cs:MPAAParentalRatingCS:2001:PG-13">
```

```
                <Name>PG-13</Name>
            </ParentalRating>
            <Region>us</Region>
        </ParentalGuidance>
    </ClassificationPreferences>
    <PreferenceCondition>
        <Place>
            <Name xml:lang="en">Japan</Name>
            <Region>jp</Region>
        </Place>
    </PreferenceCondition>
  </FilteringAndSearchPreferences>
</UserPreferences>
```

3.13.2.6 SourcePreferences DS

3.13.2.6.1 SourcePreferences DS examples

The SourcePreferences DS can be used to specify preference for sources of the content, e.g. terrestrial versus satellite. If the user has access to broadcast only, the user may not be interested in program offerings from the satellite channels. In the following example, the user has a preference for "Star Trek" programs, and content that is available from terrestrial broadcast on the day of May 23, 2000. The user has a particular preference for programs from BBC 1 and prefers content provided by the BBC in general. Such a description is useful in creating personalized electronic program guides.

```
<UserPreferences>
  <FilteringAndSearchPreferences>
    <CreationPreferences>
      <Title xml:lang="en" type="original">Star Trek</Title>
    </CreationPreferences>
    <SourcePreferences>
      <DisseminationFormat
href="urn:mpeg:mpeg7:cs:DisseminationFormatCS:2001:1">
        <Name>Terrestrial</Name>
      </DisseminationFormat>
      <DisseminationSource>BBC 1</DisseminationSource>
      <DisseminationDate>
        <TimePoint>2000-05-23</TimePoint>
      </DisseminationDate>
      <Disseminator>
        <Role href="urn:mpeg:mpeg7:cs:RoleCS:2001:PUBLISHER"/>
        <Agent xsi:type="OrganizationType><Name>BBC</Name></Agent>
      </Disseminator>
    </SourcePreferences>
  </FilteringAndSearchPreferences>
</UserPreferences>
```

The MediaFormat DS can be used to describe user's preference for desired media formats, which may be dictated, in some cases, by the resources available to the user. In the following example, the user has a preference for MPEG format and widescreen aspect ratio (2.35:1) for video, and a preference for DTS, for the audio coding format. The user's second preference is for full screen (1.33:1) aspect ratio for video, and Dolby AC-3 for the audio coding format.

```
<UserPreferences allowAutomaticUpdate="false">
  <FilteringAndSearchPreferences>
    <SourcePreferences>
      <MediaFormat preferenceValue="15">
        <Content href="urn:mpeg:mpeg7:cs:ContentCS:2001:2">
          <Name>audiovisual</Name>
        </Content>
        <FileFormat href="urn:mpeg:mpeg7:cs:FileFormatCS:2001:3">
          <Name>mpg</Name>
        </FileFormat>
        <VisualCoding>
```

```
                <Frame aspectRatio="2.35"/>
            </VisualCoding>
            <AudioCoding>
                <Format href="urn:mpeg:mpeg7:cs:AudioCodingFormatCS:2001:2">
                    <Name>DTS</Name>
                </Format>
            </AudioCoding>
        </MediaFormat>
        <MediaFormat preferenceValue="12">
            <Content href="urn:mpeg:mpeg7:cs:ContentCS:2001:2">
                <Name>audiovisual</Name>
            </Content>
            <FileFormat href="urn:mpeg:mpeg7:cs:FileFormatCS:2001:3">
                <Name>mpg</Name>
            </FileFormat>
            <VisualCoding>
                <Frame aspectRatio="1.33"/>
            </VisualCoding>
            <AudioCoding>
                <Format href="urn:mpeg:mpeg7:cs:AudioCodingFormatCS:2001:1">
                    <Name>AC-3</Name>
                </Format>
            </AudioCoding>
        </MediaFormat>
    </SourcePreferences>
</FilteringAndSearchPreferences>
</UserPreferences>
```

3.13.2.7 BrowsingPreferences DS

3.13.2.7.1 BrowsingPreferences DS examples

The `BrowsingPreferences` DS and its main part, the `SummaryPreferences` DS, are container preference components that group individual preference components.

The following is a simple example of a `UserPreferences` description with `BrowsingPreferences` that apply only during a particular period of time, in Seoul, and only for content matching the "Daily news" genre. Also, the user wishes to keep the information in the `UserIdentifier` and `BrowsingPreferences` private as indicated by the protected attribute.

```
<UserPreferences allowAutomaticUpdate="false">
    <UserIdentifier protected="true">
        <Name xml:lang="en">Yoon</Name>
    </UserIdentifier>
    <BrowsingPreferences protected="true">
        <SummaryPreferences>
            <!-- Summary preference elements -->
        </SummaryPreferences>
        <PreferenceCondition>
            <Place><Name xml:lang="en">Seoul</Name></Place>
            <Time recurrence="daily">
                <TimePoint>T21:00+09:00</TimePoint>
                <Duration>PT1H</Duration>
            </Time>
            <Genre href="urn:mpeg:mpeg7:cs:GenreCS:2001:1.3.1">
                <Name>Daily news</Name>
            </Genre>
        </PreferenceCondition>
    </BrowsingPreferences>
</UserPreferences>
```

3.13.2.8 SummaryPreferences DS

3.13.2.8.1 SummaryPreferences DS examples

A simple example is given as follows, where the user is interested in viewing particular events in sports programs.

```
<UserPreferences>
    <BrowsingPreferences>
        <SummaryPreferences>
            <SummaryType>keyThemes</SummaryType>
            <SummaryTheme>Free-kicks</SummaryTheme>
            <SummaryTheme>Goals</SummaryTheme>
        </SummaryPreferences>
    </BrowsingPreferences>
</UserPreferences>
```

A user may prefer a key-frame summary containing a limited number of key frames over a video highlight summary during a usage mode with low-bandwidth mobile connection to a media server. Similarly, a user may prefer audio skims of a particular duration as he/she receives the information in his/her car. An example where a user prefers to visualize summaries based on key video clips with a duration between 5 and 10 minutes while in the office, but prefers a visualization based on a limited number of key frames (less than 50) while on the train or in the car, is as follows.

```
<UserPreferences allowAutomaticUpdate="false">
    <UserIdentifier protected="true">
        <Name xml:lang="en">Mike</Name>
    </UserIdentifier>
    <BrowsingPreferences protected="true">
        <SummaryPreferences>
            <SummaryType>keyVideoClips</SummaryType>
            <MinSummaryDuration>PT5M</MinSummaryDuration>
            <MaxSummaryDuration>PT10M</MaxSummaryDuration>
        </SummaryPreferences>
        <PreferenceCondition>
            <Place>
                <Name xml:lang="en">Office</Name>
            </Place>
            <Time recurrence="daily">
                <TimePoint>T08:00+01:00</TimePoint>
                <Duration>PT8H</Duration>
            </Time>
        </PreferenceCondition>
    </BrowsingPreferences>
    <BrowsingPreferences protected="true">
        <SummaryPreferences>
        <SummaryType>keyFrames</SummaryType>
            <MaxNumOfKeyFrames>50</MaxNumOfKeyFrames>
        </SummaryPreferences>
        <PreferenceCondition>
            <Place>
                <Name xml:lang="en">Train</Name>
            </Place>
        </PreferenceCondition>
        <PreferenceCondition>
            <Place>
                <Name xml:lang="en">Car</Name>
            </Place>
        </PreferenceCondition>
    </BrowsingPreferences>
</UserPreferences>
```

3.13.3 Usage History

Usage History tools are used to describe usage history information gathered over extended periods of time. The collected usage history provides a list of the actions carried out by a user during an observation period on multimedia content, and can subsequently be used for personalized searching, filtering and browsing or making recommendations to a user.

3.13.3.1 UsageHistory DS

3.13.3.1.1 UsageHistory DS examples

The following is an example of a usage history description for user "John Doe," who desires to keep the identifier part of this description private, and allows tracking of his consumption habits. The description contains user actions of type "PlayStream", and the description of the first user action identifies the multimedia content subject to the action.

```
<Mpeg7>
   <Description xsi:type="UserDescriptionType">
      <UsageHistory allowCollection="true">
         <UserIdentifier protected="true">
            <Name>John Doe</Name>
         </UserIdentifier>
         <UserActionHistory>
            <!-- User action history description -->
            <UserActionList>
               <ActionType
                  href="urn:mpeg:mpeg7:cs:ActionTypeCS:2001:1.2">
                  <Name>PlayStream</Name>
               </ActionType>
               <UserAction>
                  <ProgramIdentifier>
                     urn:mycontent:av:01-mnf-100900
                  </ProgramIdentifier>
               </UserAction>
               <!-- More user actions -->
         </UserActionHistory>
      </UsageHistory>
   </Description>
</Mpeg7>
```


3.13.3.1.2 UsageHistory DS extraction

In general, UsageHistory descriptions can be constructed automatically, based on the actions that users of multimedia content have carried out over specified periods of time. Such a UsageHistory description can be constructed by simply logging the interaction of a user with a multimedia system and the actions of the user with respect to the multimedia content.

For example, an interactive TV device may keep track of the TV programs that a user watches, and what actions (such as viewing, pausing, rewinding) the user performs at what time. An example of a chronologically ordered log of user actions is illustrated in Table 20. Each program in this log is assigned a unique ProgramIdentifier to enable unambiguous referencing. This identifier, and other information about the program, such as the program title, can be obtained from electronic program guides and/or other sources of content description.

Table 20 - Chronologically ordered list of user actions for 10/09/00.

Start Time	Duration	Action	Program Title	Program Identifier
18:45:55	0:19:07	PlayStream	Monday Night Football	02-mnf-100900
18:48:01	N/A	ClickThrough	Monday Night Football	02-mnf-100900
19:05:10	0:02:44	Pause	Monday Night Football	02-mnf-100900
19:07:54	0:02:18	PlayStream	Monday Night Football	02-mnf-100900
19:10:12	0:00:08	FFWD	Monday Night Football	02-mnf-100900
19:10:20	0:09:49	PlayStream	Monday Night Football	02-mnf-100900

19:20:09	0:00:09	Rewind	Monday Night Football	02-mnf-100900
19:32:23	0:27:39	PlayStream	Drew Carey Show	03-dcs-000084
19:55:13	0:05:44	Mute	Drew Carey Show	03-dcs-000084
20:01:10	0:11:04	PlayStream	King of Queens	03-tkoq-000046
20:12:28	0:04:56	PlayStream	Antiques Roadshow	08-ar-000123
20:17:30	0:08:28	PlayStream	King of Queens	03-tkoq-000046
20:27:02	0:25:49	PlayStream	Antiques Roadshow	08-ar-000123
20:53:02	0:05:15	PlayStream	Tucker	03-tkr-000002
21:00:33	0:27:27	PlayStream	Everybody Loves Raymond	03-elr-000074
21:12:35	0:03:51	Mute	Everybody Loves Raymond	03-elr-000074
21:30:10	0:25:14	PlayStream	Becker	03-bec-000062
21:55:00	1:10:00	Record	Family Law	04-flw-000048
21:55:44	N/A	Off	N/A	N/A
23:04:10	N/A	On	N/A	N/A
23:04:27	0:18:14	PlayStream	Channel 2 News	01-katu-100900:2300
23:24:01	0:08:15	PlayStream	KOIN 6 News at 11	01-koin-100900:2300
23:34:20	0:25:40	PlayStream	Late Show	06-lsdl-002321

3.13.3.1.3 UsageHistory DS use

In general, UsageHistory descriptions may be used directly for personalized searching, filtering and browsing, or may be mapped to a description of the user's preferences.

3.13.3.2 UserActionHistory DS

3.13.3.2.1 UserActionHistory DS examples

This example illustrates the use of the `ObservationPeriod` element to describe the time interval during which the accompanying user action history information was collected. The specified time interval can comprise multiple discrete observation periods. In this case, the user's activities were observed between 6PM-12PM PST on 10/09/2000 and 10/10/2000. The user would like to keep his identity protected, but does not mind distribution of his user action history to other parties.

```
<Mpeg7>
   <Description xsi:type="UserDescriptionType">
      <UsageHistory id="usage-history-002" allowCollection="true">
         <UserIdentifier protected="true">
            <Name xml:lang="en">John Doe</Name>
         </UserIdentifier>
         <UserActionHistory id="useraction-history-001" protected="false">
            <ObservationPeriod>
               <TimePoint>2000-10-09T18:00-08:00</TimePoint>
               <Duration>PT6H</Duration>
            </ObservationPeriod>
            <ObservationPeriod>
               <TimePoint>2000-10-10T18:00-08:00</TimePoint>
               <Duration>PT6H</Duration>
            </ObservationPeriod>
            <UserActionList>
               <!-- user action list (sequence of user actions) -->
            </UserActionList>
         </UserActionHistory>
      </UsageHistory>
   </Description>
</Mpeg7>
```

3.13.3.3 UserActionList DS

3.13.3.3.1 UserActionList DS examples

The following example depicts two instantiations of the `UserActionList` DS as part of the `UsageHistory`, for "Record" and "PlayStream" actions. The example offers alternative representations of user actions by instantiating a subset of the available set of description schemes. Specifically, more comprehensive information is provided for the "Record" action, with each individual `UserAction` instantiated. For the "PlayStream" action, on the other hand, only the number of instances and the total duration is provided, which reduces the size of the description significantly. The description scheme allows differentiation between various types of actions, and provide the means for implementers to instantiate each action type in a specific way.

```
<Mpeg7>
    <Description xsi:type="UserDescriptionType">
        <UsageHistory id="usage-history-003" allowCollection="true">
            <UserIdentifier protected="true">
                <Name xml:lang="en">John Doe</Name>
            </UserIdentifier>
            <UserActionHistory id="useraction-history-002" protected="false">
                <ObservationPeriod>
                    <TimePoint>2000-10-09T18:00-08:00</TimePoint>
                    <Duration>PT6H</Duration>
                </ObservationPeriod>
                <UserActionList numOfInstances="2" totalDuration="PT2H30M">
                    <ActionType
                        href="urn:mpeg:mpeg7:cs:ActionTypeCS:2001:1.3">
                        <Name>Record</Name>
                    </ActionType>
                    <UserAction>
                        <!-- user action description -->
                    </UserAction>
                    <UserAction>
                        <!-- user action description -->
                    </UserAction>
                </UserActionList>
                <UserActionList numOfInstances="25" totalDuration="PT1H2M">
                    <ActionType
                        href="urn:mpeg:mpeg7:cs:ActionTypeCS:2001:1.2">
                        <Name>PlayStream</Name>
                    </ActionType>
                </UserActionList>
            </UserActionHistory>
        </UsageHistory>
    </Description>
</Mpeg7>
```

3.13.3.4 UserAction DS

3.13.3.4.1 UserAction DS examples

The following example highlights instantiations of the `UserAction` DS, and the functionality provided by the `ActionTime` DS. `MediaTime` and `GeneralTime` elements are different for user actions such as "Rewind," "FastForward" and "SlowMotion." For example, as shown in the example, a "FastForward" action that lasts only a few seconds in terms of general time may actually correspond to several minutes in terms of the media time base. Relying only on the general time to represent the time of occurrence and duration of an action may lead to inconsistencies and ambiguity. Thus the proposed syntax supports representation of `ActionTime` in terms of both media time and general time.

The `ActionDataItem` element can be used in two main capacities: (i) to refer to a specific part of a content description (such as the description of a segment that the user reviews in slow motion); and (ii) to provide a reference to related content material through the `RelatedMaterial` element of the `CreationMetaInformation` description scheme. In the first case, a usage history processor may, for example, use these references to keep local copies of the content description relevant to an action. An

example of the second functionality is illustrated below for the "ClickThrough" action, where a user follows a URL that is defined as part of the `RelatedMaterial` DS.

```
<Mpeg7>
   <Description xsi:type="UserDescriptionType">
      <UsageHistory id="usage-history-004" allowCollection="true">
         <UserIdentifier protected="true">
            <Name xml:lang="en">John Doe</Name>
         </UserIdentifier>
         <UserActionHistory id="useraction-history-003" protected="false">
            <ObservationPeriod>
               <TimePoint>2000-10-09T18:00-08:00</TimePoint>
               <Duration>PT6H</Duration>
            </ObservationPeriod>
            <ObservationPeriod>
               <TimePoint>2000-10-10T18:00-08:00</TimePoint>
               <Duration>PT6H</Duration>
            </ObservationPeriod>
            <UserActionList id="ua-list-003"
               numOfInstances="2" totalDuration="PT2H30M">
               <ActionType
                  href="urn:mpeg:mpeg7:cs:ActionTypeCS:2001:1.3">
                  <Name>Record</Name>
               </ActionType>
               <UserAction>
                  <!-- user action description -->
               </UserAction>
               <UserAction>
                  <!-- user action description -->
               </UserAction>
            </UserActionList>
            <UserActionList id="ua-list-004"
               numOfInstances="25" totalDuration="PT7H02M">
               <ActionType
                  href="urn:mpeg:mpeg7:cs:ActionTypeCS:2001:1.2">
                  <Name>PlayStream</Name>
               </ActionType>
               <UserAction>
                  <ProgramIdentifier>
                     urn:myidorg:myid:01-mnf-100900
                  </ProgramIdentifier>
               </UserAction>
               <UserAction>
                  <ProgramIdentifier>
                     urn:myidorg:myid:02-mnf-100900
                  </ProgramIdentifier>
                  <ActionDataItem
                     href="www.abc.com/content/mnf/100900/mnf-
stream.xml#segment_145"/>
               </UserAction>
               <!-- more user actions . . . -->
            </UserActionList>
            <UserActionList id="ua-list-005"
               numOfInstances="3" totalDuration="PT4M20S">
               <ActionType
                  href="urn:mpeg:mpeg7:cs:ActionTypeCS:2001:1.6">
                  <Name>FastForward</Name>
               </ActionType>
               <UserAction>
                  <ActionTime>
                     <MediaTime>
                        <MediaTimePoint>
                           2000-10-09T19:10:12
                        </MediaTimePoint>
```

```
                        <MediaDuration>PT1M45S</MediaDuration>
                    </MediaTime>
                    <GeneralTime>
                        <TimePoint>2000-10-09T19:10:12-08:00</TimePoint>
                        <Duration>PT8S</Duration>
                    </GeneralTime>
                </ActionTime>
                <ProgramIdentifier>
                    urn:myidorg:myid:02-mnf-100900
                </ProgramIdentifier>
                <ActionDataItem
              href="www.abc.com/content/mnf/100900/mnf-
stream.xml#comm_break_17"/>
            </UserAction>
            <UserAction>
                <ActionTime>
                    <MediaTime>
                        <MediaTimePoint>
                            2000-10-10T18:16:08
                        </MediaTimePoint>
                        <MediaDuration>PT1M35S</MediaDuration>
                    </MediaTime>
                    <GeneralTime>
                        <TimePoint>2000-10-10T18:16:08-08:00</TimePoint>
                        <Duration>PT7S</Duration>
                    </GeneralTime>
                </ActionTime>
                <ProgramIdentifier>
                    urn:myidorg:myid:01-wnpj-101000
                </ProgramIdentifier>
                <ActionDataItem
href="www.abc.com/content/news/101000/wnpj.xml#news-item-8"/>
            </UserAction>
            <UserAction>
                <ActionTime>
                    <MediaTime>
                        <MediaTimePoint>
                            2000-10-10T20:05:34
                        </MediaTimePoint>
                        <MediaDuration>PT1M</MediaDuration>
                    </MediaTime>
                    <GeneralTime>
                        <TimePoint>2000-10-10T20:05:34-08:00</TimePoint>
                        <Duration>PT5S</Duration>
                    </GeneralTime>
                </ActionTime>
                <ProgramIdentifier>
                    urn:myidorg:myid:03-tss-000063
                </ProgramIdentifier>
                <ActionDataItem href="www.fox.com/xml/that70sshow/063/tss-
063.xml#break_2"/>
            </UserAction>
        </UserActionList>
        <UserActionList id="ua-list-006" numOfInstances="1">
            <ActionType
                href="urn:mpeg:mpeg7:cs:ActionTypeCS:2001:3.1">
                <Name>ClickThrough</Name>
            </ActionType>
            <UserAction>
                <ActionTime>
                    <GeneralTime>
                        <TimePoint>2000-10-09T18:48:01-08:00</TimePoint>
                    </GeneralTime>
                </ActionTime>
```

```
                    <ProgramIdentifier>
                       urn:myidorg:myid:02-mnf-100900
                    </ProgramIdentifier>
                    <ActionDataItem
                       href="www.abc.com/content/mnf/100900/mnf-
stream.xml#rel_media_12"/>
                 </UserAction>
              </UserActionList>
           </UserActionHistory>
        </UsageHistory>
    </Description>
</Mpeg7>
```

4 Visual tools

4.1 Basic visual tools

4.1.1 Grid layout

The grid layout is a splitting of the image into a set of rectangular regions, so that each region can be described separately. Each region of the grid can be described in terms of other descriptors such as color, texture, or structure.

4.1.1.1 DDL instantiation examples

In the following example, Color layout are instanciated and assigned at (0, 1) and (1, 0).

```
<GridLayout numOfPartX="2" numOfpartY="2" descriptorMask="0110">
    <!--instance at (0 1) -->
    <Descriptor xsi:type="ColorLayoutType">
        <YDCCoeff>50</YDCCoeff>
        <CbDCCoeff>34</CbDCCoeff>
        <CrDCCoeff>30</CrDCCoeff>
        <YACCoeff5>16 12 15 12 17</YACCoeff5>
        <CbACCoeff2>12 17</CbACCoeff2>
        <CrACCoeff2>12 14</CrACCoeff2>
    </Descriptor>
    <!--instance at (1 0) -->
    <Descriptor xsi:type="ColorLayoutType">
        <YDCCoeff>48</YDCCoeff>
        <CbDCCoeff>34</CbDCCoeff>
        <CrDCCoeff>32</CrDCCoeff>
        <YACCoeff5>12 10 13 9 10</YACCoeff5>
        <CbACCoeff2>14 15</CbACCoeff2>
        <CrACCoeff2>16 12</CrACCoeff2>
    </Descriptor>
</GridLayout>
```

4.1.1.2 Conditions of Usage

Each region of the grid can be described in terms of other descriptors. Therefore, limitation and the extraction/matching procedures of this descriptor are followed the selected descriptor for each region.

4.1.2 Visual time series

The VisualTimeSeries describes a temporal series of visual descriptors in a video segment and provides image to video-frame matching and video-frames to video-frames matching functionalities. Two types of VisualTimeSeries are available: RegularVisualTimeSeries and IrregularVisualTimeSeries. These are useful in particular to build descriptors that contain a time series of descriptors. Each of them basically consists of a series of visual descriptors and temporal intervals between them as illustrated in Figure 66. They correspond to the following two cases:

a. Descriptors locate regularly (with constant intervals) within a given time span.

b. Descriptors locate irregularly (with various intervals) within a given time span.

For the case a, specifying the temporal interval can be saved by means of introducing its default value. For the case b, the temporal interval can be associated with a descriptor by means of describing the series of (descriptor, time info.) pairs. However, it is apparently redundant for the case a. Therefore, separate tools are provided.

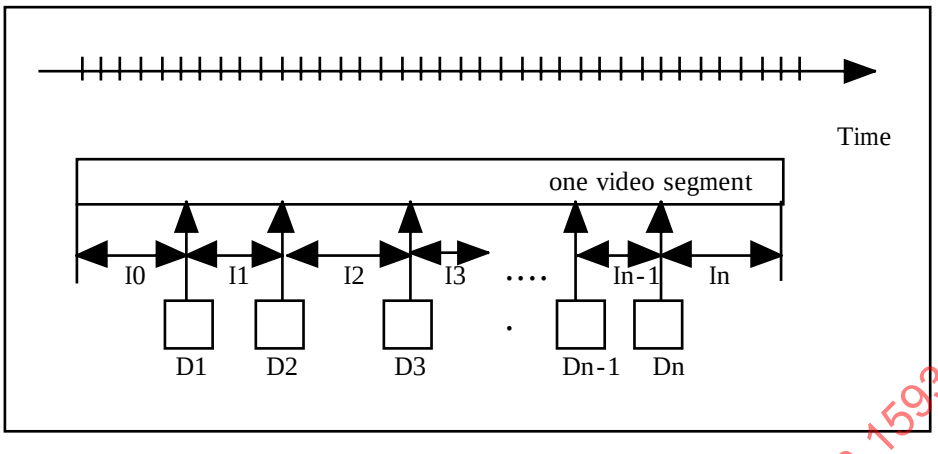


Figure 66 - Overview of the Visual Time Series.

(1) RegularVisualTimeSeries

RegularVisualTimeSeries is appropriate to describe the time series in that visual descriptors locate regularly within a given time span. This enables a simple representation for the application that requires low complexity.

(2) IrregularVisualTimeSeries

IrregularTimeSeries is appropriate to describe the time series in that visual descriptors locate irregularly within a given time span. This enables an efficient representation for the application that has the requirement of narrow transmission bandwidth or low storage capability.

4.1.2.1 Feature extraction

4.1.2.1.1 Regular visual time series

The extraction method of each descriptor should follows in the one of the assigned descriptor. Descriptors in the VisualTimeSeries are extracted with the specified constant interval by starting on the specified time point ***offset***. The offset is illustrated as “I0” in Figure 66. The constant interval between the descriptors is specified at the ***TimeIncr*** field in the RegularVisualTimeSeries.

4.1.2.1.2 Irregular visual time series

The extraction method of each descriptor should follows in the one of the assigned descriptor. The extraction process consists of two steps:

Step 1: Extraction of the descriptor with fixed interval,

Step 2: Adaptive sub-sampling of the derived descriptors

Figure 67 illustrates these processes.

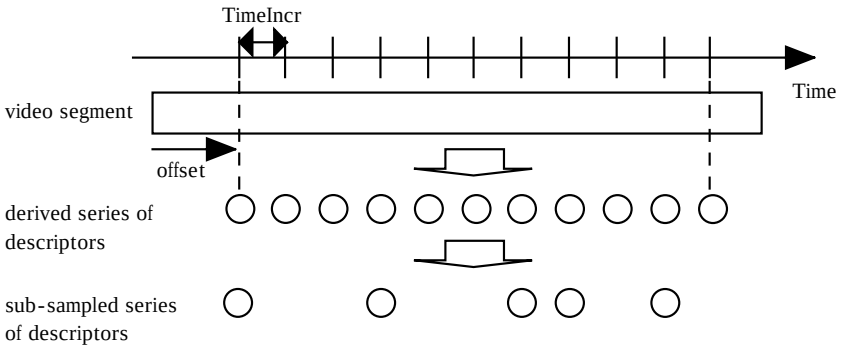


Figure 67 - Extraction method of a series of descriptors.

The first step is the repetition of the descriptor extraction process. Descriptors in the VisualTimeSeries are extracted with the specified constant interval by starting on the specified time point ***offset***. The offset is illustrate as "I0" in Figure 1. The constant interval between the descriptors is specified at the ***TimeIncr*** field in the IrregularVisualTimeSeries. The derived series of descriptors will be sub-sampled as follows. The first descriptor is selected as a reference descriptor, and the following process is applied from the second descriptors. The derived descriptor is compared with its previous reference descriptor. If the difference is larger than threshold Th, the descriptor is set as a new reference descriptor. The time interval is derived as the number of merged descriptors. The collection of the descriptors selected as the reference descriptor form the description of the irregular visual time series, which is the adaptive sub-sampled series of the descriptor. Figure 68 shows the flow chart of the extraction of the time interval.

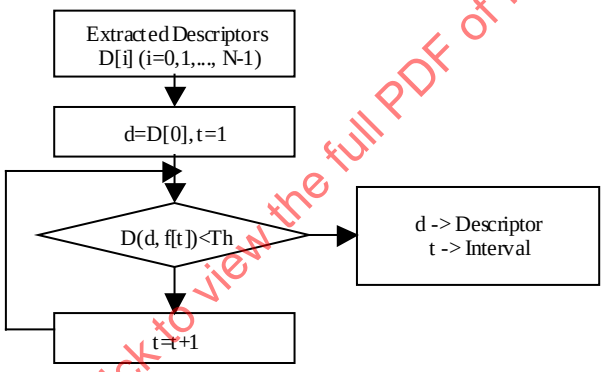


Figure 68 - Flow chart to extract time intervals.

4.1.2.2 Similarity matching

The similarity of the two descriptor-values should be calculated as following the calculation method of the descriptor assigned in the RegularVisualTimeSeries/IrregularVisualTimeSeries. Here, the distance between two descriptor-values is denoted as ***Dist***.

4.1.2.2.1 Regular visual time series

4.1.2.2.1.1 Image to sequence matching

The descriptor-value of the query image can be compared with each in the series easily. The distance between the image and each in the series is calculated as Dist. The most similar frame to the image can be derived by selecting the video frame whose distance is the minimum of all.

4.1.2.2.1.2 Sequence to sequence matching

The similarity calculation method of two RegularVisualTimeSeries, the longer one RTS1 and the shorter one RTS2 are defined as the following two cases:

(1) Two sets of series have the same value of ***TimeIncr***

(2) Two sets of series have different values of ***TimeIncr***

The most similar part of RTS1 to the RTS2 series can be derived by the clipped series whose distance is the minimum of all.

(1) The same ***`TimeIncr`*** value

When two sets of RegularVisualTimeSeries have the same value of ***TimeIncr***, the similarity calculation between them consists of the following two steps:

- Step 1: Candidate series clipping (clipping the longer RTS1 segment)

  The candidate series whose length is equal to the shorter RTS2 is clipped out of the longer RTS1 so that the number of descriptors in the candidate is as many as the shorter RTS2. Here, n denotes the number of descriptors.

- Step 2: Similarity calculation between the RTS2 series and the clipped series

  The distance between RTS2 and the clipped one can be defined as:

$$DD = \sum_{l=1}^{n} Dist_l \ / \ n$$

  where $Dist_l$ denotes the distance between the ***l***-th descriptors in the series.

Whole of the RTS1 series are scanned on the first step. The clipping of the candidate series starts from the beginning of the RTS1 series and continues to the end of the series by shifting a ***TimeIncr*** step.

(2) Different ***TimeIncr*** values

On the other hand, when two sets of RegularVisualTimeSeries have different value of ***TimeIncr***, each series should be converted into a new IrregularVisualTimeSeries. The ***TimeIncr*** value of new IrregularTimeSeries is derived as the greatest common divisor between two values of the original series. In this case, the similarity calculation method is the same as that presented in subclause 4.1.2.2.2 for comparison of two IrregularVisualTimeSeries that have the same ***TimeIncr*** value.

4.1.2.2.2 Irregular visual time series

4.1.2.2.2.1 Image to sequence matching

The descriptor-value of the query image can be compared with each in the series easily. The distance between the image and each in the series is calculated as ***Dist***. The most similar frame to the image can be derived by selecting the video frame whose distance is the minimum of all.

4.1.2.2.2.2 Sequence to sequence matching

The similarity calculation method of two RegularVisualTimeSeries, the longer one ITS1 and the shorter one ITS2 are defined as the following two cases:

1. Two sets of series have the same value of TimeIncr
2. Two sets of series have different values of TimeIncr

The most similar part of ITS1 to the ITS2 series can be derived by the clipped series whose distance is the minimum of all.

(1) The same TimeIncr value

When two sets of IrregularVisualTimeSeries have the same value of TimeIncr, the similarity calculation between them consists of the following two steps:

- Step 1: Candidate series clipping (clipping the longer ITS1 segment)

  The candidate series is clipped from the ITS1 series. Figure 69 shows an overview of this step. Summing up interval values in the stored video from a start position pos until the sum is over L, where L denotes the total intervals of ITS2 series, performs clipping. Then, similarity is calculated between the ITS2 series and the clipped segment in the next step.

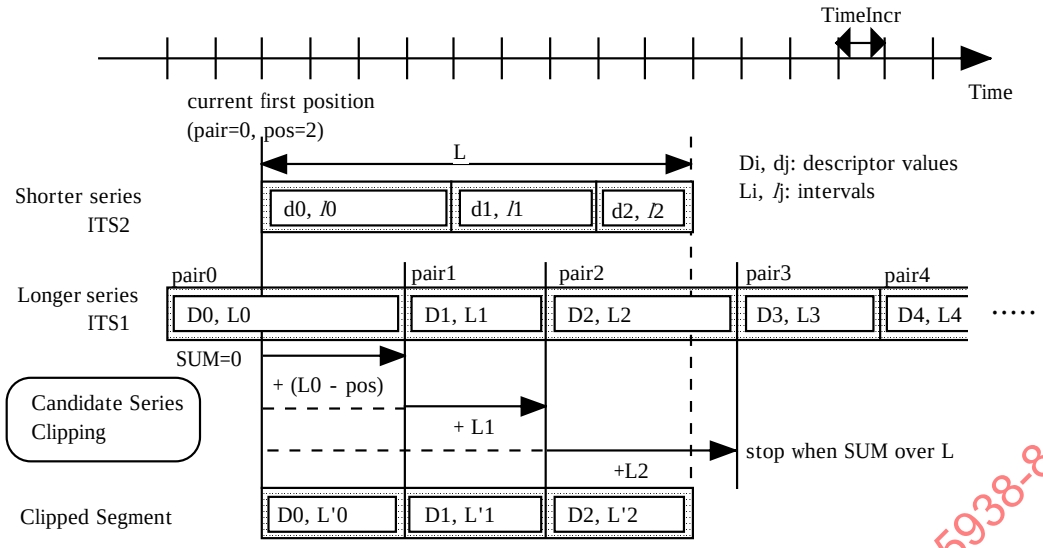


Figure 69 - Overview of video segment clipping.

- Step 2: Similarity calculation between the ITS2 series and the clipped series

In this step, the ITS2 series and the clipped series are compared and series of distances will be calculated to derive the distance between them. Figure 70 shows an overview of this step. The distance Dist between two descriptors Di and dj should be calculated only on descriptor-value change points (comparison points). Therefore, similarity calculations between two descriptors could be reduced using IrregularVisualTimeSeries. Also intervals in the series of distances are calculated between the change points.

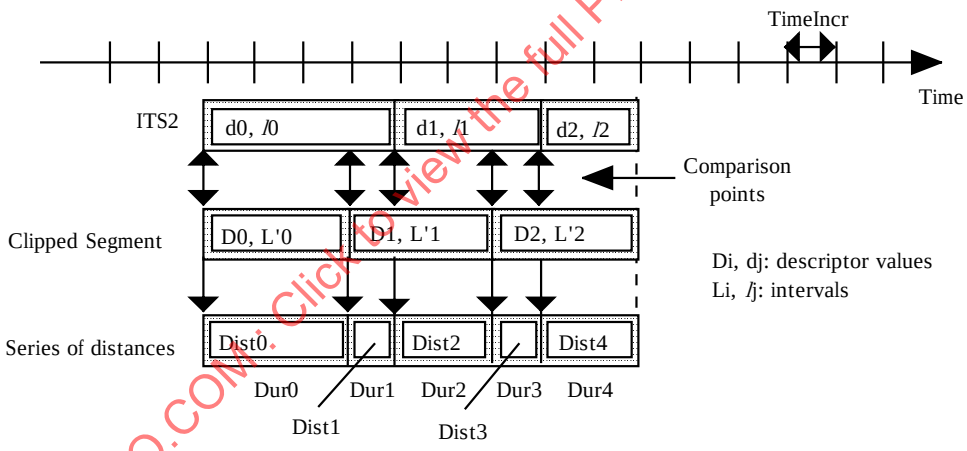


Figure 70 - Overview of similarity calculation between two IrregularVisualTimeSeries.

The distance between two sets of IrregularVisualTimeSeries should be calculated as follows:

$$DD = \sum_{l=1}^{m} (Dist_l \times Dur_l) / L$$

$$L = \sum_{l=1}^{m} Dur_l$$

Here, $\boldsymbol{Dist_l}$ denotes the distance between descriptors on the l-th comparison point, $\boldsymbol{Dur_l}$ denotes the ***l***-th interval following the ***l***-th comparison point, m denote the number of comparison points and ***L*** denotes the time length (total intervals) of the ITS2 series.

Whole of the ITS1 series are scanned on the first step. The clipping of the candidate series starts from the beginning of the ITS1 series and continues to the end of the series by shifting a ***TimeIncr*** step.

These two steps explained above are equivalent to the following C-like pseudo codes. Let the ITS2 series be {(***d***(i), ***l***(i)): i=0,1,…,I-1}, where ***d*** denotes the descriptor value and ***l*** denotes the interval value, respectively. The ITS1 series is denoted as {(***D***(j), ***L***(j)): j=0,1, …, J-1}.

double DistanceofSeries(d, l, I, D, L, J){

```
    int i=j=0; double Sum=0; int len=0; int dur;
    Descriptor des, Des;
    int interval, Interval;
    des=d(i), interval=l(i), Des=D(i), Interval=L(i)
    do {
        // Select shorter one to find a change point sequentially in temporal ascending order
        dur=minimum(interval, Interval)
        len=len+dur;
        Sum+=Distance(des, Des);          // Distance between two descriptors
        if( (interval=interval-l)==0 ) {
            i++;
            if(i==I) break;               // reached the end of the query
            des=d(i); interval=l(i);
        }
        if( (Interval=Interval-l)==0 ){
            j++;
            if(j==J) break;               // reached the end of the clipped segment
            Des=Des(j); Run=T(j);
        }
    } while( 1 );
    return Sum=Sum / len;
}
```

(2) Different ***TimeIncr*** values

On the other hand, when two sets of IregularVisualTimeSeries have different values of ***TimeIncr***, each series should be converted into a new IrregularVisualTimeSeries. The ***TimeIncr*** value of two new IrregularVisualTimeSeries is derived as the greatest common divisor between two values of the original series. In this case, the similarity calculation method is the same as that presented above for comparison of two IrregularVisualTimeSeries that have the same ***TimeIncr*** value.

4.1.2.3 Conditions of usage

Selection of RegularVisualTimeSeries and IrregularVisualTimeSeries

The usage depends on applications. The IrregularVisualTimeSeries has an advantage in the transmission/storage cost. This is appropriate to the application that has the requirement of narrow transmission bandwidth or low storage capability because it enables an efficient description. On the other hand, the RegularVisualTimeSeries has a different advantage, which is in its easy handling capability. If two temporal series of elemental visual descriptors have the regular structure (with the same constant time intervals), it is easy to calculate the similarity between the temporal series since there are no needs to consider about the difference of temporal positions. This is appropriate for a simple representation to the application that requires low complexity.

Appropriate descriptor assigned to the VisualTimeSeries

The VisualTimeSeries (binary version) assumes that only the descriptor identifier and the descriptor length are the common information of the series. Therefore, it is appropriate for descriptors of which the size is constant.

TimeIncr

The value of TimeIncr is recommended to be the same between the query series and the target series, because of the lower complexity of similarity calculation and easy handling capability. For example, in the case of ColorLayout descriptor, the following setting show superior performance in terms of retrieval efficiency (accuracy vs description cost):

TimeIncr is equal to 2 frames per second (every 0.5second), Th is equal to 3

Available image types

As VisualTimeSeries is a container of visual descripters, available image types (e.g. width, height, or color quantizations) of this is following the ones of the contained descriptor.

Video length

According to length of a video, VisualTimeSeries has enough flexibility. The number of contained descriptors is represented 32bit positive integer. Concerning a lower limitation of length, 1 frame image. Conserning a upper limitation of length, practically no limitations. In case of NTSC video (29.97 frames per second) with descripters binded on each frame, this is able to represent over 4-years-length video.

4.1.2.4 DDL instantiation examples

4.1.2.4.1 Regular visual time series

The description of a series of MyDescriptor located at 0.0s, 0.2s, 0.4s, 0.6s, 0.8s within a time span [0.0s,1.0s] becomes:

```
<RegularVisualTimeSeries>
    <TimeIncr>PT2N10F</TimeIncr>
    <Descriptor xsi:type="ColorLayoutType">
        <YDCCoeff>50</YDCCoeff>
        <CbDCCoeff>34</CbDCCoeff>
        <CrDCCoeff>30</CrDCCoeff>
        <YACCoeff5>16 12 15 12 17</YACCoeff5>
        <CbACCoeff2>12 17</CbACCoeff2>
        <CrACCoeff2>12 14</CrACCoeff2>
    </Descriptor>
    <Descriptor xsi:type="ColorLayoutType">
        <YDCCoeff>48</YDCCoeff>
        <CbDCCoeff>34</CbDCCoeff>
        <CrDCCoeff>32</CrDCCoeff>
        <YACCoeff5>12 10 13 9 10</YACCoeff5>
        <CbACCoeff2>14 15</CbACCoeff2>
        <CrACCoeff2>16 12</CrACCoeff2>
    </Descriptor>
</RegularVisualTimeSeries>
```

If the locations of MyDescriptor are at 0.1s, 0.4s and 0.7s then the description becomes:

```
<RegularVisualTimeSeries offset="PT1N10F">
    <TimeIncr>PT3N10F</TimeIncr>
    <Descriptor xsi:type="ColorLayoutType">
        <YDCCoeff>50</YDCCoeff>
        <CbDCCoeff>34</CbDCCoeff>
        <CrDCCoeff>30</CrDCCoeff>
        <YACCoeff5>16 12 15 12 17</YACCoeff5>
        <CbACCoeff2>12 17</CbACCoeff2>
        <CrACCoeff2>12 14</CrACCoeff2>
    </Descriptor>
    <Descriptor xsi:type="ColorLayoutType">
        <YDCCoeff>48</YDCCoeff>
        <CbDCCoeff>34</CbDCCoeff>
        <CrDCCoeff>32</CrDCCoeff>
        <YACCoeff5>12 10 13 9 10</YACCoeff5>
        <CbACCoeff2>14 15</CbACCoeff2>
        <CrACCoeff2>16 12</CrACCoeff2>
    </Descriptor>
</RegularTimeSeries>
```

4.1.2.4.2 Irregular visual time series

The description of series of MyDescriptor located at 0.0s, 0.4s, 0.5s, 0.8s and 0.9s within a time span [0.0s,1.0s] becomes:

```
<IrregularVisualTimeSeries>
    <TimeIncr>PT1N10F</TimeIncr>
    <Descriptor xsi:type="ColorLayoutType">
        <YDCCoeff>50</YDCCoeff>
        <CbDCCoeff>34</CbDCCoeff>
        <CrDCCoeff>30</CrDCCoeff>
        <YACCoeff5>16 12 15 12 17</YACCoeff5>
        <CbACCoeff2>12 17</CbACCoeff2>
        <CrACCoeff2>12 14</CrACCoeff2>
    </Descriptor>
    <Interval>4</Interval>
    <Descriptor xsi:type="ColorLayoutType">
```

```
        <YDCCoeff>46</YDCCoeff>
        <CbDCCoeff>34</CbDCCoeff>
        <CrDCCoeff>30</CrDCCoeff>
        <YACCoeff5>16 12 15 12 17</YACCoeff5>
        <CbACCoeff2>12 17</CbACCoeff2>
        <CrACCoeff2>12 14</CrACCoeff2>
    </Descriptor>
    <Interval>1</Interval>
    <Descriptor xsi:type="ColorLayoutType">
        <YDCCoeff>40</YDCCoeff>
        <CbDCCoeff>34</CbDCCoeff>
        <CrDCCoeff>30</CrDCCoeff>
        <YACCoeff5>16 12 15 12 17</YACCoeff5>
        <CbACCoeff2>12 17</CbACCoeff2>
        <CrACCoeff2>12 14</CrACCoeff2>
    </Descriptor>
    <Interval>3</Interval>
    <Descriptor xsi:type="ColorLayoutType">
        <YDCCoeff>48</YDCCoeff>
        <CbDCCoeff>34</CbDCCoeff>
        <CrDCCoeff>32</CrDCCoeff>
        <YACCoeff5>12 10 13 9 10</YACCoeff5>
        <CbACCoeff2>14 15</CbACCoeff2>
        <CrACCoeff2>16 12</CrACCoeff2>
    </Descriptor>
    <Interval>1</Interval>
    <Descriptor xsi:type="ColorLayoutType">
        <YDCCoeff>48</YDCCoeff>
        <CbDCCoeff>34</CbDCCoeff>
        <CrDCCoeff>32</CrDCCoeff>
        <YACCoeff5>15 11 13 9 8</YACCoeff5>
        <CbACCoeff2>14 15</CbACCoeff2>
        <CrACCoeff2>16 12</CrACCoeff2>
    </Descriptor>
    <Interval>1</Interval>
</IrregularVisualTimeSeries>
```


Note that the interval must be always specified for each descriptor in this tool.

4.1.3 2D-3D multiple view

The 2D/3D Descriptor specifies a structure which combines 2D Descriptors representing a visual feature of a 3D object seen from different view angles. The descriptor forms a complete 3D view-based representation of the object. Any 2D visual descriptor, such as for example contour-shape, region-shape, colour or texture can be used. The 2D/3D descriptor suports integration of the 2D descriptors used in the image plane to describe features of the 3D (real world) objects.

4.1.3.1 Feature extraction

The following Figure 71 shows an example of 7 views for the object “Bicycle-1”. The viewing directions, associated with these views, have proven to give good retrieval results, if a Contour Descriptor is used, that provides invariance to mirrored shapes, and the extracted features for front and back view are identical.

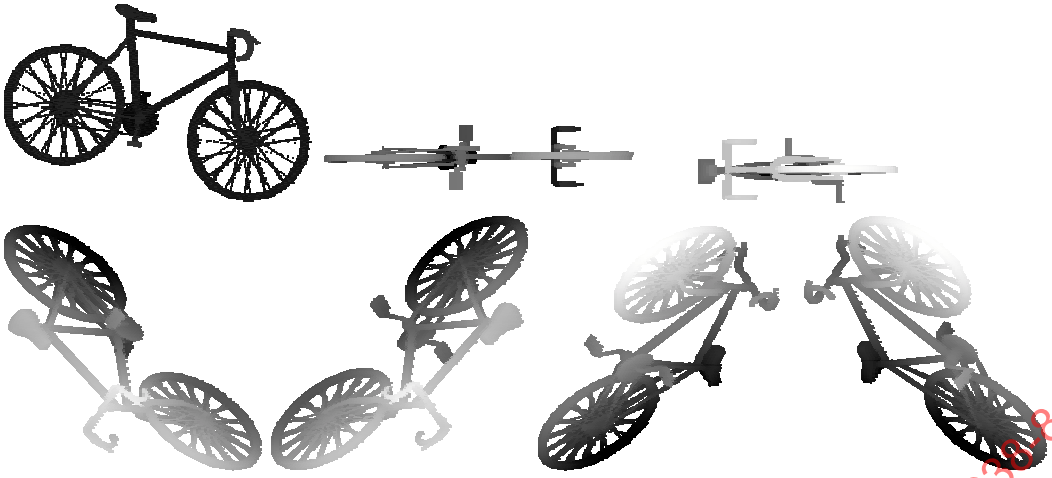


Figure 71 - Different views of model "Bicycle-1.wrl": Top: pri., sec. and ter. View, Bottom: Intermediate views 4, 5, 6 and 7

For obtaining typical views from the 3D object, the following approach is recommended:

The primary, secondary and tertiary viewing directions are determined by the analysis of the covariance matrix of the 3D object

$$\underline{C} = \frac{1}{N}\sum_{n=1}^{N}(\underline{x}-\underline{m})(\underline{x}-\underline{m})^{T}$$

where

$$\underline{x} = \begin{pmatrix} x \\ y \\ z \end{pmatrix} \qquad \underline{m} = \begin{pmatrix} m_x \\ m_y \\ m_z \end{pmatrix}$$

are the coordinates of all volume elements and the mass center of the 3D object, respectively, and N is the number of volume elements. An Eigenvector analysis is now performed, where the Eigenvalues λ1-λ3 are associated with primary, secondary and tertiary views, and the corresponding Eigenvectors p1-p3 indicate the view directions:

$$\underline{\Lambda} = \underline{T^{-1}CT} \quad \text{with} \quad \underline{\Lambda} = \begin{pmatrix} \lambda_1 & 0 & 0 \\ 0 & \lambda_2 & 0 \\ 0 & 0 & \lambda_3 \end{pmatrix}, \qquad \underline{T} = \begin{pmatrix} \underline{p_1} & \underline{p_2} & \underline{p_3} \end{pmatrix}$$

In the case of a Contour-based shape description, another 4 views are added addition to these3 views,with the following directions to obtain an object coverage with most spatial distance:

View_4 45° between the Primary and the Secondary views
View_5 45° between the Primary and the Tertiary views
View_6 45° between the Secondary and the Tertiary views
View_7 45° between the Primary, the Secondary and the Tertiary views

Figure 72 shows the position of all generated views. For the similarity search by shape, only the hemisphere y>0 needs to be considered. Respective views in other octants would only yield mirrored shapes of the 7 available views.

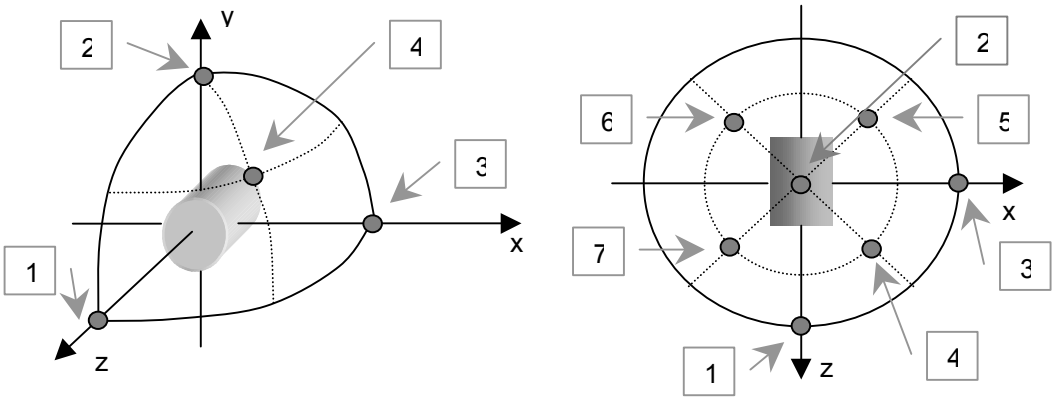


Figure 72 - Viewing directions onto the 3D object in the origin: Left: perspective view and view directions in the first octant, Right: top view and view directions in the hemisphere y>0.

In the case of other underlying descriptor, e.g. color or texture, arbitrary views are recommended, since front and back view of an object may no longer yield identical descriptor values. An example of the arbitrary views is shown on Figure 73. Arbitrary views can be used in the representation of 3D objects contained within photographs and movie sequences, when obtaining views from the fixed directions is impractical or impossible.

Figure 73 - The construction of a multi-view descriptor of a real 3D car.

4.1.3.2 Similarity matching

Matching can be achieved by comparing a number of views of one object (A) to the same number of views of the other object (B), using the matching procedure of the underlying Image Descriptor in the following way:

Each view from A is compared to each view from B, giving N^2 matching results where N is the number of used views. The overall matching error is obtained by adding the underlying error measures of all possible view combinations between A and B.

This procedure can also be described by the Error Matrix **E** between Object A and B, where each matrix element $e_{k,l}$ represents the underlying error measure between the k^{th} view of object A and the l^{th} view of object B. Finding the overall matching error is similar to calculating the smallest trace of all possible column changes of **E**.

As an example, the following 6 column changes and resulting traces are possible when using 3 views:

$$\begin{pmatrix} e_{1,1} & e_{1,2} & e_{1,3} \\ e_{2,1} & e_{2,2} & e_{2,3} \\ e_{3,1} & e_{3,2} & e_{3,3} \end{pmatrix}, \begin{pmatrix} e_{1,1} & e_{1,3} & e_{1,2} \\ e_{2,1} & e_{2,3} & e_{2,2} \\ e_{3,1} & e_{3,3} & e_{3,2} \end{pmatrix}, \begin{pmatrix} e_{1,2} & e_{1,1} & e_{1,3} \\ e_{2,2} & e_{2,1} & e_{2,3} \\ e_{3,2} & e_{3,1} & e_{3,3} \end{pmatrix}, \begin{pmatrix} e_{1,2} & e_{1,3} & e_{1,1} \\ e_{2,2} & e_{2,3} & e_{2,1} \\ e_{3,2} & e_{3,3} & e_{3,1} \end{pmatrix}, \begin{pmatrix} e_{1,3} & e_{1,1} & e_{1,2} \\ e_{2,3} & e_{2,1} & e_{2,2} \\ e_{3,3} & e_{3,1} & e_{3,2} \end{pmatrix}, \begin{pmatrix} e_{1,3} & e_{1,2} & e_{1,1} \\ e_{2,3} & e_{2,2} & e_{2,1} \\ e_{3,3} & e_{3,2} & e_{3,1} \end{pmatrix}$$

$e_{1,1}+e_{2,2}+e_{3,3}$ $e_{1,1}+e_{2,3}+e_{3,2}$ $e_{1,2}+e_{2,1}+e_{3,3}$ $e_{1,2}+e_{2,3}+e_{3,1}$ $e_{1,3}+e_{2,1}+e_{3,2}$ $e_{1,3}+e_{2,2}+e_{3,1}$

The minimum of the 6 traces (sums) listed below the possible column-arranged error matrix represents the overall matching error.

A second matching approach is to compare an unknown 2D view with the 3D object. Here the descriptor of the unknown 2D view is compared to each view of the 3D object seperately and the minimum error represents the similarity between unknown 2D view and 3D object.

4.1.3.3 Visible views

The multi-view descriptor contains a number of descriptors that represent an object from different views. It is also nessesary to describe which of these views are actually visible from within the image or sequence of images that the multi-view description object relates to. Figure 74 gives an example of a car object within a photo-graph being described using the multi-view descriptor, and a visibility flag for each of the views. Figure 75 shows how the visible flags can affect the search results obtained from a multi-view search. Figure 75 (a) shows a search using a side view of a car without using the visible flags: it finds pictures of cars with a similar side views though they are not necessarily visible from the photo. If the person performing the search wishes to view only side views of cars it is not possible without the use of the visible view flag. Figure 75 (b) shows the same search but this time the visible flags are being used. The results contain only side views of cars.

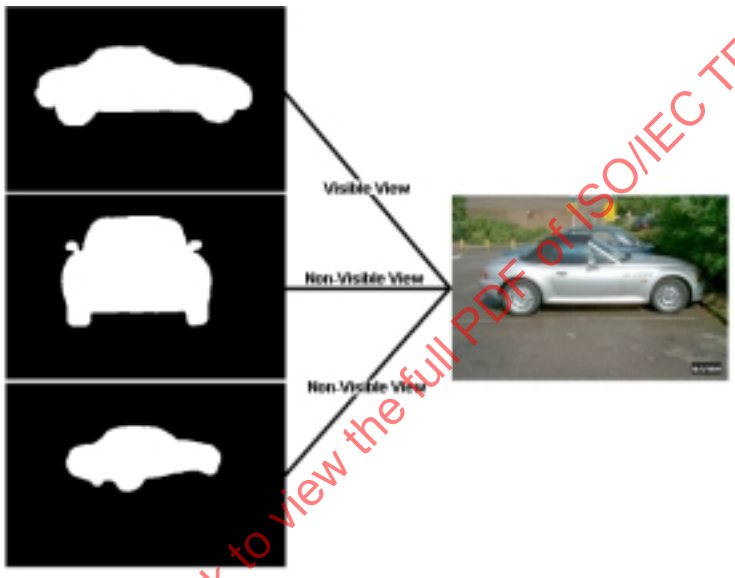


Figure 74 - An example of a multi-view descriptor using shape including visible view information

(a) Without the visible view flag the multi-view search finds car from any angle.

(b) Using the visible views flag the search returns only the required side views.

Figure 75 - Visible view flag usage.

4.1.3.4 DDL instantiation examples

In the following example, Contour shape descriptors are instanciated.

```
<MultipleView fixedViewsFlag="true">
   <IsVisible>true</IsVisible>
   <Descriptor xsi:type="mpeg7:ContourShape">...</Descriptor>
```

```
    <IsVisible>false</IsVisible>
    <Descriptor xsi:type="mpeg7:ContourShape">...</Descriptor>
    <IsVisible>false</IsVisible>
    <Descriptor xsi:type="mpeg7:ContourShape">...</Descriptor>
</MultipleView>
```

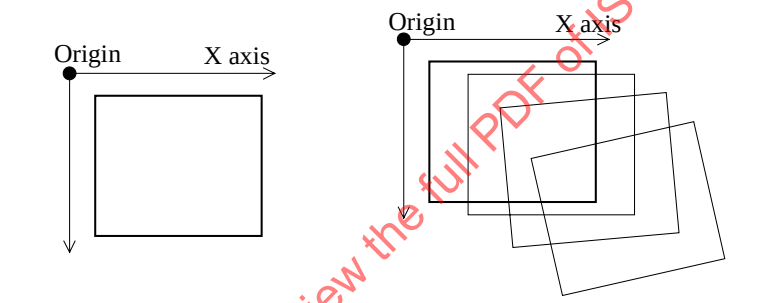
4.1.3.5 Conditions of use

When the multiple-view descriptor is used to describe an object within an image or movie frame it is recomended that the descriptor be inserted into the MPEG 7 framework via the StillRegionDS.

4.1.4 Spatial 2D coordinates

This description defines a 2D spatial coordinate system and a unit to be used by reference in other Ds/DSs when relevant. The coordinate system is defined by a mapping between an image and the coordinate system. One of the advantages using this descriptor is that MPEG-7 descriptions need not to be modified even if the image size is changed or a part of the image is clipped. In this case, only the description of the mapping from the original image to the edited image is required.

It supports two kinds of coordinate systems: “local” and “integrated” (Figure 76). In a “local” coordinate system, the coordinates used for the calculation of the description are mapped to the coordinate system currently applicable. In an “integrated” coordinate system, each image (frame) of e.g. a video may be mapped to different areas with respect to the first frame of a shot or video. So, an integrated coordinate system can for instance be used to represent coordinates on a mosaic of a video shot.



a) “Local” coordinates *b) “Integrated” coordinates*

Figure 76 - “local” and “integrated” coordinate system.

In the normative syntax, IntegratedCoordinateSystem allows to specify an integrated coordinate system, and LocalCoordinateSystem allows to specify a local one, when it is different from the default local coordinate system. The default local coordinate system is the pixel based coordinate system whose origin is placed at the top left corner of the image and whose first and the second axis are aligned to the horizontal respectively vertical boarder of the image with increasing indixes to the right respectively bottom of the image. Thus a LocalCoordinateSystem provides the possibility to map a default local coordinate system which was used to compute visual descriptors to the coordinate system of the current image or video transmitted or rendered. By referencing this mapping, the visual descriptors do not have to be recomputed even though e.g. the format of the current image or video has changed. The specification of the local coordinate system is applicable for images or video. If additionally an Integrated coordinate system is additionally specified, the mapping applies to the coordinate system of the first frame.

4.1.4.1 DDL instantiation examples

Figure 77 depicts an example of the definition of the local coordinate system. In this example, the current image (right-image) is generated by scaling of the original image (left-image). This coordinate system is defined by the sets of CurrentPixel and SrcPixel, which specifies the mapping between the current image and the original image. The advantage of the use of this description is explained in “Condition of use”.

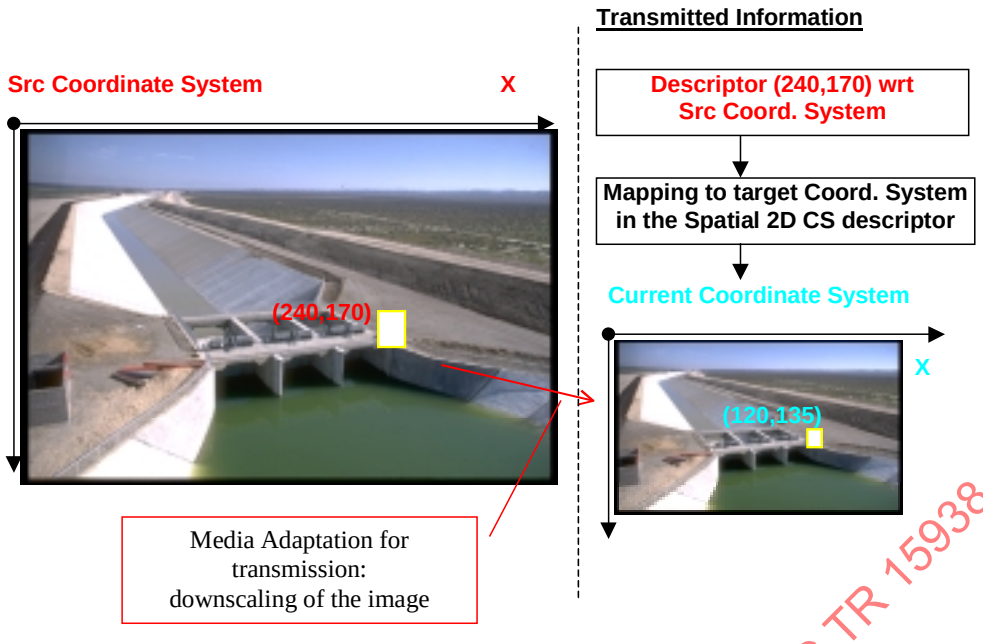


Figure 77 - Coordinate changes by scaling of an image: original descriptor in the src coordinate system and its mapping into the target coordinate system (in this example both pixel based).

```
<Spatial2DCoordinateSystem " xRepr="16" yRepr="16" xSrcSize="384" ySrcSize="256"
id="SCSNewImg1">
    <LocalCoordinateSystem name="PixelCoords">
        <CurrentPixel>0 0</CurrentPixel>
        <SrcPixel>0 0</SrcPixel>
        <CurrentPixel>150 100</CurrentPixel>
        <SrcPixel>300 200</SrcPixel>
    </LocalCoordinateSystem>
</Spatial2DCoordinateSystem>
```

Figure 78 depicts the integrated coordinate system defined for the segment of the sport sequence. The integrated corrdinate system is defined by the sets of motion parameters, which specify the motion from the first image. The temporal spacing of the motion parameter description can be arbitrary. In this example, the motion parameters at the frame #8 and at the frame #16 are described. The advantage of the use of this description is also explained in 4.1.4.2.

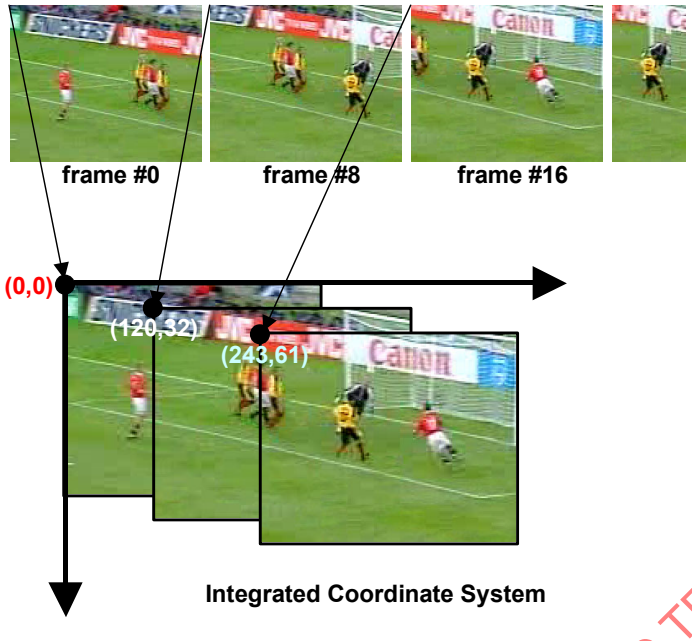


Figure 78 - Example of an integrated coordinate system: the integrated coordinate system is defined by the sets of translational motion parameters.

```
<Spatial2DCoordinateSystem xRepr="16" yRepr="16">
    <!-- LocalCoordinateSystem is omitted -->
    <!-- (default local coordinate sytem is used) -->
    <IntegratedCoordinateSystem modelType="translational"
           xOrigin="0.0" yOrigin="0.0">
        <!-- description of the frame #8 -->
        <TimeIncr> ... </TimeIncr> <!-- see MediaIncrDuration -->
        <MotionParams>120.0</MotionParams>
        <MotionParams>32.0</MotionParams>
        <!-- description of the frame #16 -->
        <TimeIncr> ... </TimeIncr> <!-- see MediaIncrDuration -->
        <MotionParams>243.0</MotionParams>
        <MotionParams>61.0</MotionParams>
        <!-- description of other frames follows -->
        ...
    </IntegratedCoordinateSystem>
</Spatial2DCoordinateSystem>
```

4.1.4.2 Conditions of use

As mentioned above, the Spatial2DCoordinateSystem description can be referenced in Ds/DSs instantiating coordinates. This reference is optional, driven by a 1-bit flag in all the relevant Ds/DSs. If the Spatial 2D Coordinate System is not referenced, all relevant Ds/DSs have embedded all the data they need to be used in most usual basic cases. If it is referenced, further advanced functionalities and advantages are possible. We describe below these advantages and functionalities, and the cases in which we recommend to reference the Spatial 2D Coordinates System.

- Flexibility with respect to the media format which is described

For the so called universal multimedia access applications (UMA) the multimedia content has to be adapted to the user device or to different bandwidth conditions. In these contexts, resizing and cropping of the visual content are common adaptation mechanisms, beside several others. The resizing is depicted in Figure 77. These operations affect visual descriptors which specify coordinates based on one of the following coordinate systems:

- Normalized coordinates: the coordinate specification is normalized to the image size.
- Pixel coordinates: the coordinates refer to the pixel position within an image or frame, the origin lying in the upper left corner.

After applying a resize operation, the coordinates in a normalized coordinate system maintain valid while the ones in a pixel-based coordinate system are not correct anymore. In the case of the cropping operation,

Ds/DSs making use of any of these coordinate systems have to be recomputed. So in the majority of the cases the spatial descriptions which are assuming one of these implicit coordinate systems have to be recomputed to stay valid with respect to the transmitted data.

If we specify a coordinate system which relates the spatial description to the image or video delivered (e.g. see Figure 77), only the coordinate system has to be changed. The remaining description stays the same, and always uses the original pixel or normalized coordinates (src coordinate system in Figure 77). These coordinates are mapped to the pixel coordinates of the modified image or video (current coordinate system in Figure 77). For retrieval the mapping does not have to be applied. The descriptor with respect to the src coordinate system can be used as it would be the case for the original image without the spatial 2D coordinate system. In the example of Figure 77 the resizing of the image can be described by the following spatial 2D coordinate system.

- Generalized approach to global motion

When there is a global motion in a scene, which has been calculated as a sequence of parametric motion parameters, referencing the Spatial2DCoordinateSystem allows storing this information using the IntegratedCoordinateSystem element. All Ds/DSs referencing the Spatial2DcoordinateSystem can access the global motion information.

Then, a 1-bit flag in each D/DS referencing the Spatial2DcoordinateSystem specifies whether the coordinate values are given with respect to the local coordinate system, or with respect to the integrated one. This bit should be chosen depending on the targeted application. It allows coordinate values to be accessed in a form, which is directly useful for the application.

For instance, let us assume that an IntegratedCoordinateSystem has been defined for a segment of a sport sequence where the camera is moving. Then, if the application wants to offer object hyperlinking, it is useful to directly access the image-local coordinates of the object, as the cursor coordinates are also known in the image. On the contrary, if the application proposes similarity-based retrieval taking into account object motion, it is useful to have direct access to the coordinates in the Integrated CS, as they represent object behaviors independently from the movements of the camera.

4.1.5 Temporal interpolation

4.1.5.1 Feature extraction

The algorithm CALC_INTERPOLATION gives an example of key points extraction method for variable key point intervals. It determines key points sequentially based on the approximation error of interpolation functions.

In the algorithm, the interpolation is initialized with the first two points. The interpolation is then widened to include one point at a time until the approximation error of the interpolation becomes larger than a given threshold. At that point a new key point is added and a new interpolation interval is started with the new key point (starting point) and the immediately following point (ending point). This procedure is interated until all points have been processed. When the interpolation models matches the variable values well, this algorithm results in a small number of long intervals. Conversely, when the match is poor, a large number of short intervals will result.

To describe the algorithm formally, define the following notation. Let $d\ (>0)$ be the number of variables (dimension) and denote the value of the j-th variable at time t by $v_t^{(j)}\ (j=1,2,\cdots,d)$. A series of time points is denoted by $t_i\ (i=0,1,\cdots)$. For a (candidate) interpolation interval, the starting time (ending time) is denoted by t_{START} (t_{END}). Let $f_{t_{START},t_{END}}^{(j)}(t)\ (j=1,2,\cdots,d)$ be a candidate of the j-th variable interpolation function. This can be calculated using least squares. In this case, $f_{t_{START},t_{END}}^{(j)}(t)$ is calculated to minimize

$$\sum_{i=START}^{END}\left|v_{t_i}^{(j)}-f_{t_{START},t_{END}}^{(j)}(t_i)\right|^2.$$

This calculation is easy because the function is the first or the second order polynomial. To evaluate the derived candidate function, let T_j be a threshold for the j-th variable and define error $e^{(j)}\ (j=1,2,\cdots,d)$ as

$$e^{(j)}=\max_{START\le i\le END}\left|v_{t_i}^{(j)}-f_{t_{START},t_{END}}^{(j)}(t_i)\right|.$$

$e^{(j)}$ is the maximum approximation error of the j-th variable in the range $t_{START} \le t_i \le t_{END}$. If $e^{(j)} < T_j$ holds for all j, $f^{(j)}_{t_a,t_b}(t)$ is an acceptable candidate. However, another interpolation function in wider interval may be found. To try to test this possibility, the interval is widened by incrementing END and a new function is derived and tested. This procedure is repeated until a newly derived function does not meet the acceptance condition. Then, the last candidate function is accepted and both edges of the interval are fixed as key points.

The following are the steps of the algorithm.

CALC_INTERPOLATION:

1. *(Initialization)* Set $t_{START} = t_0$, $t_{END} = t_1$.
2. *(Interpolation Calculation)* Calculate interpolation functions $f^{(j)}_{t_{START},t_{END}}(t)\ (j = 1,2,\cdots,d)$. Least square estimation can be used under conditions of $f^{(j)}_{t_{START},t_{END}}(t_{START}) = v^{(j)}_{t_{START}}$ and $f^{(j)}_{t_{START},t_{END}}(t_{END}) = v^{(j)}_{t_{END}}$.
3. *(Interpolation Evaluation)* Compute the maximum approximation error $e^{(j)}\ (j = 1,2,\cdots,d)$. If there exists $e^{(j)}$ which is greater than the corresponding threshold, go to Step 4. Otherwise, go to Step 5.
4. *(KeyPoint Insertion)* Accept $f^{(j)}_{t_{START},t_{END-1}}(t)\ (j = 1,2,\cdots,d)$ as interpolation functions and set $t_{START} = t_{END-1}$.
5. *(Increment and Termination)* If t_{END} is the end of the whole interval, terminate the procedure. Otherwise, set $t_{END} = t_{END+1}$ and go to Step 2.
6. When the order of the interpolation function $f^{(j)}_{t_{START},t_{END}}(t)$ is two and the number of the points is two, the second order coefficient should be fixed to 0.

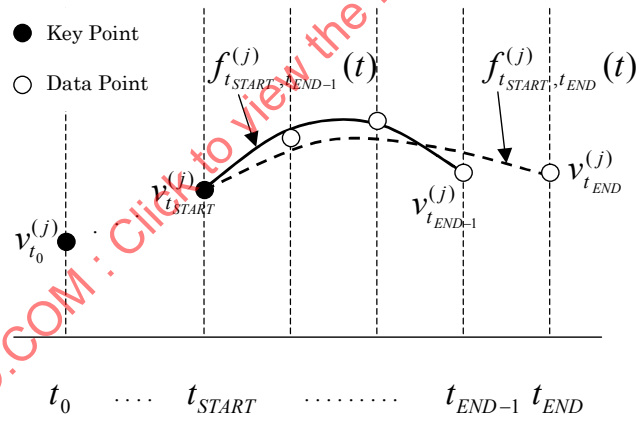


Figure 79 - Sequential key points selection and interpolation calculation method: If the error of $f^{(j)}_{t_{START},t_{END}}(t)$ is greater than the threshold, let $v^{(j)}_{t_{END-1}}$ be a key point and accept $f^{(j)}_{t_{START},t_{END-1}}(t)$. Otherwise, keep the new function $f^{(j)}_{t_{START},t_{END}}(t)$ as a candidate and discard the old function $f^{(j)}_{t_{START},t_{END-1}}(t)$.

4.1.5.2 Decoding

In the following, the procedure to get a value of a temporal interpolation at a given time is explained. Let **NumOfKeyPoints** be the number of key points and t_0 be the given time, Then, define T[i] (0<=i<**NumOfKeyPoints**) as an array of the key point time and V[i] (0<=i<**NumOfKeyPoints**) as an array of the key point values in the description.

1. Find i_0 (0<=i_0<**NumOfKeyPoints**-1) such that T[i_0]<=t_0<=T[i_0+1]. If there are two i_0 satisfying the condition, choose the smaller one. If there does not exist i_0 satisfying the condition, terminate the procedure and return false value.

2. According to the interpolation type of the interval $T[i_0]<=t<=T[i_0+1]$, calculate the coefficient v_a using $t_a=T[i_0]$, $t_b=T[i_0+1]$, $f_a=V[i_0]$, $f_b=V[i_0+1]$ and a_a=**param** based on the equations in Table 3 inISO/IEC 15938-3.
3. Calculate $f(t_0)$ in the table and return the value.

4.1.5.3 DDL instantiation examples

In the following example, the position in 2D (x and y axes) is described by the TemporalInterpolation D, which is used in the MotionTrajectory Descriptor. Since four key points are used in the example, four key point positions and three interpolation functions for each axis are described. All the key points and the interpolation functions are shown in the table. For the y-axis only the default functions (first order polynomials) are used for the interpolation function, so the descriptions of type are omitted.

When TwoDimMotionTrajectory is defined as:

```
<element name="TwoDimMotionTrajectory" type="mpeg7:TemporalInterpolationType" />
```

then the description can be given as:

```
<TwoDimMotionTrajectory>
    <!-- time of 4 key points -->
    <KeyTimePoint>
        <MediaTimePoint>T00:00:00:0F10</MediaTimePoint>
        <MediaTimePoint>T00:00:02:0F10</MediaTimePoint>
        <MediaTimePoint>T00:00:10:5F10</MediaTimePoint>
        <MediaTimePoint>T00:00:15:00F10</MediaTimePoint>
    </KeyTimePoint>

    <!-- X values of 4 key points -->
    <InterpolationFunctions>
        <KeyValue type="startPoint>118.9</KeyValue>
        <KeyValue type="secondOrder" param="2.1">102.1</KeyValue>
        <KeyValue type="firstOrder">82.35</KeyValue>
        <KeyValue type="secondOrder" param="0.2">85.5</KeyValue>
    </InterpolationFunctions>
    <!-- Y values of 4 key points -->
    <InterpolationFunctions>
        <KeyValue>210.0</KeyValue>
        <KeyValue>220.8</KeyValue>
        <KeyValue>228.9</KeyValue>
        <KeyValue>215.1</KeyValue>
    </InterpolationFunctions>
</TwoDimMotionTrajectory>
```

Table 21 - Key points and interpolation functions used in this example. Red colored numbers, which are necessary to derive interpolation functions, can be found in the above description.

t	0.0	0.0 <= t <= 2.0	2.0	2.0 <= t <= 10.5	10.5	10.5 <= t <= 15.0	15.0
x	118.9	$x=2.1t^2-12.6t+118.9$	102.1	$x=-2.3t+106.73$	82.35	$x=0.2t^2-4.4t+106.5$	85.5
y	210.0	$y=5.4t+210.0$	220.8	$y=0.95t+218.89$	228.9	$y=3.07t+261.13$	215.1

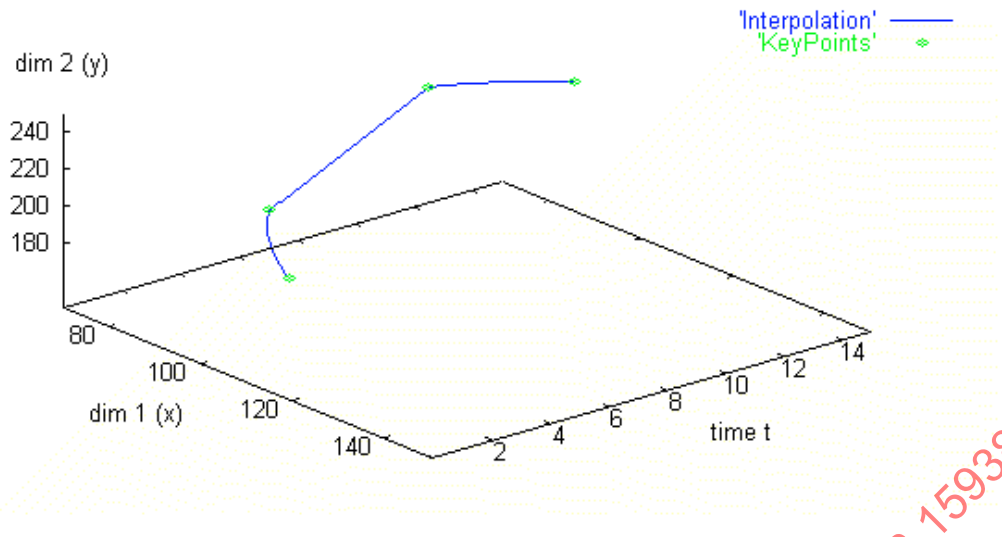


Figure 80 - The MotionTrajectory described in this example.

When the interval between the key points is constant, then we can obtain a description as:

```
<TwoDimMotionTrajectory>
    <WholeInterval>
        <MediaDuration>PT15S</MediaDuration>
    </WholeInterval>

    <!-- X values of 4 key points -->
    <InterpolationFunctions>
        <KeyValue type="startPoint>118.9</KeyValue>
        <KeyValue type="secondOrder" param=”2.1”>102.1</KeyValue>
        <KeyValue type="firstOrder">82.35</KeyValue>
        <KeyValue type="secondOrder" param=”0.2”>85.5</KeyValue>
    </InterpolationFunctions>
    <!-- Y values of 4 key points -->
    <InterpolationFunctions>
        <KeyValue>210.0</KeyValue>
        <KeyValue>220.8</KeyValue>
        <KeyValue>228.9</KeyValue>
        <KeyValue>215.1</KeyValue>
    </InterpolationFunctions>
</TwoDimMotionTrajectory>
```

4.2 Color description tools

This subclause describes all the entities that describe visual features related to color.

4.2.1 Color space

The feature is the color space that is to be used in other color based descriptions.

In the current description, the following color spaces are supported:

- RGB
- YCbCr
- HSV
- HMMD
- Linear transformation matrix with reference to R, G, B
- Monochrome

4.2.1.1 DDL instantiation examples

Example 1: HMMD color space is defined by the Color space descriptor.

```
<ColorSpace type = "HMMD"/>
```

Example 2: The Color space descriptor describes a linear matrix transformation between the components (C1, C2, and C3) of an arbitrary color space and the components of the RGB color space.

C1 = ColorTransMat[0][0]*R + ColorTransMat[0][1]*G + ColorTransMat[0][2]*B;
C2 = ColorTransMat[1][0]*R + ColorTransMat[1][1]*G + ColorTransMat[1][2]*B;
C3 = ColorTransMat[2][0]*R + ColorTransMat[2][1]*G + ColorTransMat[2][2]*B.

Suppose the linear matrix (ColorTransMat) is specified as follows:

ColorTransMat[0][0] = 0.299;
ColorTransMat[0][1] = 0.587;
ColorTransMat[0][2] = 0.144;
ColorTransMat[1][0] = -0.169;
ColorTransMat[1][1] = -0.331;
ColorTransMat[1][2] = 0.5;
ColorTransMat[2][0] = 0.5;
ColorTransMat[2][1] = -0.419;
ColorTransMat[2][2] = -0.081;

In this matrix specification, each coefficient of the matrix is expressed a real number between –1 and 1. To convert the real number into a coded value (16 bit unsigned integer), the following equation is used.

$V_{int} = V_{fp}*2^{14}$.

Therefore, coded values of the coefficients are

ColorTransMat[0][0]$_{\_coded}$ = 4898;
ColorTransMat[0][1]_coded = 9617;
ColorTransMat[0][2]$_{\_coded}$ = 2359;
ColorTransMat[1][0]$_{\_coded}$ = –2769;
ColorTransMat[1][1]$_{\_coded}$ = –5424;
ColorTransMat[1][2]$_{\_coded}$ = 8192;
ColorTransMat[2][0]$_{\_coded}$ = 8192;
ColorTransMat[2][1]$_{\_coded}$ = –6865;
ColorTransMat[2][2]$_{\_coded}$ = –1328.

These coeffiecients of the linear matrix are described by the Color space descriptor as follows:

```
<ColorSpace type = "LinearMatrix">
   <ColorTransMat>
   4898 9617 2359 -2769 -5424 8192 8192 -6865 -1328
   </ColorTransMat>
</ColorSpace>
```

4.2.2 Color quantization

This descriptor defines the uniform quantization of a color space when the color space is quantized uniformly in all the color components to be quantized.

4.2.2.1 DDL instantiation examples

In the following example, a uniform quantization is described by color quantization descriptor in which each of H, Diff, and Sum component of HMMD color space is uniformly quantized by 256 levels.

```
<ColorQuantization>
   <Component> H </Component>
   <NumOfBins> 256 </NumOfBins>
   <Component> Diff </Component>
   <NumOfBins> 256 </NumOfBins>
   <Component> Sum </Component>
   <NumOfBins> 256 </NumOfBins>
</ColorQuantization>
```

4.2.2.2 Conditions of usage

Color quantization descriptor is used for describing a uniform color quantization of a color space specified in the color space descriptor. Non-uniform color quantization is not supported by the current description. If the defined color space is a linear matrix in the color space descriptor, any three arbitrary components are used in the color quantization descriptor to define the number of bins. Each number of bins of the three arbitrary components corresponds to that of C1, C2, and C3, respectively.

4.2.3 Dominant color

This descriptor specifies a set of dominant colors in any arbitrary shaped region.

It targets content-based retrieval for color, either for the whole image or for any arbitrary shaped region (rectangular or irregular).

4.2.3.1 Feature extraction

The dominant color extraction algorithm takes as input a set of pixel color values (specified in the RGB color space). It quantizes the color vectors in the image based on the Generalized Lloyd Algorithm (GLA).

The dominant colors are extracted as a result of successive divisions of the color clusters with the GLA algorithm in between each division and then merging of the color clusters. The detailed algorithm is explained in the following.

Note on the notation;

Each color cluster center will be called the *colorBin,* and the number of Bins will be denoted as *BinNum*. So, the initial number of Bins will be denoted by the *InitBinNum*, the final number of Bins will be denoted by *FinalBinNum*, etc. Also each color will have a unique index, called *IndexOfColor*, and this indicates the Bin that the color is associated to.

1. Convert the color in an input image from RGB space to CIE LUV space.

2. Set InitBinNum=1, FinalBinNum=8, and *CurrentBinNum* = *InitBinNum* (3 bits).

3. Apply the GLA algorithm to the set of *CurrentBinNum* color clusters.

- assign each color to its cluster

```
for ( i=0; i<NumOfColors; i++ ) {
    for ( j=0; j<CurrentBinNum; j++ )
        distance[j] = EuclideanDistance (color[i],colorBin[j]);
    IndexOfColor[i] = IndexOf (Minimum (distance) );
}
```

- calculate cluster centroid

```
for ( j=0; j<CurrentBinNum; j++ ) {
    for ( i=0; i<NumOfColors; i++ )
        if ( IndexOfColor[i] == j )   colorBin[j] = colorBin[j] + color[i];
    colorBin[j] = colorBin[j] / NumOfColorInBinJ;
}
```

4. Calculate the total distortion and split colorBins to increase CurrentBinNum until *CurrentBinNum* = *FinalBinNum*.

```
for ( i=0; i<NumOfColors; i++ )
        Distortion = Distortion + SquareofL2Norm (colorBin[IndexOfColor[i]] - color[i]);
if ( Change in Distortion > 5 percents )  Repeat Step 3;
else {
        Split colorBins using Step 5;
        CurrentBinNum = CurrentBinNum +1;
        if ( CurrentBinNum < FinalBinNum ) Repeat Step 3;
        else  Out of GLA loop and Goto Step 6;
}
```

5. One colorBin is split into two colorBins. The old one is discarded.

```
NewcolorBin1 = OldcolorBin + PerturbanceVector;
NewcolorBin2 = OldcolorBin - PerturbanceVector;
```

Here, 10% of standard deviation of color values in the cluster is recommended as *PerturbanceVector*.

6. Merge *colorBins* using an agglomerative clustering method.

- calculate mutual distances between codevectors

```
for ( i=0; i<FinalBinNum; i++ ) {
    for ( j=0; j<FinalBinNum; j++ )
        DistanceTable[i][j] = distance (colorBin[i],colorBin[j]);
}
minimumDist = Minimum (DistanceTable);
```

- merge two color bins with the smallest distance and update table; the Threshold is set to 255.0 for CIE LUV space

```
while ( minimumDist<Threshold ) {
    NewColor =  PercentOfColorsInI*ColorBin[i] + PercentOfColorsInJ*ColorBin[j];
    Update DistanceTable;
    minimumDist = Minimum (DistanceTable);
}
```

7. Convert colorBins from CIELUV to RGB.
8. Quantize ColorBins to Dominant Colors using the feature descriptor syntax.
9. If the ColorVariances are required, calculate distortion components per dominant color as follows:

```
for ( i=0; i<NumOfColors; i++ ) {
    index=IndexOfColor[i];
    for ( c=0; c<NumOfColComponents; c++ )
     ColorVariance[index][c] +=
     (colorBin[index][c]-color[i][c])*( colorBin[index][c]-color[i][c]);
}
for ( j=0; j<NumOfDominantColors; j++ )
    for ( c=0; c<NumOfColComponents; c++ )
      ColorVariance[j][c] /= NumberOfPixels[j];
```

and quantize it using the feature descriptor syntax.

4.2.3.1.1 Spatial coherency extraction:

The SpatialCoherency (SC) can be calculated as follows:

$$SC = \Sigma_{\text{for all } i}(COH\_Ci \times COUNT\_PELS\_Ci / TOTAL\_PELS\_OF\_R)$$

where COH_Ci is the per-dominant color spatial coherency of Ci, COUNT_PELS_Ci is the number of corresponding pixels of Ci in the region R and TOTAL_PELS_OF_R is the size of the region R calculated by counting pixels in the region R.

Algorithm to calculate SpatialCoherency (SC) is described as follows:

1 Set SC = 0.

2 Set SUM_COUNT_PELS = 0.

3 For all pixels p in R

  3.1 VISITED PELp=FALSE;

4 For all Dominant Colors Ci.

  4.1 Get COH_Ci and COUNT_PELS_Ci.

  4.2 SC = SC + COH_Ci×COUNT_PELS_Ci.

5 SC = SC / TOTAL_PELS_OF_R.

6 Output SC.

In the step 3.1, COH_Ci (per-dominant color spatial coherency of Ci) and COUNT_PELS_Ci are calculated as follows:

1 Input the size of the Coherency Checking Mask (CCM) such as CCM_WIDTH (=3) by CCM_HEIGHT (=3).

2 COUNT_PELS_Ci = 0, TOTAL_NUM_COHERENT = 0.

3 For all pixels PELj in R,

3.1 If (Ci == COLOR_OF_PELj & VISITED_PELj == FALSE)

3.1.1 VISITED_PELj = TRUE;

3.1.2 COUNT_PELS_Ci = COUNT_PELS_Ci +1.

// align PELj with center of CCM to check 8-connectedness connectivity as follows

3.1.3 For all masked pixels MASKED_PIXELk (except the center pixel, PELj)

3.1.3.1 If (Ci == COLOR_OF_MASKED_PIXELk)

3.1.3.1.1 TOTAL_NUM_COHERENT ++;

4 COH_Ci = TOTAL_NUM_COHERENT / COUNT_PELS_Ci / (CCM_WIDTH * CCM_HEIGHT-1)

5 Output COH_Ci and COUNT_PELS_Ci.

4.2.3.2 Similarity matching

The following describes a matching method using the dominant color(s) descriptor.

Difference(D1, D2) = W1*SC_Diff *DC_Diff + W2*DC_Diff.

Where SC_Diff = abs(SpatialCoherency_1 – SpatialCoherency_2), SpatialCoherency_1 and SpatialCoherency _2 are normalized from 0 to 1 and non-uniformly quantized in prior to calculate SC_Diff. DC_Diff is the difference between two set of dominant colors, W1 (e.g. set to 0.3) is the weight of the first term and W2 (e.g. set to 0.7) is the weight of the second term. Set W1 to 0 if SpatialCoherency is not available.

DC_Diff, normalized from 0 to 1, can be computed by the following distance function:

For clarity, these notations corresponding to the descriptor syntax (normative parts) are used:

- F: Dominant_Color
- N: DominantColorsNumber
- c: ColorValue
- p: Percentage.

Percentage values are normalized to 1, i.e., $\sum_i p_i = 1$. This means that, if the original sum does not add up to 100%, the rest of the colors are completely ignored.

The similarity between two feature descriptions, F_1 and F_2, can be measured by the following distance function $D(F_1, F_2)$

$$D^2(F_1, F_2) = \sum_{i=1}^{N_1} p_{1i}^2 + \sum_{j=1}^{N_2} p_{2j}^2 - \sum_{i=1}^{N_1}\sum_{j=1}^{N_2} 2a_{1i,2j} p_{1i} p_{2j}$$

where the subscripts 1 and 2 in all variables stand for descriptions F_1 and F_2 respectively, and $a_{k,l}$ is the similarity coefficient between two colors c_k and c_l,

$$a_{k,l} = \begin{cases} 1 - d_{k,l} / d_{\max} & d_{k,l} \le T_d \\ 0 & d_{k,l} > T_d \end{cases}$$

where $d_{k,l}$ is the Euclidean distance between two colors c_k and c_l,

$$d_{k,l} = \| c_k - c_l \|$$

T_d is the maximum distance for two colors to be considered similar, and $d_{max} = \alpha T_d$. A normal value for T_d is between 10-20 in the CIE LUV color space and for α is between 1.0-1.5.

The procedure to calculate $D(F_1,F_2)$ is as follows:

- Step 1: Calculate the 2 positive squared terms in the distance function.
- Step 2: Take either color feature description, say F_1, as the reference. For each color in F_1, find all its similar colors in F_2, i.e., the colors that have distance less than T_d.
- Step 3: Calculate the similarity coefficients and the negative term in the distance function.

If color variances are present, the following similarity measure is used:

$$D_V^2(F_1,F_2)=\sum_{i=1}^{N_1}\sum_{j=1}^{N_2}p_{1i}p_{1j}f_{1i1j}+\sum_{i=1}^{N_1}\sum_{j=1}^{N_2}p_{2i}p_{2j}f_{2i2j}-\sum_{i=1}^{N_1}\sum_{j=1}^{N_2}2p_{1i}p_{2j}f_{1i2j},$$

where $$f_{xiyj}=\frac{1}{2\pi\sqrt{v_{xiyjl}v_{xiyju}v_{xiyjv}}}\exp\left[-\left(\frac{c_{xiyjl}}{v_{xiyjl}}+\frac{c_{xiyju}}{v_{xiyju}}+\frac{c_{xiyjv}}{v_{xiyjv}}\right)/2\right]$$

and $$c_{xiyjl}=(c_{xil}-c_{yjl})^2,\ v_{xiyjl}=(v_{xil}+v_{yjl}).$$

In the equations above, c_{xil} and v_{xil} are dominant color values and color variances, respectively.

The above matching method assumes that the feature description is extracted using the method described in subclause 4.2.3.1. In particular, this means that any two dominant colors from one single description are at least T_d distance apart.

4.2.3.3 Conditions of usage

The dominant color descriptor is useful for image and video retrieval. It targets content-based retrieval for color, either for the whole image or for any arbitrary shaped region (rectangular or irregular). It is a very compact descriptor, requiring less than 6-8 colors per region. Since colors are not pre-quantized as in the histogram type color descriptors, the representation is more accurate. It is intended for applications that use object based representations (objects or regions in an image).

4.2.4 Scalable color

The Scalable Color Descriptor is a Color Histogram in HSV Color Space, which is encoded by a Haar transform. Its binary representation is scalable in terms of bin numbers and bit representation accuracy over a broad range of data rates.

4.2.4.1 Feature extraction

The feature extraction consists of a histogram extraction in HSV color space, uniformly quantized into 256 bins according to the tables provided in the normative parts, and histogram values then nonlinearly quantized. The 4-bit values then undergo a Haar transform according to flow diagrams in Figure 81, which is the forward transform compatible to the inverse transform as described in the normative parts.

The usage of the Scalable Color Descriptor can be adapted to different situations, either by discarding coefficient groups according to Table 12 of the standard text, or by discarding bit planes according to Table 13. There is no general rule whether it is better to first discard coefficient groups or to discard bit planes. To achieve good retrieval efficiency with natural image material, a minimum of 64 coefficients should be retained.

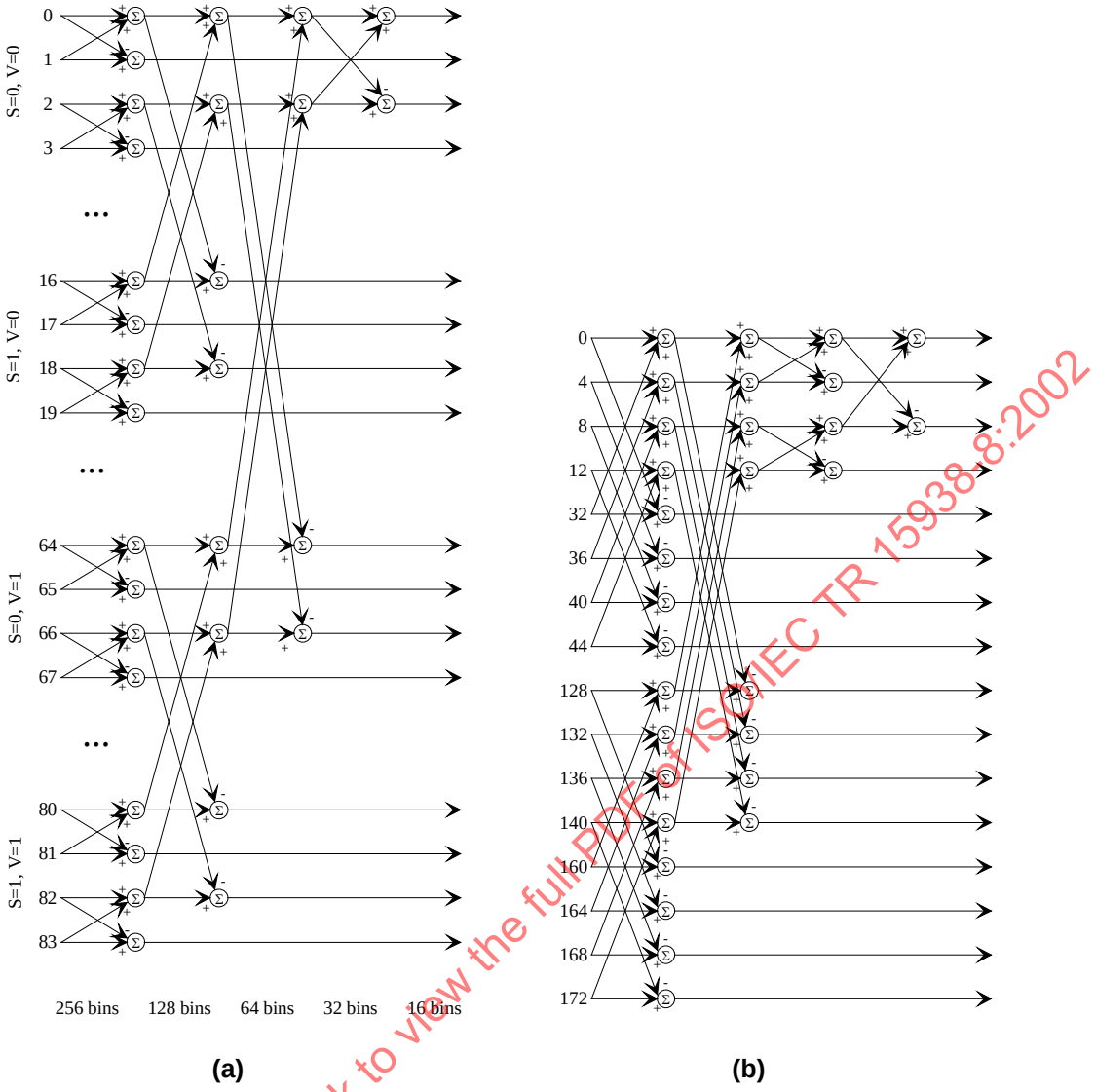


Figure 81 - Haar transform of 256-bin HSV color histogram. (a) first four levels, (b) levels 5-8 (index values corresponding to the indices of bins in a HSV color histogram with 256 bins, according to Table 11 of normative part an index assignment of uniform color quantization D)

4.2.4.2 Similarity matching

The reconstruction of color histogram from Haar coefficients allows matching with highest retrieval efficiency. It is recommended, however, to perform the matching directly in the Haar coefficient domain, which induces only marginal loss in the precision of the similarity matching with considerable savings in computational cost.

✓ **Matching in the Haar coefficient domain**

It is recommended to use the L1 norm for matching in the coefficient domain. In the case where only the CoefficientSigns are retained, however, the recommended matching measure is the Hamming distance, because of its very low complexity. To compute the Hamming distance, the sign bit of first coefficient (the "DC" coefficient of the transform with index CI=0) can be ignored, as it is always positive. The Hamming distance is therefore computed by comparing the signs of the remaining coefficients ("AC" coefficients with CI≠0) from two descriptors and by finding the number of bit positions at which the sign bits are different. One way of implementing the above is to compute the XOR of the two descriptors to be compared and computing the number of '1' bits in the resulting bitstream.

The descriptor is scalable either in number of bins (respectively number of coefficients) or in number of bitplanes. The accuracy of similarity retrieval is directly dependant on the number of bits present in the description. It is well possible to match Scalable Color Descriptors of different size, however the matching process must always relate to the minimum number of coefficients and the minimum number of bit planes. For example, if one instantiation of the Descriptor was generated using 64 coefficients (numOfCoeff=010) and no bit planes discarded (numOfBitplanesDiscarded=000); a second instantiation has 256 coefficients

(numOfCoeff=100) and 3 bit planes discarded (numOfBitplanesDiscarded=011), matching can only be performed using 64 coefficients, each with 3 bit planes discarded. For the scalable description, all bitplanes available represent the magnitude values of the coefficients. For bit planes discarded, the bits should be set to 0 in an integer representation. The magnitude together with the sign gives the full interpretation of the coefficient value. For coefficients where only the sign is available, sign differences are weighted as 1 in the L1 norm calculation.

✓ **Matching in the histogram domain**

It is recommended also to use the L1 norm for matching in the histogram domain. If matching is performed in the histogram domain, better results can be obtained if the index values defined in the normative part are matched instead of the actual histogram values. Matching in the histogram domain is only useful to achieve high quality, i.e. when all coefficients are available.

The descriptor is scalable either in number of bins (respectively number of coefficients) or in number of bitplanes. The accuracy of similarity retrieval is directly dependant on the number of bits present in the description. For the scalable description, all bitplanes available are arranged together as magnitude value of the coefficient. If no bit is available for a coefficient in a specific bitplane, this bit is set to 0 in the integer representation. The magnitude together with the sign gives the full interpretation of the coefficient value. For coefficients where only sign is available, sign differences are weighted as 1 in the L1 norm calculation.

4.2.5 Color layout

This descriptor specifies a spatial distribution of colors for high-speed retrieval and browsing. It targets not only image-to-image matching and video-clip to video-clip matching, but also layout-based retrieval for color, such as sketch-to-image matching, which is not supported in other color descriptors. This descriptor can be applied either for whole image or any (arbitrary shaped) part of the image.

4.2.5.1 Feature extraction

4.2.5.1.1 Extraction from still images

The descriptor is extracted from the 8x8 array of local representative colors as described in subclause 6.6.3 in ISO/IEC 15938-3. This subclause presents an example to obtain the array using average colors as dominants.

At first, we should partition the original picture into 64 blocks. The (i, j)th block is a set of pixels whose size is approximately W/8 x H/8, {I(x,y)| i*W/8≤x<(i+1)*W/8, j*H/8≤y<(i+1)*H/8}, where W and H denotes the width and height of the original picture, respectively. The averaged value of each block is calculated and rounded into integer values. The following function CreateSmallImage() is a pseudo C code to implement both partitioning and averaging processes. Here, the arbitrary shaped region information at (x, y), which is represented as *shape[y*W+x]*, is assumed to be 0 if location (*x*, *y*) is out of valid region.

```
void CreateSmallImage  (unsigned char src[3][W*H], unsigned char shape[W*H], unsigned char
      dst[3][8*8])
{
        int y_axis, x_axis, i, j, k, x, y;
        long int sum[3][64];
        int cnt[64];
        double yy;
        for (i=0; i<64; i++){
            cnt[i]=0;
            sum[0][i]=sum[1][i]=sum[2][i]=0;
            dst[0][i]=dst[1][i]=dst[2][i]=0;
    }
    for(y=0; y<H; y++)
    for(x=0; x<W; x++){
        if(shape[y*W+x]==0x00) continue;
                // averaging must be performed using only on valid pixels inside the region.
                y_axis=(int)(y/(H/8.0)); x_axis=(int)(x/(W/8.0));
            k=y_axis*8+x_axis;
            sum[0][k] += src[0][y*W+x];
            sum[1][k] += src[1][y*W+x];
            sum[2][k] += src[2][y*W+x];
            cnt[k]++;
```

```
        }
        for(i=0; i<8; i++)
        for(k=0; j<3; k++)
            dst[k][i]=(sum[k][i]/cnt[i]);
    }
```

It should be noted that in case the image size is smaller than 8x8, up-sampling is requested to obtain the small icon.

4.2.5.1.2 Extraction from video segments

The color layout descriptor can be also applied for video segment to achieve video segment retrieval using RegularVisualTimeSeries or IrregularVisualTimeSeries. The extraction process consists of three steps, extraction of Color layout with fixed interval, adaptive sub-sampling of the derived descriptors, and mapping in IrregularVisualTimeSeries.In the case to use RegularVisualTimeSeries, the second step is not requested. Figure 82 illustrates these processes.

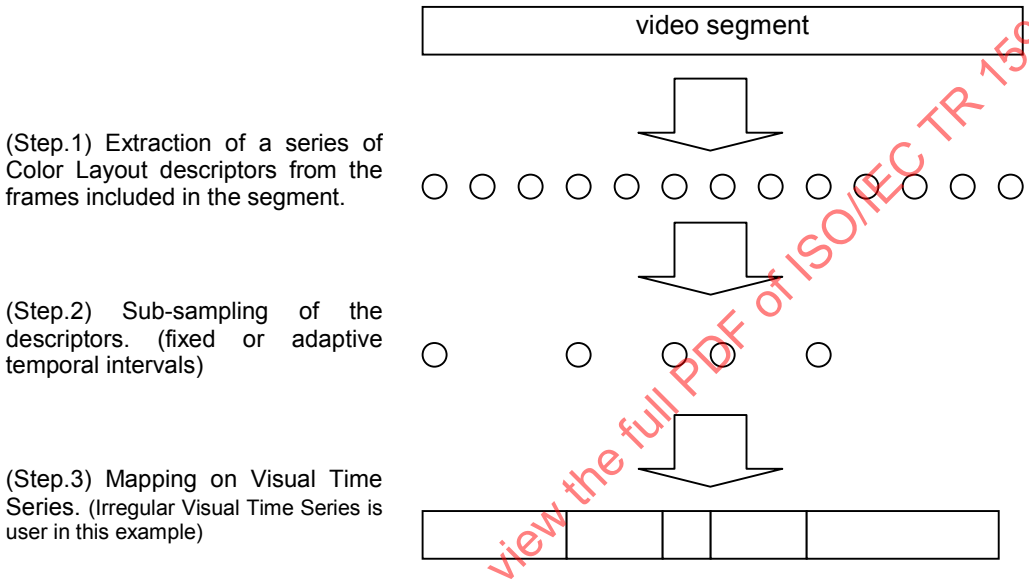


Figure 82 - Extraction method of a series of Color Layout descriptors for video segment retrieval

The first stage is the repetition of the Color layout extraction process. It should be perfromed; for instance, every half-second and a series of Color Layout descriptors are obtained.

The derived series of descriptors will be sub-sampled as follows. The first descriptor is selected as a reference descriptor, and the following process is applied from the second descriptors. The derived descriptor is compared with its previous reference descriptor. If the difference is larger than threshold *Th*, the descriptor is set as a new reference descriptor. The collection of the descriptors selected as the reference descriptor form spatio-temporal color layout description, which is the adaptive sub-sampled series of Color Layout descriptor.

Finally, the derived temporal series of Color layout descriptors is mapped on IrregularVisualTimeSeries or RegularVisualTimeSeries.

4.2.5.2 Similarity matching

4.2.5.2.1 Similarity between images

The distance between two descriptor values CLD1(YCoeff, CbCoeff, CrCoeff) and CLD2(YCoeff', CbCoeff', CrCoeff') should be calculated as follows.

$$D = \sqrt{\sum_{i=0}^{Max\{NumberOfYCoeff\}-1} \lambda_{Yi}(YCoeff[i] - YCoeff'[i])^2}$$

$$+ \sqrt{\sum_{i=0}^{Max\{NumberOfCCoeff\}-1} \lambda_{Cbi}(CbCoeff[i] - CbCoeff'[i])^2}$$

$$+\sqrt{\sum_{i=0}^{Max\{NumberOfCCoeff\}-1}\lambda_{Cri}(CrCoeff[i]-CrCoeff'[i])^2}$$

Here, lamdas denote weighting values for each coefficient. They should be decreased according to the zigzag-scan-line order. Table 22 shows an example of weighting values for default descriptor. They are designed to be implemented using only shift operations. If the NumberOf(X)Coeff is different between CLD1 and CLD2, the missing element values on the shorter descriptor should be regarded as 16(0x10), means 0 value on AC coefficient fields, or the redundant element values on the longer descriptor should be ignored.

Table 22 - An example of weighting values for the default descriptor

(X)	Coefficient Order					
	0	**1**	**2**	**3**	**4**	**5**
Y	2	2	2	1	1	1
Cb	2	1	1			
Cr	4	2	2			

4.2.5.2.2 Similarity between video segments

The distance between video segments is defined as averaged distance between corresponding descriptor values.

4.2.5.2.3 Use of local representative colors (Visualization for Image Browsing)

The Color layout descriptor is also useful to visualize image contents using a series of tiny picture icons for browsing since the descriptor values could be converted into small icons through the following two steps. The first step is coefficient decoding and the second one is inverse DCT transformation. Both processes are the inverse operation as shown in the semantics of (X)Coeff in subclause 6.6.3 in ISO/IEC 15938-3.

(1) Descriptor decoding

This process consists of three sub processes. The first one is the interpolation of truncated coefficients.

```
for(k=NumberOfYCoeff; k<64; k++) YCoeff[k]=16;
for(k=NumberOfCCoeff; k<64; k++) CbCoeff[k]=CrCoeff[k]=16;
```

The second one is the projection from zigzag-scanned 1D coefficient array into 2D-coefficient array.

```
YC[i][j]= YCoeff[zigzag(i, j)]
CbC[i][j]=CbCoeff[zigzag(i, j)]
CrC[i][j]=CrCoeff[zigzag(i, j)]
```

The third one is the inverse quantization as follows

```
yc[0][0]=iquant_Y_DC(YC[0][0]),      yc[i][j]=iquant_Y_AC(YC[i][j])
cbc[0][0]=iquant_CbCr_DC(YC[0][0]),  cbc[i][j]=iquant_CbCr_AC(CbC[i][j])
crc[0][0]=iquant_CbCr_DC(YC[0][0]),  crc[i][j]=iquant_CbCr_AC(CrC[i][j])
```

Here, the iquant functions should be implemented as in Table 23.

Table 23 - The inverse quantization table of DCT coefficients.

	Y	Cb, Cr

DC	`int iquant_Y_DC(int i) {`
	`  int j;`
	`  i=i<<1;`
	`  if(i>112) j=194+(i-112)*4;`
	`  else if(i>96) j=162+(i-96)*2;`
	`  else if(i>32) j=96+(i-32);`
	`  else if(i>16) j=66+(i-16)*2;`
	`  else j=i*4;`
	`  return j*8;`
	`}`
		`int iquant_CbCr_DC(int i) {`
		`  int j;`
		`  if(i>63) j=192;`
		`  else if(i>56) j=162+(i-56)*4;`
		`  else if(i>48) j=145+(i-48)*2;`
		`  else if(i>16) j=112+(i-16);`
		`  else if(i>8) j=97+ (i-8)*2;`
		`  else if(i>0) j=66+ i*4;`
		`  else j=64;`
		`  return j*8;`
		`}`

AC	`int iquant_Y_AC(int i) {`
	`  int j;`
	`  i=i<<3;`
		`int iquant_CbCr_AC(int i) {`
		`  int j;`
		`  i=i<<3;`

	i-=128; *if(i>128) i= 128;* *if(i<-128) i= -128;* *if ((abs(i)) > 96) j= (abs(i))*4 - 256;* *else if ((abs(i)) > 64) j=(abs(i))*2 - 64;* *else j=abs(i);* *j = (i<0)?-j:j;* *return j*2;* *}*	*i-=128;* *if(i>128) i= 128;* *if(i<-128) i= -128;* *if ((abs(i)) > 96) j= (abs(i))*4 - 256;* *else if ((abs(i)) > 64) j=(abs(i))*2 - 64;* *else j=abs(i);* *j = (i<0)?-j:j;* *return j;* *}*

(2) Inverse DCT

The 8x8 icon (yd[8][8], cbd[8][8], crd[8][8]) on Y/Cb/Cr color space can be obtained from decoded descriptor values:

yd= ic*yc, cbd=ic*cbc, crd=ic*crc

where ic denotes the IDCT matrix which shall conform to IEEE Standard Specification for the implementations of 8 by 8 inverse Discrete Cosine Transform, Std 1180-1990, December 6, 1990.

4.2.5.3 DDL Instantiation Examples

The following examples are synthesized instances of the `ColorLayout` descriptor. Six coefficients for illumination (Y) and three coefficients for each chrominance component (Cb and Cr) are used in the first example

```
<ColorLayout>
    <YDCCoeff>50</YDCCoeff>
    <CbDCCoeff>34</CbDCCoeff>
    <CrDCCoeff>30</CrDCCoeff>
    <YACCoeff5>16 12 15 12 17</YACCoeff5>
    <CbACCoeff2>12 17</CbACCoeff2>
    <CrACCoeff2>12 14</CrACCoeff2>
</ColorLayout>
```

In the second example, six coefficients for all components (Y, Cb and Cr) are used in the second example.

```
<ColorLayout>
    <YDCCoeff> 50</YDCCoeff>
    <CbDCCoeff>34</CbDCCoeff>
    <CrDCCoeff>30</CrDCCoeff>
    <YACCoeff5> 16 12 15 12 17</YACCoeff5>
    <CbACCoeff5>12 17  9 10  8</CbACCoeff5>
    <CrACCoeff5>12 14 15 19 10</CrACCoeff5>
</ColorLayout>
```

4.2.5.4 Conditions of usage

- Interoperability

The feature supported by this descriptor can be represented using grid-based dominant colors, a combination of the Grid layout datatype and the Dominant color descriptor, or grid-based color histogram, a combination of the Grid layout datatype and the Scalable color (or Color structure) descriptor, even though these alternative two methods show much worse performance on retrieval efficiency, speed, and description storage cost compared to the color layout. There are two ways to guarantee the interoperability between color layout and grid-based dominant colors/grid-based color histogram.

Scenario A) The color layout descriptor can be converted into 8x8 size small picture icon as shown in subclause 4.2.5.2.3. Both the grid-based dominant colors and the grid-based color histogram can be extracted from the derived small picture icon.

Scenario B) The grid-based dominant colors and the grid-based color histogram can be converted into color layout using the following process. The averaged color of each gird should be calculated using the weighted sum of dominant colors or representative colors for bins. This process creates a small picture whose size is equal to the grid size. The color layout descriptor can be extracted from the created small picture as shown in 4.2.5.1.

- Optimal conditions of use

The default *numberOf(Y/C)Coefficient*, 6 for luminance (Y) and 3 for each chrominance (C), is recommended for video segment retrieval and most of still picture retrieval. However, the performance using the first default number of coefficient may not be sufficient for some pictures in which relatively large foreground object containing a very few number of similar colors are centered. The usage of the second default *numberOf(Y/C)Coefficient*, 6 for both Y and Cs, should be considered when high retrieval efficiency is expected for the application even though it increases the description cost about 40%.

- Limitations

There are no limitations on the usage of this descriptor.

4.2.6 Color structure

The *Color Structure* (CS) *Descriptor* (D) jointly embeds information about the color distribution within an image (similar to a color histogram) and, in addition, the local spatial structure of those colors. The extra spatial information makes the descriptor sensitive to certain image features to which an ordinary color histogram is blind. The primary function of the CS D is image-to-image matching for still-image indexing and retrieval applications. Extraction of a CS D is defined for both rectangular images and images that consist of arbitrarily shaped, possibly disconnected, regions.

Why is the CS D able to distinguish between images that an ordinary histogram cannot? The M bins of both a CS D and an ordinary color histogram are associated to the M color cells of a quantized color space. The set of image pixels whose colors lie within the m^{th} quantization cell quantizes to color c_m and forms an *iso-color* plane[2] within the image.

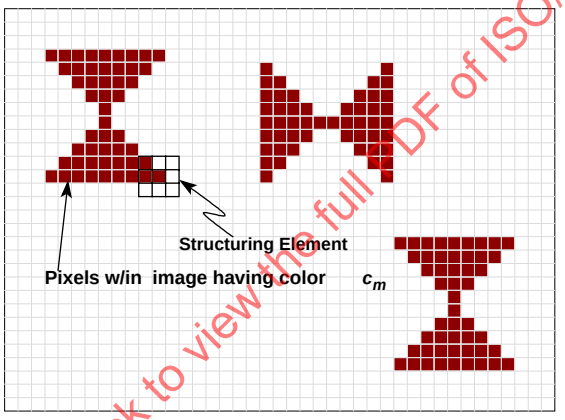


Figure 83 - Highly structured iso-color plane.

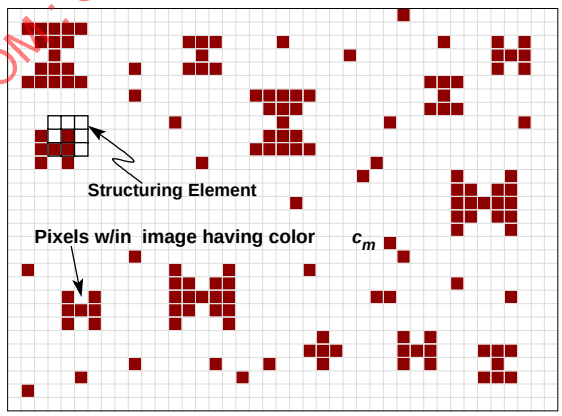


Figure 84 - Un-structured iso-color plane

Figure 83 and Figure 84 each consist of two iso-colors planes: 150 foreground pixels of color c_m, and the remaining white background pixels. The left image is composed of three large structured areas of color whereas the right image is made up of many small and medium sized clumps of pixels and is therefore considered un-structured.

[2] An image quantized to M colours is composed of M iso-colour planes. The m^{th} plane is the set of all pixels having the m^{th} quantized colour, $m \in \{0,\ldots, M\text{-}1\}$.

Each bin value of an ordinary color histogram records the number of pixels that have the particular color associated to it. The CS D, on the other hand, employs a square *structuring element* several pixels in size to jointly measure a color's local spatial structure as well as its frequency-of-occurrence within an image. The value of a CS D bin is a function of the number of overlapped structuring elements that can be positioned within the image such that each contains at least one pixel of the color associated to that bin.

Consequently, an (un-normalized) ordinary histogram would record a value of 150 in its m^{th} bin for both figures whereas the (un-normalized) CS D, using a 3×3 structuring element, would record a value of around 300 for Figure 83 but around 580 for Figure 84. This large difference reflects the structural difference of the foreground iso-color planes and enables a Similarity Measure to easily distinguish the two images.

4.2.6.1 Feature extraction

Extraction of the CS D is best understood in terms of the *Color Structure* (CS) *Histogram (H)* from which the CS D is derived. Indeed, the CS D can be viewed as a CS H restricted in the following ways:

i. color space in which the CS H is accumulated,

ii. number of allowable bins (viz. *operating points*),

iii. method by which more compact (i.e. shorter), lower performance, CS Histograms are generated, and

iv. scheme used to quantize bin amplitude values.

None of these restrictions is assumed to initially hold in the discussion of CS H accumulation that follows. Subsequent subsections discuss each restriction. Finally the restrictions are together applied to form a CS D from a general CS H.

Note that in the discussion to follow the term *accumulation* is used to denote the initial extraction of a CS H from an image. The term *extraction*, itself, is reserved to denote the entire process of fabricating a CS D from an image.[3]

4.2.6.1.1 CS Histogram accumulation

The CS H is identical in form to an ordinary color histogram but differs from it semantically. Specifically, the CS H is a one-dimensional array of values,

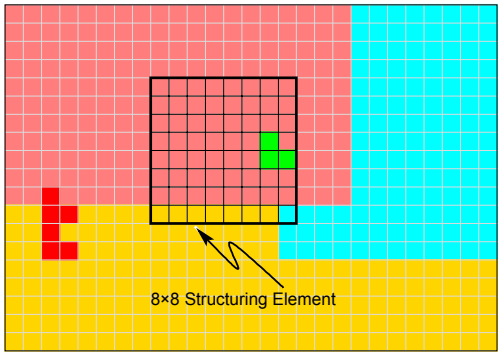
$$\text{CS H} = h_s(m), \quad m \in \{0, \ldots, M\text{-}1\},$$

where M is the number of bins and s is the scale of the associated square structuring element. In the preceding figures, $s = 3^2$. The M bins (array elements) of h_s are associated in a bijective[4] manner to the M cells of a quantized color space. From now on the subscript s will be dropped for convenience.

The process of extracting the CS D begins with accumulating a CS Histogram. Figure 85 depicts a simple five-color "image" together with an 8×8 structuring element ($s = 8^2$). An eight bin histogram, $h(m)$, whose bins are associated to colors c_m, $m \in \{0, \ldots, 7\}$, is shown in tabular form to the right.

[3] An *image* is defined as a rectangular array of pixels where each pixel is classified into one of two categories: *active* or *passive*, and where the active pixels form arbitrarily shaped, possibly disconnected, regions. The dimensions of the image are taken to be the dimensions of the rectangular array. The values of active pixels, and only those values, participate in the extraction of the descriptor; the values of passive pixels are ignored. In practice the active and passive pixels of an image are determined by some indirect means such as a binary mask. An image in the usual sense is one in which all pixels in the rectangular array are classified as active.

[4] A map, $f : A \rightarrow B$, is said to be *bijective* if f maps set A onto set B in a one-to-one manner.



Color	Bin Value
c_0	h (0) + 1
c_1	h (1)
c_2	h (2)
c_3	h (3) + 1
c_4	h (4)
c_5	h (5) + 1
c_6	h (6) + 1
c_7	h (7)

Figure 85 - Accumulation of Color Structure Histogram.

In nominal operation, the structuring element scans the image such that it visits every position in the pixel grid subject to the restriction that the element always lies entirely inside the image. At every position, each bin value is incremented if and only if the associated color is present within the element. In its position in Figure 85, four of the five image colors are present within the structuring element so the four corresponding bins of the CS Histogram are incremented by one. Hence the final value of $h(m)$ is determined (up to normalization) by the number of positions at which the structuring element contains c_m. The small green region of color c_6, for example, contributes a value of 80 to $h(6)$ when the CS Histogram is fully accumulated.

Note that the (un-normalized) CS H reduces to an ordinary histogram when $s = 1^2$. Hence the CS H may be viewed as a generalization of an ordinary color histogram.

A scale of $s = 8^2$ was determined by experiment to be optimal for images of approximately CIF size. For images of larger size the spatial extent of the structuring element is increased to reflect the probable increase in size of color structures within the image. In addition, accumulation is done on a sparse grid of samples to reduce the computational load.

In principle these algorithmic changes are equivalent to preceding nominal accumulation by uniform subsampling, both horizontally and vertically, of incoming images of general size. The subsampling factor is given by $K = 2^p$ where

$$p = \max\{0, \lfloor \log_2 \sqrt{W \cdot H} - 7.5 \rfloor\},$$

where W and H are the picture width and height respectively, and where $\lfloor . \rfloor$ is the *floor* operator. A value of $p = 0$ implies "no subsampling", i.e., nominal behaviour.

The subsampling can be done *implicitly* (and practically) by adjusting the algorithm such that

- scale is reset to $s = (8K)^2$,
- movement of the element is restricted to the sparse grid of coördinates, (Kx, Ky),
- the structuring element always lies entirely within the image,
- accumulation within the structuring element is restricted to coördinates, (Kx, Ky), where x and y are taken from the integers.

Two examples are illustrated in Figure 86 where "×" denotes image pixels. Pixels marked with a box indicate those that participate in accumulation within the structuring element. The red square shows the spatial extent of the element. Note that for $K>1$ the spatial extent of the structuring element is larger than the square formed by the marked pixels.

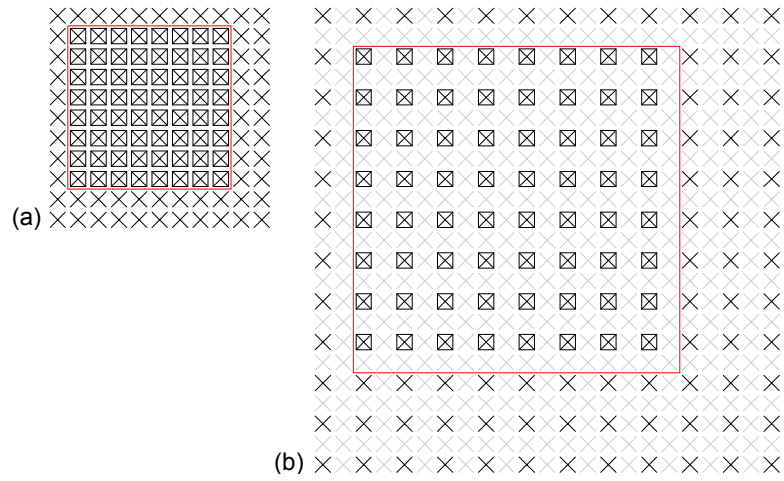


Figure 86 - (a): Structuring Element spatial extent and accumulation for K=1 (nominal operation). (b): For (K=2).

Nominal operation is depicted in (a) where $s = 8^2$, where the upper left corner of the element visits every[5] pixel, and where all pixels in the element participate in accumulation. Non-nominal behaviour is shown in (b) where $p = 1$ (hence $K = 2$), $s = 16^2$, the upper left corner of the element visits just the pixels shown in black, and only a quarter of the pixels within the element are used in accumulation.

In the following pseudo-code $i[x][y]$ is the input color image, M is the number of quantized colors as determined by the colorQuant attribute defined in ISO/IEC 15938-3, and $h[m]$ is the CS Histogram to be accumulated. In addition, W and H are picture width and height respectively, and $t[m]$ is temporary storage for a local histogram of pixels at one location of the structuring element. The ranges of x, y are as discussed above, $m \in \{0, \ldots, M\text{-}1\}$, K is as above, and $E = 8K$. The CS Histogram accumulation step of CS Descriptor extraction is any algorithm equivalent to:

```
// initialize the Color Structure Histogram h[m]
for (m=0; m < M; m++) h[m] = 0.0;
for (y=0; y < H-E+1; y+=K) {
    for (x=0; x < W-E+1; x+=K) {
        // (re-)initialize the local histogram t[m]
        for (m=0; m < M; m++) t[m] = 0;
        // collect local histogram over pixels in structuring element
        for (yy=y; yy < y+E; yy+=K) {
            for (xx=x; xx < x+E; xx+=K) {
                // get quantized pixel color and update local histogram
                m = quantizedColorIndex(i[xx][yy]);
                t[m]++;
            }
        }
        // Increment the color structure histogram for each color present in the structuring element
        for (m=0; m < M; m++)
            if (t[m] > 0)  h[m]++;
    }
}
```

The function `quantizedColorIndex`() represents in abstract form the process of computing from pixel $i[xx][yy]$ the quantized color c_m and hence the index m itself. This is elaborated later in the discussion.

The normalized CS Histogram $(h/R_{max})(m)$, $m \in \{0, \ldots, M\text{-}1\}$, is a real valued quantity whose range lies in the interval [0, 1]. The normalizer, given by

$$R_{max} = \left[\frac{W - \sqrt{s}}{K} + 1\right] \cdot \left[\frac{H - \sqrt{s}}{K} + 1\right],$$

[5] Assumption: pixels in the figure are from a central image region, i.e., image borders are at some distance from the edges in the figure.

represents the number of possible positions within the image that the structuring element can visit. Therefore h/R_{max} is in [0, 1]. On the other hand $\Sigma(h/R_{max})$ will, in general, exceed unity in contrast to a color histogram where the sum of normalized values always equals unity. Furthermore, no data-independent method has been discovered to bring the CS Histogram into conformity with an ordinary histogram *and at the same time* preserve its superior retrieval performance. The CS Histogram (with $s > 1$) is, therefore, incompatible and hence not inter-operable with the color histogram.

This subsection has dealt with CS H accumulation apart from any consideration of a particular color space, the method by which to get histograms of different length, and the inter-operability of different length histograms. The following three subsections discuss these topics and therefore cover items (i), (ii), and (iii) at the beginning of subclause 4.2.6.1.

4.2.6.1.2 Scalable color space quantization and bin unification

This subsection defines the notions of *scalable quantization* and *bin unification*. As will be seen in the next subsection, they are necessary ingredients for re-sizing CS Histograms in an inter-operable way.

A *quantization* of a color space is a *partition* of the space into cells. A partition of a space, S, is a collection, $\{p_0,\ldots,p_{N-1}\}$, of cells such that

$$p_i \subseteq S,\ \ p_i \cap p_j = \varnothing \text{ for } i \neq j, \text{ and } \bigcup_{i=0}^{N-1} p_i = S.$$

Let $P = \{p_0,\ldots, p_{M-1}\}$ and $Q = \{q_0,\ldots, q_{N-1}\}$ be two partitions of S where $M > N$. P and Q are said to be *scalable* if the following conditions hold:

$$\text{For each } n,\ \text{there is a } J_n = \{n_1,\ldots,n_{k_n}\} \text{ such that } q_n = \bigcup_{m\in J_n} p_m, \qquad (1)$$

$$J_i \cap J_j = \varnothing \ \text{ for } \ i \neq j.$$

The first condition states that every cell in Q is *covered* by some collection of cells from P. The second condition guarantees that the covering for q_i does not overlap q_j when $i \neq j$.

Scalable quantization is illustrated in Figure 87. Shown in (a) is an arbitrary 16-cell partition of an abstract space. In (b) the space is re-quantized more coarsely into 8-cells in a way that is non-scalable with respect to (a). A scalable 8-cell partition is shown in (c) from which the index subsets, J_n, are easily seen. For instance the cell with index 3 in (c) is (precisely) covered by the cells from (a) whose indices form the index set J_3 = {1, 2, 3, 11}.

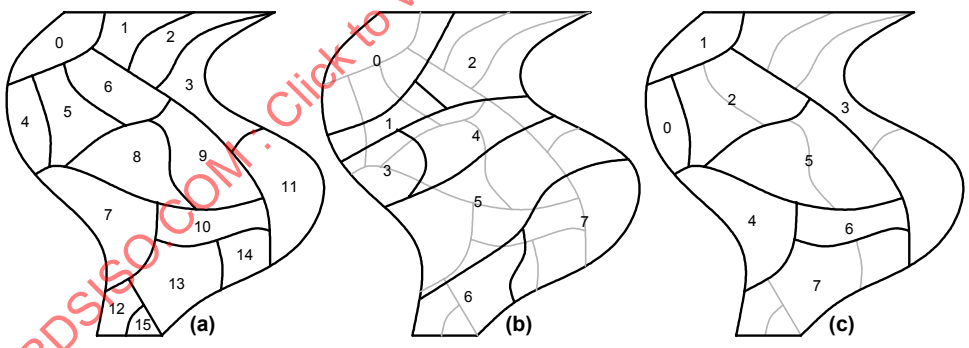


Figure 87 - Non-scalable and scalable partitions (quantizations) of an abstract space. (a): Partition of space into 16 cells. (b): 8-cell partition of same space that is non-scalable w.r.t. (a). (c): Scalable partition of space into 8 cells.

One way to obtain an N-bin CS H is to accumulate an M-bin CS H from an image quantized to $M > N$ colors and then *re-size* it by appropriately unifying the bins to obtain the N-bin Histogram. The process of *bin unification* is defined by

$$h^N(n) = \sum_{m\in J_n} h^M(m),\ \ n \in \{0,\ldots,N-1\}, \qquad (2)$$

where the superscripts denote the respective histogram length, where J_n is the index subset given by eq. (1), and where here and in the remainder of the discussion the histograms are assumed to be normalized by R_{max}.

Mathematically, eq. (2) is the function induced on the histogram bins by (1) via the identification of bins and cells. In particular, the cell union in (1) induces the bin summation in (2) via the bijection. As an example,

suppose a 16-bin histogram, h^{16}, is accumulated from an image quantized in the color space of Figure 87a. To re-size h^{16} to h^8 where the 8 bins correspond to the quantized color space of Figure 87c, put

$$h^8(0) = h^{16}(4),$$

$$h^8(1) = h^{16}(0),$$

$$h^8(2) = h^{16}(5) + h^{16}(6),$$

$$h^8(3) = h^{16}(1) + h^{16}(2) + h^{16}(3) + h^{16}(11),$$

and so on.

The previous subsection stated that $0 \le h \le 1$ for a properly normalized CS H. It also stated that $\Sigma h \ge 1$ generally holds. The latter relation implies that application of (2) to a normalized histogram may violate the former relation. To avoid the problem it is necessary to *clip to unity* those values of h^N that exceed it.

Such clipping possesses the following attractive property. Suppose $L > M > N$ are the sizes of three normalized histograms, h^L, h^M, and h^N. And suppose two stages of clipped re-sizing, ($h^L \rightarrow h^M \rightarrow h^N$), are used to obtain h^N from h^L. This yields the same result as having obtained h^N, in a single clipped re-sizing step, from h^L. This behaviour will be useful later in the discussion.

4.2.6.1.3 Inter-operability and histogram re-sizing

Suppose for the moment that Color Histograms (either ordinary or CS) are considered as image descriptors. In retrieval applications it may be the case that a query descriptor presented to a remote search engine has a length, in terms of number of bins, which differs from the descriptors in the database. The sizes must somehow be equalized to compute the similarity between query and database descriptors.

Now a length N histogram can be obtained either

- by extracting it directly from an image quantized to N colors, or
- by extracting from the same image, quantized to $M > N$ colors, a length M histogram and then unifying bins in the manner defined above to form the N-bin histogram.

For an ordinary color histogram both methods yield the *same histogram* as long as the scalability condition is met by the color space quantizations.

The CS H (and, hence, the CS D) does not enjoy this property because the color quantization of an image affects its color structure. For example, suppose an image contains two unstructured iso-color planes whose colors, c_i and c_j, are in close enough proximity in the color space that they merge into a single iso-color plane under a coarser color space quantization. Suppose, further, that a significant portion of the pixels in the c_i plane are in close spatial proximity (relative to the scale of the structuring element) to those of the c_j plane. Then the merged plane, after coarsely re-quantizing the color space, will have greater structure than each of the individual planes. As a result, a CS Histogram obtained from an image by one scheme will, in general, lead to different retrieval results than a CS H from the same image by the other scheme. In other words the two extraction/re-sizing methods are not inter-operable (as they are with ordinary histograms).

To guarantee inter-operability, all CS Histograms shorter than the longest specified by ISO/IEC 15938-3 are obtained strictly by bin unification from longer histograms, never by direct accumulation from appropriately quantized images. The longest CS H is accumulated directly from an image quantized by the finest, i.e., the least coarse, color space partition.

4.2.6.1.4 Non-uniform quantization of HMMD color space

HMMD color space is defined in subclause 6.2 of the ISO/IEC 15938-3. Figure 88 shows the double cone geometry of the space. *Hue* is defined as in HSV color space but HMMD is parameterized differently in its remaining two variables, *sum* and *diff*, which behave roughly like lightness and saturation. The space naturally lends itself to a non-uniform quantization that tends to “spend bits” where the human visual system is sensitive. For example, close to the vertical *sum*-axis, where color saturation is low, fewer bits are used to encode *hue*. The available bits are used to finely quantize *sum*; *diff* thresholds are also more closely spaced near the *sum*-axis.