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Information technology – Multimedia content description interface – Part 3: Visual

Contents

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.

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In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. 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.

Attention is drawn to the possibility that some of the elements of this part of ISO/IEC 15938 may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

International Standard ISO/IEC 15938-3 was prepared by Joint Technical Committee ISO/IEC JTC 1, *JTC*, Subcommittee SC 29, .

This second/third/... edition cancels and replaces the first/second/... edition (), [clause(s) / subclause(s) / table(s) / figure(s) / annex(es)] of which [has / have] been technically revised.

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
- **Description Definition Language (DDL)** defines Description Schemes, Descriptors, and Datatypes by specifying their syntax, and allows their extension.
- **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.

This document contains the visual elements (Descriptors and Description Schemes) that are considered for being part of the standard. All these Descriptive Structures are classified according to the types of visual features they describe. For each Descriptive Structure, there is one corresponding section in this document. The section specifies textual and binary syntax and semantics of the structures.

Information technology – Multimedia content description interface – Part 3: Visual

1 Scope

1.1 Organization of the document

The structure of this document is as follows. Clauses **2**-4 specify the terms, abbreviations, symbols and conventions used throughout the document. Clauses 5-11 contain definitions of the description tools standardized by 15938-3 grouped by the visual features they are associated with, starting with basic structures and containers in Clause 5, through color, texture, shape, motion, localization in Clause 10. Clause 11 contains the remaining, unclassified items.

Each description tool is described by the following subclauses:

- Syntax: Normative DDL specification of the Ds or DSs.
- Binary Syntax: Normative binary representation of the Ds or DSs.
- Semantic: Normative definition of the semantics of all the components of the corresponding D or DS.

1.2 Overview of Visual Description Tools

This part of ISO/IEC 15938 specifies tools for description of visual content, including still images, video and 3D models. These tools are defined by their syntax in DDL and binary representations and semantics associated with the syntactic elements. They enable description of the visual features of the visual material, such as color, texture, shape and motion, as well as localization of the described objects in the image or video sequence. An overview of the visual description tools is shown in Figure. 1.

The basic structure description tools include five supporting tools of visual descriptions defined in clauses 6–11. They are categorized into two groups, descriptor containers and basic supporting tools. The former consists of three datatypes, GridLayout providing efficient representations of visual features on grids, TimeSeries representing temporal arrays of several descriptions, and MultipleView describing a 3D object using several pictures captured from different view angles. The latter contains two tools, Spatial2DCoordinateSystem used to specify the 2D coordinate system and TemporalInterpolation indicating the interpolation method between two samples on a time axis.

The remaining description tools, except for the FaceRecognition descriptor, are associated with visual features and are grouped into five feature categories: Color, Texture, Shape, Motion and Localization.

The color description tools include four color descriptors to represent different aspects of color features: representative colors (DominantColor), color distribution (ScalableColor), spatial distribution of colors (ColorLayout and ColorStructure). It also contains two supporting tools, ColorSpace and ColorQuantization used in DominantColor and an extension of ScalableColor to a group of frames or pictures (GoFGoPColor). All the color descriptors can be extracted from arbitrarily shaped regions.

The texture description tools facilitate browsing (TextureBrowsing) and similarity retrieval (HomogeneousTexture and EdgeHistogram) using the texture of a still or moving image region. All the texture descriptors can be extracted from arbitrarily shaped regions.

The shape description tools include two descriptors that characterize different shape features of a 2D object or region. The RegionShape descriptor captures the distribution of all pixels within a region and the Contour Shape descriptor characterizes the shape properties of the contour of an object. The Shape3D descriptor provides an intrinsic shape characterization of 3D mesh models.

The motion description tools include four descriptors that characterize various aspects of motion. The CameraMotion descriptor specifies a set of basic camera operations such as, for example, panning and tilting. The motion of a key point (pixel) from a moving object or region can be characterized by the MotionTrajectory descriptor. The ParametricMotion descriptor characterizes an evolution of an arbitrarily shaped region over time in terms of a 2D geometric transformation. Finally, the MotionActivity descriptor captures the pace of the motion in the sequence, as perceived by the viewer. All motion descriptors except for CameraMotion can be extracted from arbitrarily shaped regions.

The localization description tools can be used to indicate regions of interest in the spatial (RegionLocator) and spatio-temporal (SpatioTemporalLocator) domains.

The FaceRecognition descriptor is not associated with any particular visual feature and can be used to describe a human face for applications requiring the matching and retrieval of face images.

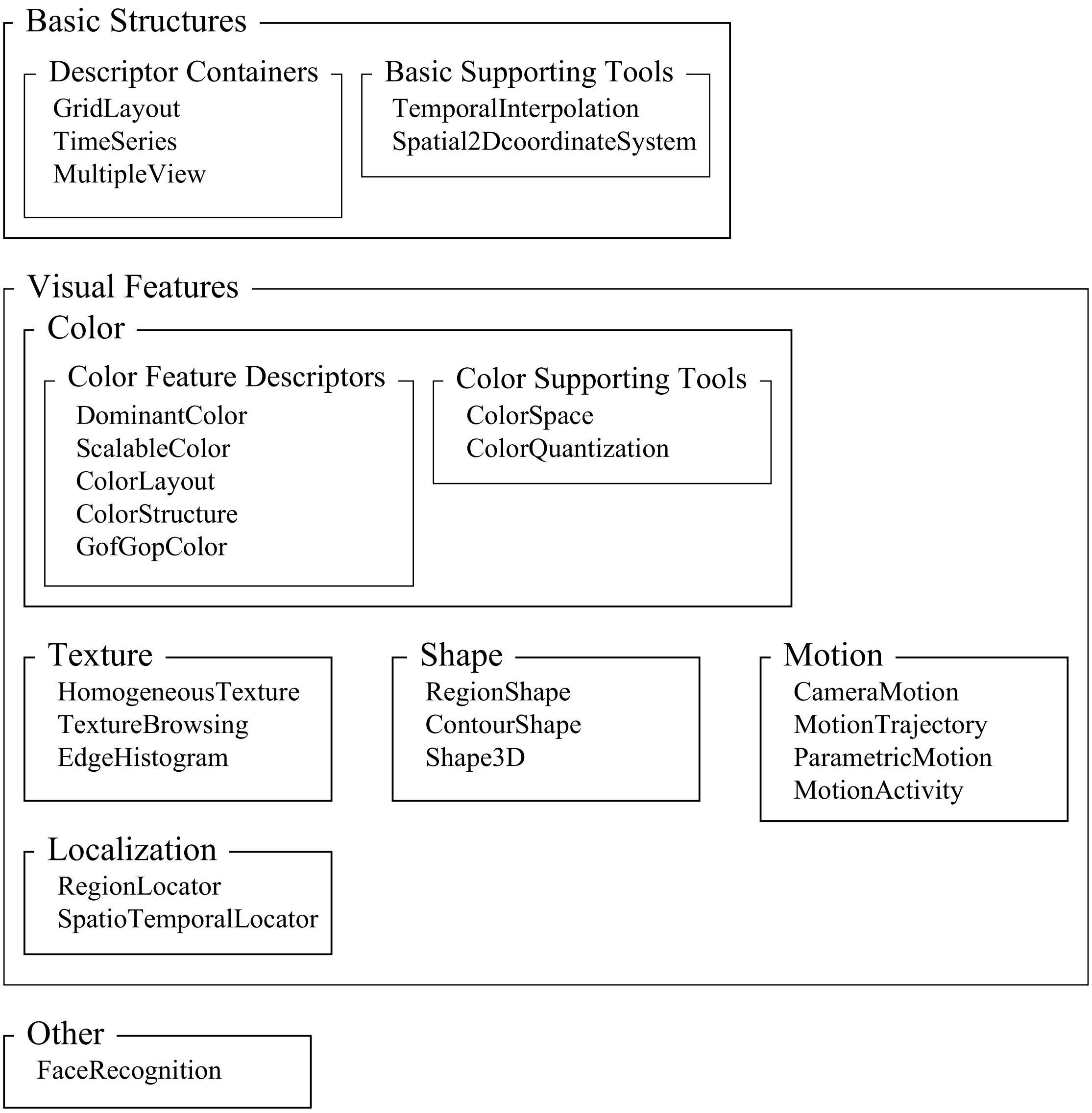


Figure 1 — Overview of Visual Description Tools

2 Terms and Definitions

2.1 Default reference axis

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

2.2 DCT coefficients

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

AC coefficient

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

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

2.3 Data element

An item of data as represented before encoding and after decoding.

3 Abbreviations and Symbols

3.1 General

The mathematical symbols used to describe ISO/IEC 15938-3 are similar to those used in the C programming language. However, integer divisions with truncation and rounding are specifically defined. Numbering and counting loops generally begin with zero.

3.2 Abbreviations

ART	Angular-Radial Transform
CSS	Curvature Scale Space
DDL	Description Definition Language
DS	Description Scheme
D	Descriptor
DCT	Discrete Cosine Transform
FOC	Focus of Contraction
FOE	Focus of Expansion
GoF	Group of Frames
GoP	Group of Pictures
HMMD	Hue-Min-Max-Difference
HSV	Hue-Saturation-Value
RGB	Red-Green-Blue

3.3 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
*	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

3.4 Logical operators

||	Logical OR
&&	Logical AND
!	Logical NOT

3.5 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

3.6 Bitwise operators

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

3.7 Conditional operator

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

3.8 Assignment

= Assignment operator

3.9 Mnemonics

The following mnemonics are defined to describe the different data types used in the coded bitstream.

bslbf Bit string, left bit first, where "left" is the order in which bits are written in ISO/IEC 15938-3. Bit strings are generally written as a string of 1s and 0s within single quote marks, e.g. '1000 0001'. Blanks within a bit string are for ease of reading and have no significance. For convenience, large strings are occasionally written in hexadecimal, in which case conversion to a binary in the conventional manner will yield the value of the bit string. Thus, the left-most hexadecimal digit is first and in each hexadecimal digit the most significant of the four digits is first.

vluimsbf5 Variable length unsigned integer most significant bit first representation consisting of two parts. The first part defines the number *n* of 4-bit bit fields used for the value representation, encoded by a sequence of *n-1* "1" bits, followed by a "0" bit signaling its end. The second part contains the value of the integer encoded using the number of bit fields specified in the first part.

uimsbf Unsigned integer, most significant bit first.

simsbf Signed integer, in two's complement format, most significant bit (sign) first.

vlclbf Variable length code, left bit first, where "left" refers to the order in which the VLC codes are written in ISO/IEC 15938-3. The byte order of multibyte words is most significant byte first.

fsbf Float (32 bit), sign bit first. The semantics of the bits within a float are specified in the IEEE Standard for Binary Floating Point Arithmetic (ANSI/IEEE Std 754-1985).

UTF-8 Binary string encoding defined in ISO 10646/IETF RFC 2279.

3.10 Constants

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

3.11 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*.

L1 norm $L1(\mathbf{x},\mathbf{y}) = \sum_i |x_i - y_i|$

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

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

4 Conventions

4.1 Method of describing the DDL representation syntax

The method of describing the DDL representation syntax is defined in ISO/IEC 15938-2 (MPEG-7 Description Definition Language).

4.2 Method of describing the binary representation syntax

4.2.1 Introduction

The video description elements can be encoded using the generic encoding mechanism defined in ISO/IEC 15938-1 or the video-specific binary representation syntax defined in the “Binary representation syntax” subclauses below.

4.2.2 Generic binary representation

The use of the video-specific syntax is signaled using the codec configuration mechanism defined in ISO/IEC 15938-1 and the following classification scheme is defined for this purpose.

```
<ClassificationScheme uri="urn:mpeg:mpeg7:cs:VisualDescriptorCodecCS:2001">
   <Term termID="1">
      <Name xml:lang="en">MPEG7CameraMotion</Name>
      <Definition xml:lang="en">ISO/IEC 15938-3 Binary Camera Motion
            Codec</Definition>
   </Term>
   <Term termID="2">
      <Name xml:lang="en">MPEG7ColorLayout</Name>
      <Definition xml:lang="en">ISO/IEC 15938-3 Binary Color Layout
            Codec</Definition>
   </Term>
   <Term termID="3">
      <Name xml:lang="en">MPEG7ColorQuantization</Name>
      <Definition xml:lang="en">ISO/IEC 15938-3 Binary Color Quantization
            Codec</Definition>
   </Term>
```

```
<Term termID="4">
   <Name xml:lang="en">MPEG7ColorSpace</Name>
   <Definition xml:lang="en">ISO/IEC 15938-3 Binary Color Space
         Codec</Definition>
</Term>
<Term termID="5">
   <Name xml:lang="en">MPEG7ColorStructure</Name>
   <Definition xml:lang="en">ISO/IEC 15938-3 Binary Color Structure
         Codec</Definition>
</Term>
<Term termID="6">
   <Name xml:lang="en">MPEG7ContourShape</Name>
   <Definition xml:lang="en">ISO/IEC 15938-3 Binary Contour Shape
         Codec</Definition>
</Term>
<Term termID="7">
   <Name xml:lang="en">MPEG7DominantColor</Name>
   <Definition xml:lang="en">ISO/IEC 15938-3 Binary Dominant Color
         Codec</Definition>
</Term>
<Term termID="8">
   <Name xml:lang="en">MPEG7EdgeHistogram</Name>
   <Definition xml:lang="en">ISO/IEC 15938-3 Binary Edge Histogram
         Codec</Definition>
</Term>
<Term termID="9">
   <Name xml:lang="en">MPEG7FaceRecognition</Name>
   <Definition xml:lang="en">ISO/IEC 15938-3 Binary Face Recognition
         Codec</Definition>
</Term>
<Term termID="10">
   <Name xml:lang="en">MPEG7FoFGoPColor</Name>
   <Definition xml:lang="en">ISO/IEC 15938-3 Binary GoFGoP Color
         Codec</Definition>
</Term>
<Term termID="11">
   <Name xml:lang="en">MPEG7GridLayout</Name>
   <Definition xml:lang="en">ISO/IEC 15938-3 Binary Grid Layout
         Codec</Definition>
</Term>
<Term termID="12">
   <Name xml:lang="en">MPEG7HomogeneousTexture</Name>
   <Definition xml:lang="en">ISO/IEC 15938-3 Binary Homogeneous Texture
         Codec</Definition>
</Term>
<Term termID="13">
   <Name xml:lang="en">MPEG7IrregularVisualTimeSeries</Name>
   <Definition xml:lang="en">ISO/IEC 15938-3 Binary Irregular Time Series
         Codec</Definition>
</Term>
<Term termID="14">
   <Name xml:lang="en">MPEG7MotionActivity</Name>
   <Definition xml:lang="en">ISO/IEC 15938-3 Binary Motion Activity
         Codec</Definition>
</Term>
<Term termID="15">
   <Name xml:lang="en">MPEG7MotionTrajectory</Name>
   <Definition xml:lang="en">ISO/IEC 15938-3 Binary Motion Trajectory
         Codec</Definition>
</Term>
<Term termID="16">
```

```
      <Name xml:lang="en">MPEG7MultipleView</Name>
      <Definition xml:lang="en">ISO/IEC 15938-3 Binary Multiple View
            Codec</Definition>
   </Term>
   <Term termID="17">
      <Name xml:lang="en">MPEG7ParametricMotion</Name>
      <Definition xml:lang="en">ISO/IEC 15938-3 Binary Parametric Motion
            Codec</Definition>
   </Term>
   <Term termID="18">
      <Name xml:lang="en">MPEG7RegionLocator</Name>
      <Definition xml:lang="en">ISO/IEC 15938-3 Binary Region Locator
            Codec</Definition>
   </Term>
   <Term termID="19">
      <Name xml:lang="en">MPEG7RegionShape</Name>
      <Definition xml:lang="en">ISO/IEC 15938-3 Binary Region Shape
            Codec</Definition>
   </Term>
   <Term termID="20">
      <Name xml:lang="en">MPEG7RegularVisualTimeSeries</Name>
      <Definition xml:lang="en">ISO/IEC 15938-3 Binary Regular Time Series
            Codec</Definition>
   </Term>
   <Term termID="21">
      <Name xml:lang="en">MPEG7ScalableColor</Name>
      <Definition xml:lang="en">ISO/IEC 15938-3 Binary Scalable Color
            Codec</Definition>
   </Term>
   <Term termID="22">
      <Name xml:lang="en">MPEG7Shape3D</Name>
      <Definition xml:lang="en">ISO/IEC 15938-3 Binary Shape 3D
            Codec</Definition>
   </Term>
   <Term termID="23">
      <Name xml:lang="en">MPEG7Spatial2DCoordinateSystem</Name>
      <Definition xml:lang="en">ISO/IEC 15938-3 Binary Spatial 2D Coordinate
            System Codec</Definition>
   </Term>
   <Term termID="24">
      <Name xml:lang="en">MPEG7SpatioTemporalLocator</Name>
      <Definition xml:lang="en">ISO/IEC 15938-3 Binary SpatioTemporal Locator
            Codec</Definition>
   </Term>
   <Term termID="25">
      <Name xml:lang="en">MPEG7TemporalInterpolation</Name>
      <Definition xml:lang="en">ISO/IEC 15938-3 Binary Temporal Interpolation
            Codec</Definition>
   </Term>
   <Term termID="26">
      <Name xml:lang="en">MPEG7TextureBrowsing</Name>
      <Definition xml:lang="en">ISO/IEC 15938-3 Binary Texture Browsing
            Codec</Definition>
   </Term>
</ClassificationScheme>
```

4.2.3 Video binary representation

The video-specific bitstream retrieved is described in subclauses entitled “Binary syntax representation” in clauses 5—11. Each data item in the bitstream is in bold type. It is described with its name, its length in bits, and a mnemonic for its type and order of transmission.

The action caused by a decoded data element in a bitstream depends on the value of that data element and on data elements previously decoded. The following constructs are used to express the conditions when data elements are present and are in normal type.

while (condition) {
  data_element
  …
}
	If the condition is true, then the group of data elements occurs next in the data stream. This repeats until the condition is not true.

do {
  data_element
  …
} while (condition)
	The data element always occurs at least once.
	The data element is repeated until the condition is not true.

if (condition) {
  data_element
  …
} else {
  data_element
  …
}
	If the condition is true, then the first group of data elements occurs next in the data stream.
	If the condition is not true, then the second group of data elements occurs next in the data stream.

for (i=m ; i<n ; i++) {
  data_element
  …
}
	The group of data elements occurs (n-m) times. Conditional construct within the group of data elements may depend on the value of the loop control variable i, which is set to m for the first occurrence, incremented by one for the second occurrence, and so forth.

/* comments */	Explanatory comments that may be deleted entirely without in any way altering the syntax.

The syntax uses a 'C-code' convention that a variable or expression evaluating to a non-zero value is equivalent to a condition that is true and a variable or expression evaluating to zero is equivalent to a condition that is false. In many cases a literal string is used in a condition. In such cases a literal string is used to describe the value of a bitstream element.

As noted, a group of data element may contain nested conditional constructs. For compactness, the brackets {} are omitted when only one data element follows. The elements of a multidimensional table are represented as follows.

data_element[n] data_element[n] is the $n+1^{st}$ element in an array of data

data_element[m][n] data_element[m][n] is the $m+1^{st}$,$n+1^{st}$ element in a two-dimensional array of data

data_element[l][m][n] data_element[l][m][n] is the $l+1^{st}$,$m+1^{st}$,$n+1^{st}$ element in a three-dimensional array

The elements of a multidimensional array are transmitted in the bitstream starting with data_element[0][0] and with the outermost elements incremented first, i.e. data_element[0][1] is sent second, data_element[0][2] third, etc.

4.3 Method of describing the descriptor semantics

The general semantics of the descriptors are defined in the introductory sections of respective subclauses. The semantics of the syntax components is defined in sections "Descriptor components semantics". The ordering in the semantics sections normally follows the order in which the items appear in the binary representation syntax, which is typically equivalent to the order of items in the DDL instantiation (not schema specification).

5 Basic structures

5.1 Introduction

This clause introduces five supporting tools for the visual descriptions defined in clauses 6−11. They are categorized into two groups, descriptor containers and basic supporting tools. The former consists of three datatypes, GridLayout providing efficient representations of visual features on grids, VisualTimeSeries representing temporal arrays of several descriptions, and MultipleView describing a 3D object using several pictures captured from different view angles. The latter contains two tools, Spatial2DCoordinateSystem used to specify the 2D coordinate system and TemporalInterpolation indicating the interpolation method between two samples on a time axis.

5.2 Grid layout

5.2.1 Introduction

This datatype specifies a structure that allows an image to be split 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 or texture.

5.2.2 DDL representation syntax

```
<complexType name="GridLayoutType" final="#all">
   <sequence>
      <element name="Descriptor" type="mpeg7:VisualDType"
         minOccurs="1" maxOccurs="65025"/>
   </sequence>
   <attribute name="numOfPartX" type="mpeg7:unsigned8" use="required"/>
   <attribute name="numOfPartY" type="mpeg7:unsigned8" use="required"/>
   <attribute name="descriptorMask" use="optional">
      <simpleType>
         <restriction base="string">
            <pattern value="(0|1)*"/>
         </restriction>
      </simpleType>
   </attribute>
</complexType>
```

5.2.3 Binary representation syntax

GridLayout {	**Number of bits**	**Mnemonic**
DescriptorID	8	uimsbf
numOfPartX	8	uimsbf
numOfPartY	8	uimsbf
DescriptorMaskPresent	1	bslbf
if(DescriptorMaskPresent) {		
descriptorMask	partNumX*partNumY	bslbf
}		
for(k=0;k<partNumX*partNumY; k++) {		
if(DescriptorMaskPresent) {		
if(descriptorMask[k]) {		
Descriptor[k]		Descriptor instance specified by descriptorID
}		
} else {		
Descriptor[k]		Descriptor instance specified by descriptorID
}		
}		
}		

5.2.4 Descriptor components semantics

DescriptorID

This field, which is only present in the binary representation, specifies a descriptor identifier. The descriptor identifier indicates the descriptor type accommodated in the grid layout.

The assignment of IDs to the descriptors is specified in Table 1.

Table 1 — Assignment of IDs to descriptors.

ID	Descriptor
0	Forbidden
1	CameraMotion
2	ColorLayout
3	ColorSpace
4	ColorStructure
5	ColorQuantization
6	ContourShape
7	DominantColor
8	EdgeHistogram
9	FaceRecognition
10	GoFGoPColor
11	GridLayout
12	HomogeneousTexture
13	IrregularVisualTimeSeries
14	MotionActivity
15	MotionTrajectory
16	MultipleView
17	ParametricMotion
18	RegionLocator
19	RegionShape
20	RegularVisualTimeSeries
21	ScalableColor
22	Shape3D
23	Spatial2DCoordinateSystem
24	SpatioTemporalLocator
25	TemporalInterpolation
26	TextureBrowsing
27-255	Reserved

numOfPartX
This attribute specifies the number of horizontal partitions in the grid over the image.

numOfPartY
This attribute specifies the number of vertical partitions in the grid over the image.

DescriptorMaskPresent
This field, which is only present in the binary syntax, indicates whether all partitions of the image contain the descriptors. If DescriptorMaskPresent is set to 0 then all partitions contain the descriptor. If DescriptorMaskPresent is set to 1 then the DescriptorMask attribute indicates which partitions contain descriptors.

descriptorMask
This attribute specifies a bit-field that indicates whether a descriptor is assigned to the corresponding partition. The partitioned image is indexed from left to right and top to bottom. For example, if a descriptorMask of "0110" is given for a 2x2 partitioned image then the upper right and lower left quarter of the image contain a descriptor.

Descriptor
This element specifies the visual descriptors that have been assigned to the cells. When a visual descriptor is assigned to a cell within grid layout, it defines the properties of the particular cell according to the semantic definition of the descriptor used. In other words, each cell is treated as an individual image and the descriptor values are computed accordingly. For example, a dominant color descriptor assigned to a cell specifies the dominant colors of the pixels within that cell. All the restrictions on the image size, etc. are now applicable to the size of the cell within the grid. All the descriptor instances in a single GridLayout instance must be of the same type.

The following visual description tools cannot appear in the GridLayout: VisualTimeSeries, MultipleView, Spatial2DCoordinateSystem, TemporalInterpolation, ColorSpace, ColorQuantization, Shape3D, CameraMotion, MotionTrajectory, ParametricMotion, SpatioTemporalLocator.

Grid layout can be applied to a video segment, in which case the geometry of the grid layout is constant over time. Each frame in the segment is divided into the same number of cells and the cells at corresponding locations form sequences that can be viewed as a group of frames. The GoFGoPColor and MotionActivity descriptors can then be applied to each sequence defined by the grid layout.

5.3 Time series

5.3.1 Introduction

This datatype specifies a temporal series of descriptors in a video segment. Two types of time series datatypes are defined: RegularVisualTimeSeries and IrregularVisualTimeSeries. In the RegularVisualTimeSeries, descriptors are located regularly (with constant intervals) within a given time span. Alternatively, descriptors are located irregularly in the IrregularVisualTimeSeries. Both structures consist of a series of descriptors and temporal intervals between them as illustrated in Figure 2.

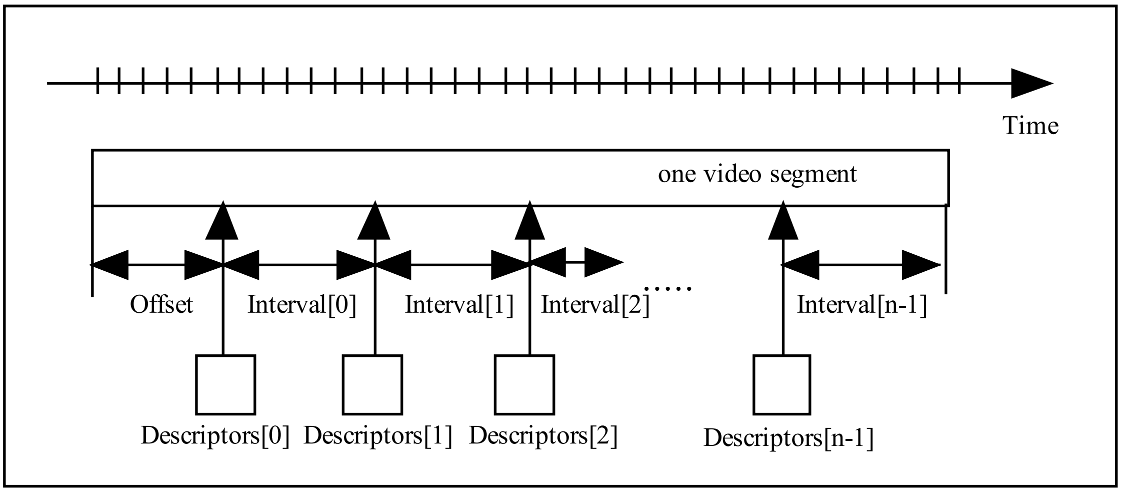


Figure 2 — Overview of the VisualTimeSeries.

5.3.2 VisualTimeSeries

5.3.2.1 Introduction

The VisualTimeSeries serves as the base type for RegularVisualTimeSeries and IrregularVisualTimeSeries. As it is an abstract type, only the DDL representation is defined.

5.3.2.2 DDL representation syntax

```
<complexType name=”VisualTimeSeriesType” abstract=”true”>
   <sequence>
      <element name=”TimeIncr” type=”mpeg7:mediaDurationType”/>
   </sequence>
   <attribute name=”offset” type=”mpeg7:mediaDurationType”
         use=”optional” default=”PT0S”/>
</complexType>
```

5.3.3 RegularVisualTimeSeries

5.3.3.1 Introduction

This datatype specifies a time series in which descriptors are located regularly within a given time span. A default value for the temporal interval can be specified thus enabling a simple representation for applications that require low complexity.

5.3.3.2 DDL representation syntax

```
<complexType name="RegularVisualTimeSeriesType" final="#all">
   <complexContent>
      <extension base="mpeg7:VisualTimeSeriesType">
         <sequence>
            <element name="Descriptor" type="mpeg7:VisualDType"
                  minOccurs="1" maxOccurs="unbounded"/>
         </sequence>
      </extension>
   </complexContent>
</complexType>
```

5.3.3.3 Binary representation syntax

RegularVisualTimeSeries {	**Number of bits**	**Mnemonic**
DescriptorID	8	bslbf
NumOf**Descriptors**	32	uimsbf
IsRandomAccess	1	bslbf
if(IsRandomAccess) {		
DescriptorLength	16	uimsbf
}		
TimeIncr	See annex B	mediaDurationType
IsOffset	1	bslbf
if(IsOffset) {		
offset	See annex B	mediaDurationType
}		
if(IsRandomAccess) {		
BitStuffing	0-7	vlclbf
}		
for(k=0; k<NumOfDescriptors; k++) {		
Descriptor[k]		Descriptor instance specified by DescriptorID
if(IsRandomAccess) {		
BitStuffing	0-8*DescriptorLength-1	vlclbf
}		
}		
}		

5.3.3.4 Descriptor components semantics

DescriptorID
This field, which is only present in the binary representation, specifies a descriptor identifier. The descriptor identifier specifies the descriptor type accommodated in the time series. The assignment of IDs to the descriptors is specified in Table 1.

NumOfDescriptors

This field, which is only present in the binary representation, specifies the number of descriptor instances accommodated in the time series.

IsRandomAccess
This field, which is only present in the binary representation, specifies the access mode, which is either:

- random access if the flag is set to 1; in this case DescriptorLength and BitStuffing elements are present in the binary representation
- no random access if the flag is set to 0; in this case no bit stuffing is allowed and descriptor instances are not padded, which means they may have different lengths

DescriptorLength
This field, which is only present in the binary representation, specifies the length of each descriptor instance in bytes. The value of this element is the size of the largest descriptor instance, aligned to a byte boundary by bit stuffing using 0-7 ‘1’ bits.

TimeIncr
This element specifies the default time interval. The time interval is defined as an interval between descriptor locations. An interval that follows a descriptor is associated with the descriptor. The type of this element “mediaDurationType” is specified in ISO/IEC 15938-5.

IsOffset
This field, which is only present in the binary representation, signals the presence of the offset attribute. If it is equal to 1 (true) offset is present, if 0 (false) offset is not specified (i.e. default value should be used).

offset
This attribute specifies the offset, i.e., the interval between the starting time point of a given time span and the location of the first descriptor. The default value is zero (represented as “PT0S” in DDL). This attribute is illustrated as “Offset” in Figure 2.

BitStuffing
This field, which is only present in the binary representation, specifies stuffing bits (a sequence of ‘1’s) to align the descriptor to a byte boundary.

Descriptor
This element specifies the visual descriptor accommodated in this time series. Only one type of child descriptor is allowed to be instantiated. Its binary syntax and semantics follow those of the assigned descriptor. In random access mode, if the size of a particular descriptor instance is smaller than DescriptorLength, it is padded with the required number of ‘1’ bits.

5.3.4 IrregularVisualTimeSeries

5.3.4.1 Introduction

This datatype is used to describe a time series in which descriptors are located irregularly within a given time span. The temporal interval can be associated with a descriptor by means of describing the series of (descriptor, time info.) pairs. This enables an efficient representation for an application that has the requirement of narrow transmission bandwidth or low storage capability.

5.3.4.2 DDL representation syntax

```
<complexType name="IrregularVisualTimeSeriesType" final=”#all”>
   <complexContent>
      <extension base=”mpeg7:VisualTimeSeriesType”>
           <sequence minOccurs=”1” maxOccurs=”unbounded”>
               <element name="Descriptor" type="mpeg7:VisualDType"/>
               <element name="Interval" type="mpeg7:unsigned32"/>
           </sequence>
        </extension>
    </complexContent>
</complexType>
```


5.3.4.3 Binary representation syntax

IrregularVisualTimeSeries {	**Number of bits**	**Mnemonic**
DescriptorID	8	bslbf
NumOf**Descriptors**	32	uimsbf
IsRandomAccess	1	bslbf
if(IsRandomAccess) {		
DescriptorLength	16	uimsbf
}		
TimeIncr	See annex B	mediaDurationType
IsOffset	1	bslbf
if(IsOffset) {		
offset	See annex B	mediaDurationType
}		
IsShortInterval	1	bslbf
if(IsRandomAccess) {		
BitStuffing	0-7	vlclbf
}		
for(i=0; i<NumOfDescriptors; i++) {		
Descriptor[i]		descriptor instance specified by DescriptorID
if(IsRandomAccess) {		
BitStuffing	0-8*DescriptorLength-1	vlclbf
}		
if (IsShortInterval) {		
ShortInterval[i]	8	uimsbf
} else {		
LongInterval[i]	32	uimsbf
}		
}		
}		

5.3.4.4 Descriptor components semantics

DescriptorID
This field, which is only present in the binary representation, specifies a descriptor identifier. The descriptor identifier specifies the descriptor type accommodated in the time series. The assignment of IDs to the descriptors is specified in Table 1.

NumOfDescriptors
This field, which is only present in the binary representation, specifies the number of descriptor instances accommodated in the time series.

IsRandomAccess
This field, which is only present in the binary representation, specifies the access mode, which is either:

- random access if the flag is set to 1; in this case DescriptorLength and BitStuffing elements are present in the binary representation
- no random access if the flag is set to 0; in this case no bit stuffing is allowed and descriptor instances are not padded, which means they may have different lengths

DescriptorLength

This field, which is only present in the binary representation, specifies the length of each descriptor instance in bytes. The value of this element is the size of the largest descriptor instance, aligned to a byte boundary by bit stuffing using 0-7 ‘1’ bits.

IsShortInterval
This field, which is only present in the binary representation, indicates the size of the ShortInterval/LongInterval field. If IsShortInterval is set to 1, then 8-bit unsigned integer (“unsigned8”) is used. If IsShortInterval is set to 0, then a 32-bit unsigned integer (“unsigned32”) is used.

TimeIncr
This element specifies the base unit of the time interval. The time interval between descriptor locations is specified as a multiple of this base unit. The type of this element, MediaDurationType, is specified in ISO/IEC 15938-5.

IsOffset
This field, which is only present in the binary representation, signals the presence of the offset attribute. If IsOffset is set to 1 then the offset attribute is present. If IsOffset is set to 0 then the offset attribute is not specified (i.e. the default value should be used).

offset
This attribute specifies the offset, i.e., the interval between the starting time point of a given time span and the location of the first descriptor. The default value is zero (represented as “PT0S” in DDL). This element is illustrated as “Offset” in Figure 2.

BitStuffing
This field, which is only present in the binary representation, specifies stuffing bits (a sequence of ‘1’s) to align the descriptor to a byte boundary.

Descriptor

This element specifies the visual descriptor accommodated in this time series. Only one type of child descriptor is allowed to be instantiated. Its binary syntax and semantics follow those of the assigned descriptor. In random access, if the size of a particular descriptor instance is smaller than DescriptorLength, it is padded with the required number of ‘1’ bits.

Interval/ShortInterval/LongInterval
This element specifies the time interval between the current and the preceding descriptor. The value of the element is specified in units defined by TimeIncr.

5.4 Multiple view

5.4.1 Introduction

The MultipleView descriptor specifies a structure that combines 2D Descriptors representing a visual feature of a 3D object seen from different view angles. The descriptor forms a 3D view-based representation of the object. Any 2D visual descriptor, such as for example contour-shape, region-shape, color or texture can be used. The Multiple View descriptor supports integration of the 2D descriptors used in the image plane to describe features of 3D (real world) objects.

The MultipleView representation of a 3D object captures the visual properties of an object at a specific time instance or during a time period. When associated with a video segment, MultipleView contains a set of visual descriptors, each describing a visual feature of an object’s view at some time instance during the persistence of the video segment. The IsVisible flag indicates for each component descriptor whether the view that it describes is actually visible in the video segment.

5.4.2 DDL representation syntax

```
<complexType name="MultipleViewType" final=”#all”>
   <sequence minOccurs=”1” maxOccurs=”16”>
      <element name="IsVisible" type="boolean"/>
      <element name="Descriptor" type="mpeg7:VisualDType"/>
   </sequence>
   <attribute name="fixedViewsFlag" type="boolean" use=”required”/>
</complexType>
```

5.4.3 Binary representation syntax

MultipleView{	**Number of bits**	**Mnemonic**
DescriptorID	8	uimsbf
fixedViewsFlag	1	bslbf
NumOfViews	4	uimsbf
for(k=0;k<NumOfViews;k++) {		
IsVisible[k]	1	bslbf
Descriptor[k]		Description instance specified by DescriptorID
}		
}		

5.4.4 Descriptor components semantics

DescriptorID
This field, which is only present in the binary representation, specifies a descriptor identifier. The descriptor identifier specifies the descriptor type accommodated in the multiple views. The assignment of IDs to the descriptors is specified in Table 1.

fixedViewsFlag
This attribute indicates whether the viewing parameters are fixed or arbitrary/unknown. If fixedViewsFlag is set to 0, the viewing parameters are arbitrary. If fixedViewsFlag is set to 1, the viewing parameters are defined as follows.

For the ContourShape descriptor, the primary, secondary and tertiary viewing directions are determined by the analysis of the covariance matrix of the 3D object. The terms primary, secondary and tertiary eigenvector are used for the eigenvector with the largest, medium and smallest eigenvalue, respectively.

View 1 is spanned by the primary and secondary eigenvector of the covariance matrix. Its direction is therefore the direction of the tertiary eigenvector. Similarly, View 2 is in the direction of the secondary eigenvector and View 3 in the direction of the primary eigenvector.

In addition, another four views are added. The position of View 4 – View 7 can best be described with reference to a coordinate system, where View 1, View 2 and View 3 define axis (1,0,0), (0,1,0) and (0,0,1):

- View 4: (1,1,1)
- View 5: (-1,1,1)
- View 6: (-1,1-1)
- View 7: (1,1,-1)

This flag can only be set to 1 if ContourShape is used.

NumOfViews
This field, which is only present in the binary representation, specifies the number of views used. In the binary representation, the following mapping of the bit patterns is used: 0000->1, …, 1111->16.

IsVisible
This element specifies a 1-D array that contains a flag for each view, specifying whether the view is visible within the associated visual material.

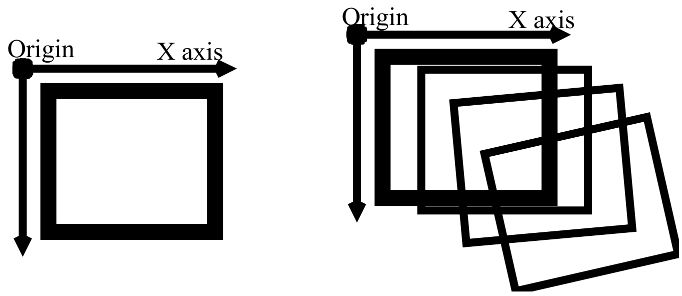
Descriptor
This element specifies the visual descriptor instance accommodated in this descriptor. Only one type of child descriptor is allowed to be instantiated.

5.5 Spatial 2D coordinates

5.5.1 Introduction

This descriptor specifies a 2-D spatial coordinate system to be used by reference in other Ds/DSs (denoted by D1). The coordinate system is defined by mapping from the points in the descriptor coordinate system (used within D1) to the points in the current image. Referring to this descriptor, the coordinates in the visual descriptor can be mapped to the current image. The *current image* is the image that is currently referenced by the description, while the *descriptor coordinate system* is the coordinate system in which the described value is valid. The descriptor coordinate system can be the source image from which the current image is extracted or the real world. The term *source image* is used to express the image from which the description is extracted. Therefore, the source image can be a frame in a video, an image from which the current image is extracted, or a mosaic. When the current image is extracted from the source image, this descriptor specifies the mapping from the source image to the current image. Thus, without modifying the descriptor instantiations, the description can be adapted to the current image by modifying the mapping.

The Spatial2DCoordinateSystem supports two kinds of coordinate systems: *local* and *integrated* (see Figure 3). In a local coordinate system, the coordinates in the descriptor coordinate system are mapped to the current image. For a video sequence, the same mapping is applied to all frames. In an integrated coordinate system, each image (frame) of e.g. a video sequence may be mapped to different areas with respect to the first frame of a shot or video. In this case, the local coordinate system is used to specify the coordinate system of the first frame (i.e. the first frame is the current frame). Thus, the integrated coordinate system can be used to represent coordinates on a mosaic of a video shot.



a) "Local" coordinates *b) "Integrated" coordinates*

Figure 3 — "Local" and "integrated" coordinate system.

In the syntax, the IntegratedCoordinateSystem element allows specification of an integrated coordinate system, and the LocalCoordinateSystem element allows specification of a local one, when it is different from the default coordinate system of the current image. In the default local coordinate system, the origin is placed at the top left corner of the image and the first and the second axis are aligned with the horizontal and vertical lines of the image and directed to the right and to the bottom of the image, respectively. If additionally an integrated coordinate system is specified, the mapping applies to the first coordinate space of the first frame.

5.5.2 DDL representation syntax

```
<complexType name="Spatial2DCoordinateSystemType" final="#all">
   <complexContent>
      <extension base="mpeg7:HeaderType">
         <sequence>
            <element name="Unit" minOccurs="0">
               <simpleType>
                  <restriction base="string">
                     <enumeration value="pixel"/>
                     <enumeration value="meter"/>
                     <enumeration value="pictureHeight"/>
                     <enumeration value="pictureWidth"/>
                     <enumeration value="pictureWidthAndHeight"/>
                  </restriction>
               </simpleType>
            </element>
            <element name="LocalCoordinateSystem" minOccurs="0">
               <complexType>
                  <sequence>
                     <choice>
                        <sequence minOccurs="1" maxOccurs="3">
                           <element name="Pixel">
                              <simpleType>
                                 <restriction base="mpeg7:integerVector">
```



```
                              <length value="2"/>
                           </restriction>
                        </simpleType>
                     </element>
                     <element name="CoordPoint">
                        <simpleType>
                           <restriction base="mpeg7:floatVector">
                              <length value="2"/>
                           </restriction>
                        </simpleType>
                     </element>
                  </sequence>
                  <sequence minOccurs="1" maxOccurs="3">
                     <element name="CurrPixel">
                        <simpleType>
                           <restriction base="mpeg7:integerVector">
                              <length value="2"/>
                           </restriction>
                        </simpleType>
                     </element>
                     <element name="SrcPixel">
                        <simpleType>
                           <restriction base="mpeg7:integerVector">
                              <length value="2"/>
                           </restriction>
                        </simpleType>
                     </element>
                  </sequence>
               </choice>
               <element name="MappingFunct" type="string"
                     minOccurs="0" maxOccurs="2"/>
            </sequence>
            <attribute name="name" type="string" use="required"/>
            <attribute name="dataSet" type="anyURI" use="optional"/>
         </complexType>
      </element>
      <element name="IntegratedCoordinateSystem" minOccurs="0">
         <complexType>
            <sequence minOccurs="0" maxOccurs="65535">
               <element name="TimeIncr"
type="mpeg7:MediaIncrDurationType"/>
               <element name="MotionParams" type="float"
                     minOccurs="2" maxOccurs="12"/>
            </sequence>
            <attribute name="modelType" use="required">
               <simpleType>
                  <restriction base="string">
                     <enumeration value="translational"/>
                     <enumeration value="rotationAndScaling"/>
                     <enumeration value="affine"/>
                     <enumeration value="perspective"/>
                     <enumeration value="quadratic"/>
                  </restriction>
               </simpleType>
            </attribute>
            <attribute name="xOrigin" type="float" use="required"/>
            <attribute name="yOrigin" type="float" use="required"/>
         </complexType>
      </element>
   </sequence>
   <attribute name="xRepr" type="mpeg7:unsigned8" use="required"/>
```



```
      <attribute name="yRepr" type="mpeg7:unsigned8" use="required"/>
      <attribute name="xSrcSize" type="positiveInteger" use="optional"/>
      <attribute name="ySrcSize" type="positiveInteger" use="optional"/>
    </extension>
  </complexContent>
</complexType>
```

5.5.3 Binary representation syntax

Spatial2DCoordinateSystem {	**Number of bits**	**Mnemonic**
id	See ISO 10646	UTF-8
xRepr	8	uimsbf
yRepr	8	uimsbf
XSrcSizeDefined	1	bslbf
if (XSrcSizeDefined) {		
xSrcSize		vluimsbf5
}		
YSrcSizeDefined	1	bslbf
if (YSrcSizeDefined) {		
ySrcSize		vluimsbf5
}		
UnitDefined	1	bslbf
LocalCoordinatesDefined	1	bslbf
IntegratedCoordinatesDefined	1	bslbf
if (UnitDefined) {		
Unit	3	bslbf
}		
if(LocalCoordinatesDefined) {		
NameLength		vluimsbf5
name	8*NameLength	bslbf
DataSetDefined	1	bslbf
if(DataSetDefined) {		
DataSetLength		vluimsbf5
dataSet	8*DataSetLength	bslbf
}		
Coord	1	bslbf
NumOfPoints	2	uimsbf
for(k=0; k<NumOfPoints; k++) {		
if(!Coord) {		
CurrPixelX	xRepr	usimsbf
CurrPixelY	yRepr	usimsbf
SrcPixelX	16	simsbf
SrcPixelY	16	simsbf
} else {		
PixelX	xRepr	usimsbf
PixelY	yRepr	usimsbf
CoordPointX	32	fsbf
CoordPointY	32	fsbf
}		
}		
NumOfMappingFuncts	2	uimsbf
for(l=0; l<NumOfMappingFuncts; l++) {		
MappingFunctLength		vluimsbf5
MappingFunct	8*MappingFunctLength	bslbf
}		

}		
if(IntegratedCoordinatesDefined) {		
modelType	3	uimsbf
xOrigin	32	fsbf
yOrigin	32	fsbf
NumOfMotionParamSets	16	uimsbf
for(k=0; k<NumOfMotionParamSets; k++) {		
TimeIncr	See annex B	MediaIncrDurationType
for(l=0; l<NumOfParams; l++) {		
MotionParams	32	fsbf
}		
}		
}		
}		

5.5.4 Descriptor components semantics

id
This attribute, which is inherited from HeaderType, allows referencing of the coordinate specification from other descriptors. The value is binary represented as a string in UTF-8 format.

xRepr, yRepr
These attributes specify the number of bits used for the representation of X and Y coordinates in the coordinate system of the source image. If the unit is pixel, the coordinates are expressed by the unsigned integer of xRepr bits for the horizontal axis and yRepr bits for the vertical axis respectively.

XSrcSizeDefined, YSrcSizeDefined
These fields, which are only present in the binary representation, indicate if the xSrcSize and ySrcSize attributes are defined. If the field is set to 1, the corresponding attribute follows. If the field is set to 0 then the attribute is not present.

xSrcSize, ySrcSize
These attributes specify the image size of the source image expressed as the number of pixels along the x (xSrcSize) and y (ySrcSize) axis. The value can be used to convert between pixel-based coordinates and coordinates normalized with respect to the image size.

UnitDefined
This field, which is only present in the binary representation, indicates if the units for the coordinate system are defined. If UnitDefined is set to 1 then the definition of units follows. If UnitDefined is set to 0 then the default units are used.

LocalCoordinatesDefined
This field, which is only present in the binary representation, indicates if a local coordinate system is defined. If LocalCoordinatesDefined is set to 1 then the definition of a local coordinate system follows. Otherwise, the default local definition is used. In the default local coordinate system the origin is placed at the top left corner of the image and the first and the second axis are aligned to the horizontal and vertical axis of the image and directed to the right and to the bottom of the image, respectively.

IntegratedCoordinatesDefined
This field, which is only present in the binary representation, indicates if an integrated coordinate system is defined. If IntegratedCoordinatesSystem is set to 1 then an integrated coordinate system is used and mappings between local images (except for the first frame) and the coordinate system follow. Otherwise, a local coordinate system is used.

Unit
This element specifies the units of the descriptor coordinate system. It is only applicable to descriptors that do not have a fixed unit specification of the descriptor coordinate values. The default unit is pixel. Other possible units are meters (only applicable to the CoordPoint element specification), or pixel coordinates normalized by pictureWidth in each dimension, or by pictureHeight in each dimension, or by pictureWidth and pictureHeight on horizontal and vertical axes respectively.

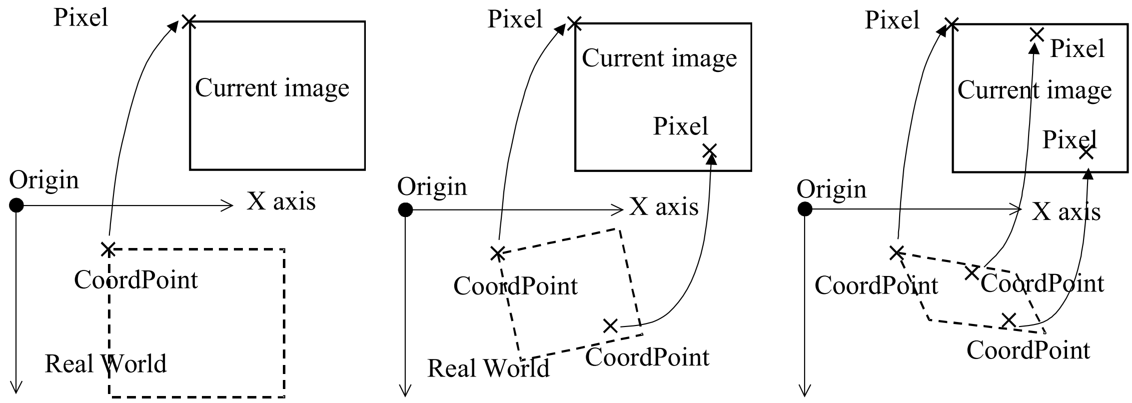
The meaning of the binary codes is specified in Table 2.

Table 2 — The meaning of Unit.

Unit	Meaning
"000"	pixel
"001"	meter
"100"	pictureHeight
"101"	pictureWidth
"110"	pictureHeightAndWidth
"010-011" and "111"	Reserved

LocalCoordinateSystem
This element specifies the mapping from the descriptor coordinate system to the current image. The descriptor coordinate system can be a source image (an image, a frame of video, or a mosaic), or a real world coordinate system. When the descriptor coordinate system is the source image, the mapping from the points in the source image (SrcPixel) to the points in the current image (Pixel) is specified. When the descriptor coordinate system is a real world coordinate system, the origin is located in the top left corner of the image, the x and y axes are aligned to the horizontal and vertical axes of the image and the pixel unit is used.

If a mapping of one point is described, the mapping is translational. If mappings of two points are described, a rotation/scaling model is used and if mappings of three points are described, a rotation/asymmetric scaling (affine) model is used (see Figure 4). If two or more mappings are described, they should be linearly independent.



a) Translational model *b) Rotation/Scaling model* *c) Rotation/Asymmetric Scaling model*

Figure 4 — Motion models described by CoordinateMapping ('SrcPixel' and 'CoordPoint')

NameLength
This field, which is only present in the binary representation, specifies the length of the following coordinate mapping name.

name
This attribute specifies the coordinate mapping name.

DataSetDefined
This field, which is only present in the binary representation, indicates the presence of a dataset definition. If DataSetDefined is set to 1 then a definition of a data set follows.

DataSetLength
This field, which is only present in the binary representation, specifies the length of the following dataSet attribute.

dataSet
This attribute specifies a reference to a data set, of which the SrcPixel based coordinate system is used for mapping to the local one. E.g. after image scaling for UMA here a reference can be specified to the data used to generate the visual descriptors referencing this coordinate system.

NumOfPoints
This field, which is only present in the binary representation, specifies the number of Pixels and SrcPixels or CoordPoints used to specify the mapping between the corresponding coordinate systems.

CurrPixelX, CurrPixelY, PixelX, PixelY, SrcPixelX, SrcPixelY, CoordPointX, CoordPointY
These elements specify a mapping between a descriptor coordinate system and the current image. A mapping is defined by points in the current image (CurrPixelX, CurrPixelY) and the corresponding points in the source image (SrcPixelX, SrcPixelY) (see Figure 5). Another possibility is to map the points of the current image (PixelX, PixelY) to points in a real world coordinate system (CoordPointX, CoordPointY). If a mapping of one point is described, the mapping is translational. If mappings of two points are described, a rotation/scaling model is used and if mappings of three points are described, a rotation/asymmetric scaling (affine) model is used (see Figure 4). Pixel positions in the current image and the source image are described assuming that the origin is located at the top-left corner of the image and the unit is pixel.

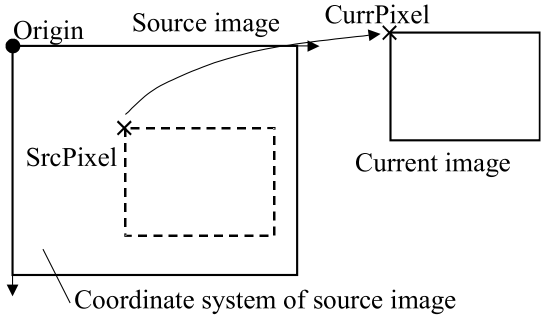


Figure 5 — CoordinateMapping (CurrPixel and SrcPixel).

Coord
This field, which is only present in the binary representation, indicates if SrcPixel or CoordPoint elements are used in the mapping. If Coord is set to 0 then the mapping between the source image and the current image is defined by SrcPixel elements. Otherwise, the mapping is defined by CoordPoint elements.

NumOfMappingFuncts
This field, which is only present in the binary representation, specifies the number of the following MappingFunct descriptions. MappingFunct's are described if the bilinear interpolation is insufficient.

MappingFunctLength
This field, which is only present in the binary representation, specifies the length of the MappingFunct element in bytes.

MappingFunct
This element is only applicable if CoordPoint elements are specified. It is needed if the specified mapping to the CoordPoint elements is not precise but only a rough approximation as it might be the case for real world coordinates used e.g. in maps. To allow a higher precision the MappingFunct specifies a functional expression in an ISO/IEC 9899 C format, using x and y according to the Pixel coordinates. Accordingly, the descriptor specifies how to map coordinate values between the Pixel and the CoordPoint elements:

- a mapping to the "x"/"y" coordinate of the CoordPoints is specified by a string starting with "x="/"y="
- the remaining part of the string consists of a functional expression in which "x" and "y" represent the x and y coordinates in the "SrcPixel" coordinates.

According to this rule, "x=" and "y=y+0.0001*x*x+100" represents a mapping from Pixels to CoordPoints by (a) shift of 100 and (b) by correcting the linear interpolation by "0.0001*x*x".

If MappingFunct is not specified, bilinear interpolation between the mapped points has to be considered as a precise mapping.

IntegratedCoordinateSystem
This element specifies an integrated coordinate system using the mappings (motions) from the first image (current image) to other images. The mapping from the descriptor coordinate system to the current image is specified by the LocalCoordinateSystem element (if this element is absent, the default coordinate system is used for the first image).

modelType
This attribute specifies the number of parameters the applied motion model consists of and with this it specifies the motion model using 3 bits. The possible values are: 2 (translational model), 4 (rotation/scaling model), 6 (affine model), 8 (planar perspective model), 12 (quadratic model). These motion models are already included in the Visual

descriptors as part of the ParametricMotion descriptor. The bit codes for this field and the associated NumOfParams values are specified in Table 43.

xOrigin, yOrigin
These attributes specify the X,Y coordinates in the local coordinate system specified by the LocalCoordinateSystem mapping. They specify the origin of the motion model.

numOfMotionParamSets
This attribute specifies the total number of motion parameter sets (frames). The IntegratedCoordinateSystem captures information over a period of time. Therefore, also temporal reference information has to be provided. The time frame (a shot) of the video sequence is assumed to be provided by a higher order DS. As illustrated in Figure 6, sets (vectors) of motion parameters (MotionParams) are spread over this period, the total number is specified by the value of the attribute numOfMotionParamSets. Each set of motion parameters carries its own temporal information in TimeIncr, which specifies the frame it is related to. This provides high flexibility for temporal spacing of the frames used. It is possible to use for instance every frame, every fifth or even an irregular spacing.

TimeIncr
This element specifies the time between the first frame of the considered video sequence and the frame that the set of motion parameters refers to (see temporal reference system in Figure 6).

MotionParams
This element specifies a motion parameter value as defined for the ParametricMotion descriptor. The motion parameters describe motion at a certain time (as indicated by TimeIncr) with respect to the first frame of the considered video sequence.

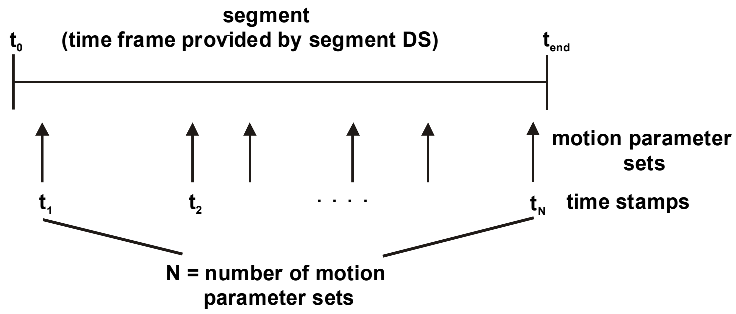


Figure 6 — Temporal reference system in relation to frame 0.

5.6 Temporal interpolation

5.6.1 Introduction

This datatype specifies temporal interpolation using connected polynomials. This can be used to approximate multi-dimensional variable values that change with time, such as an object position in a video sequence. The descriptor size is usually much smaller than would be required to describe all the real values. In Figure 7, 25 real values are represented by five linear interpolation functions and two quadratic interpolation functions. The beginning of the temporal interpolation is always aligned to time 0.

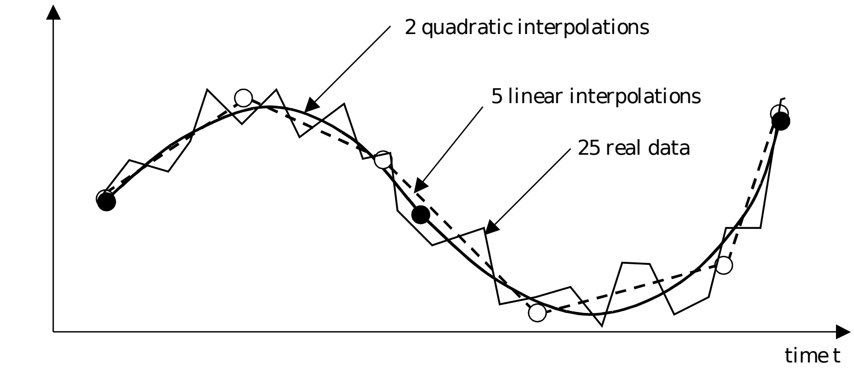


Figure 7 — Real data and interpolation functions.

The dimension of the interpolated variable is specified by the Dimension field (except for the temporal element) and some examples are shown in Table 3. The connection point is called a "key point". The number of key points is described by the NumOfKeyPoints field. The time of key points is described by the WholeInterval element or an array of KeyTimePoint elements. WholeInterval is used only for constant intervals and the length of the interval is derived by dividing the specified duration by NumOfKeyPoints-1. The values of the key points are described by an array of KeyValue element, with NumOfKeyPoints values for each dimension.

Table 3 — Examples of the value of dimension.

D or DS using TemporalInterpolation	Value of Dimension
2D MotionTrajectory	2
3D MotionTrajectory	3
ParameterTrajectory (Translational Model)	2
ParameterTrajectory (Affine Transformation Model)	6
ParameterTrajectory (Parabolic Model)	12

TemporalInterpolation can use two types of interpolation functions: first order and second order polynomials. The type of the interpolation function is indicated by the type attribute. When a first order polynomial is used (type="firstOrder"), the function can be calculated from the key points. When a second order polynomial is used (type="secondOrder"), the second order coefficient is described by the param attribute. The relation between type, interpolation functions, key points and param is shown in Table 4. In the table, t_a and t_b $(t_a < t_b)$ represent the times of two successive key points, and f_a and f_b indicate values of key points at t_a and t_b. In the calculation of interpolation functions, the values of time are expressed in seconds. c_2 is the value of param and c_1 is the value derived from the constraints and other parameter values. The constraint ensures that all interpolation function pass through the key points at both ends. If reliable interpolation functions are not obtained in the extraction process, type is set to "notDetermined". In this case, the interpolation functions are not specified and reliable values between successive key points cannot be determined from the description.

Table 4 — Interpolation function specified by type and param.

type	Interpolation Function Form	param	Constraint
notDetermined	(none)	(none)	(not applicable)
startPoint	(none)	(none)	(not applicable)
firstOrder	$f(t) = f_a + c_1(t - t_a)$	(none)	$c_1 = \frac{f_b - f_a}{t_b - t_a}$
secondOrder	$f(t) = f_a + c_1(t - t_a) + c_2(t - t_a)$	c_2	$c_1 = \frac{f_b - f_a}{t_b - t_a} - c_2(t_b - t_a)$

5.6.2 DDL representation syntax

```
<complexType name=”TemporalInterpolationType” final=”#all”>
   <sequence>
        <choice>
         <element name=”WholeInterval”>
            <complexType>
               <choice>
                  <element name=”MediaDuration”
                        type=”mpeg7:mediaDurationType”/>
                  <element name=”MediaIncrDuration”
                        type=”mpeg7:MediaIncrDurationType”/>
               </choice>
            </complexType>
         </element>
         <element name=”KeyTimePoint”>
            <complexType>
               <choice>
```



```
                <element name="MediaTimePoint"
                      type="mpeg7:mediaTimePointType"
                      minOccurs="2" maxOccurs="65535"/>
                <element name="MediaRelTimePoint"
                      type="mpeg7:MediaRelTimePointType"
                      minOccurs="2" maxOccurs="65535"/>
                <element name="MediaRelIncrTimePoint"
                      type="mpeg7:MediaRelIncrTimePointType"
                      minOccurs="2" maxOccurs="65535"/>
             </choice>
          </complexType>
       </element>
    </choice>
    <element name="InterpolationFunctions" minOccurs="1" maxOccurs="15">
       <complexType>
          <sequence>
             <element name="KeyValue" minOccurs="2" maxOccurs="65535">
                <complexType>
                   <simpleContent>
                      <extension base="float">
                         <attribute name="type" use="optional"
                               default="firstOrder">
                            <simpleType>
                               <restriction base="string">
                                  <enumeration value="startPoint"/>
                                  <enumeration value="firstOrder"/>
                                  <enumeration value="secondOrder"/>
                                  <enumeration
                                        value="notDetermined"/>
                               </restriction>
                            </simpleType>
                         </attribute>
                         <attribute name="param" type="float"
                               use="optional" default="0.0"/>
                      </extension>
                   </simpleContent>
                </complexType>
             </element>
          </sequence>
       </complexType>
    </element>
  </sequence>
</complexType>
```

5.6.3 Binary representation syntax

TemporalInterpolation {	**Number of bits**	**Mnemonic**
NumOfKeyPoints	16	uimsbf
ConstantTimeInterval	1	bslbf
QuantizationFlag	1	bslbf
if (ConstantTimeInterval) {		
WholeIntervaleDataType	1	bslbf
if (!WholeIntervalDataType) {		
MediaDuration	See annex B	mediaDurationType
} else {		
MediaIncrDuration	See annex B	MediaIncrDurationType
} else {		
KeyTimePointDataType	2	bslbf
if(KeyTimePointDataType==00) {		
for(j=0; j<NumOfKeyPoints; j++)		
MediaTimePoint	See annex B	mediaTimePointType
} else if(KeyTimePointDataType==01) {		
for(j=0; j<NumOfKeyPoints; j++)		
MediaRelTimePoint	See annex B	MediaRelTimePointType
} else if (KeyTimePointDataType==10) {		
for(j=0; j<NumOfKeyPoints; j++)		
MediaRelIncrTimePoint	See annex B	MediaRelIncrTimePointType
}		
}		
Dimension	4	uimsbf
for(j=0; j<Dimension; j++) {		
DefaultFunction	1	bslbf
for(k=0; k<NumOfKeyPoints; k++) {		
if(!DefaultFunction) {		
type	2	bslbf
if(type==10) {		
param	32	fsbf
}		
}		
if(!QuantizationFlag) {		
KeyValue	32	fsbf
} else {		
QuantizedKeyValue	if (j==0) XRepr else if (j==1) YRepr	uimsbf
}		
}		
}		
}		

5.6.4 Descriptor components semantics

NumOfKeyPoints
This field, which is only present in the binary representation, specifies the number of sampled positions, denoted as key points, used for the knots of interpolation functions: from 2 to 65535. In the DDL representation the corresponding

value can be obtained by counting the number of KeyValue elements in any InterpolationFunctions instance. The size of InterpolationFunctions must be the same for all its instances in a single descriptor. When the time points are described by the KeyTimePoint element, the number of MediaTimePoint (or MediaRelTimePoint or MediaRelIncrTimePoint) elements must also be equal to NumOfKeyPoints.

ConstantTimeInterval
This field, which is only present in the binary representation, specifies the type of key time point description. If it is set to "0", the intervals between key points are not constant and each time point is described by KeyTimePoints. Otherwise, the intervals are constant and specified by WholeInterval. In this case, the length of these intervals is calculated as WholeInterval/(NumOfKeyPoints-1)

QuantizationFlag
This field, which is only present in the binary representation, specifies if KeyValue is encoded as a floating-point number or quantized. If it is set to “0”, floating-point representation is used, otherwise quantization to integer representation is performed. When TemporalInterpolation is used in the SpatioTemporalLocator, quantization of key value is not allowed and this field must be set to “0”.

WholeIntervalDataType
This field, which is only present in the binary representation, specifies the type of WholeInterval. The meaning of the values is specified in Table 5.

Table 5 — The meaning of WholeIntervalDataType.

WholeIntervalDataType	Meaning
“0”	mediaDurationType
“1”	MediaIncrDurationType

WholeInterval
This element specifies the whole temporal interval of interest. If this field is defined, the time interval between each successive pair of key points is constant. The beginning of the whole interval is always fixed to 0, and the length of these intervals is calculated by WholeInterval/(NumOfKeyPoint-1). If the time intervals are not constant, all key time should be specified explicitly using the KeyTimePoint element. WholeInterval supports two types, MediaDurationType and MediaIncrDurationType. In the binary representation, WholeIntervalDataType specifies the type.

MediaDuration
This element specifies the value of WholeInterval using mediaDurationType (see ISO/IEC 15938-5).

MediaIncrDuration
This element specifies the value of WholeInterval using MediaIncrDurationType (see ISO/IEC 15938-5).

KeyTimePointDataType
This field, which is only present in the binary representation, specifies the type of KeyTimePoint. The meaning of the values of this field is specified in Table 6.

Table 6 — The meaning of KeyTimePointDataType.

KeyTimePointDataType	Meaning
“00”	mediaTimePointType
“01”	MediaRelTimePointType
“10”	MediaRelIncrTimePointType
“11”	prohibited

KeyTimePoint
This element specifies the series of time points for each key point. The number of time points in the series must be equal to the value of NumOfKeyPoints. Time points are always sorted in increasing order. KeyTimePoint supports three types: mediaTimePointType, MediaRelTimePointType and MediaRelIncrTimePointType. In the binary representation, KeyTimePointDataType specifies the type.

MediaTimePoint
This element specifies the KeyTimePoint using mediaTimePointType.

MediaRelTimePoint
This element specifies the KeyTimePoint using MediaRelTimePointType.

MediaRelIncrTimePoint
This element specifies the KeyTimePoint using MediaRelIncrTimePointType.

InterpolationFunctions
This element specifies interpolation functions in each dimension. The size of this element must be equal to the value of the Dimension field.

Dimension
This field, which is only present in the binary representation, specifies the dimension (number of components) of interpolated values. The allowed range is from 1 to 15. Table 3 shows examples of the value of dimension for some descriptors and tools defined in ISO/IEC 15938-3. In the DDL representation, the value of dimension is obtained by counting the number of InterpolationFunctions.

KeyValue
This element specifies the value of each key point. The number of occurrences of KeyValue in a single InterpolationFunctions must be equal to the value of NumOfKeyPoints. The KeyValue elements must appear in increasing time order.

QuantizedKeyValue
This field, which is only present in the binary representation, specifies the value of each key point using integer encoding obtained by quantization of the floating-point key values. It can only be used for 2-dimensional values. The number of bits used is specified by XRepr for the first dimension (j=0) and YRepr for the second dimension. The values of XRepr and YRepr are obtained from the description tool that uses TemporalInterpolation. In case of MotionTrajectory descriptor, for example, these are the values of xRepr/yRepr attributes of the descriptor itself or the referenced Spatial2DCoordinateSystem. The integer value is obtained by uniform quantization of the definition interval. For example, if Units is “pictureWidth” and xRepr is 3, then key value for j=0 takes values between 0 and 1 which should be quantized to 3 bits by an 8-bin uniform quantization (e.g. 0.2 would be encoded as “001”). The number of occurrences of QuantizedKeyValue in a single InterpolationFunctions must be equal to the value of NumOfKeyPoints. The QuantizedKeyValue elements must appear in increasing time order.

DefaultFunction
This field, which is only present in the binary representation, indicates if the default interpolation function is used. If DefaultFunction is set to 1 then the default interpolation function (linear interpolation) is used in the current dimension.

type
This attribute specifies the type of the key point. If this is “startPoint”, the key point is the starting point of the interpolation. If it is “firstOrder” or “secondOrder”, the key point follows the linear or quadratic interpolation function. If it is “notDetermined”, the key point is not the starting point of the interval but no interpolation function is defined between the key point and the previous key point. If it is absent, the value of firstOrder (linear interpolation) is used as a default value. In the binary representation, the relation between the binary encoding and the meaning of type is given in Table 7.

Table 7 — The meaning of type.

type	Meaning
“00”	startPoint
“01”	firstOrder
“10”	secondOrder
“11”	notDetermined

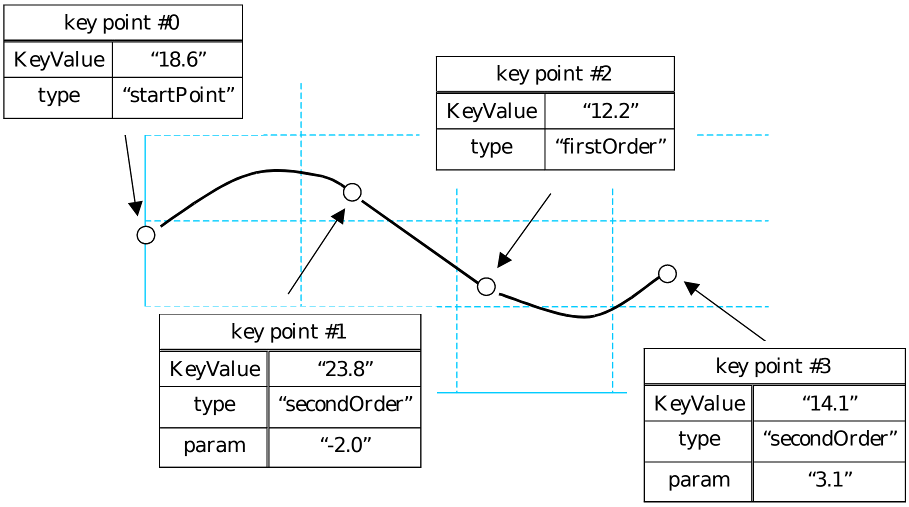


Figure 8 — Example of KeyValue, type and param

param
This attribute specifies the coefficient of the interpolation function when relevant, i.e. c_2 (see Table 4). This attribute is meaningful only when the function type is "secondOrder" and specifies the second-order coefficient of the interpolation function.

6 Color

6.1 Introduction

This clause provides four color descriptors to represent different aspects of color features: representative colors (DominantColor), color distribution (ScalableColor), global spatial distribution of colors (ColorLayout), and local spatial distribution (ColorStructure). It also contains the GoFGoPColor descriptor, which is an extension of ScalableColor to group of frames or pictures. Finally, two supporting tools are defined, ColorSpace and ColorQuantization, which are used in the DominantColor descriptor. All the color descriptors can be extracted from arbitrarily shape regions.

6.2 Color space

6.2.1 Introduction

This datatype specifies the color space in which the color descriptors are expressed. The following color spaces are supported:

- RGB

- YCbCr

- HSV

- HMMD

- Linear transformation matrix with reference to RGB

- Monochrome

A flag is also provided to allow indication of the availability of a color primaries reference.

6.2.2 DDL representation syntax

```
<complexType name="ColorSpaceType" final="#all">
   <sequence>
      <element name="ColorTransMat" minOccurs="0">
         <simpleType>
```



```
          <restriction>
             <simpleType>
                <list itemType="mpeg7:unsigned16"/>
             </simpleType>
             <length value="9"/>
          </restriction>
       </simpleType>
    </element>
 </sequence>
 <attribute name="colorReferenceFlag" type="boolean"
              use="optional" default="false"/>
 <attribute name="type" use="required">
    <simpleType>
       <restriction base="string">
          <enumeration value="RGB"/>
          <enumeration value="YCbCr"/>
          <enumeration value="HSV"/>
          <enumeration value="HMMD"/>
          <enumeration value="LinearMatrix"/>
          <enumeration value="Monochrome"/>
       </restriction>
    </simpleType>
 </attribute>
</complexType>
```

6.2.3 Binary representation syntax

ColorSpace {	**Number of bits**	**Mnemonic**
colorReferenceFlag	1	bslbf
type	4	bslbf
if (type=='LinearMatrix') {		
for(j=0; j<3; j++) {		
for(k=0; k<3; k++) {		
ColorTransMat[j][k]	16	uimsbf
}		
}		
}		
}		

6.2.4 Descriptor components semantics

colorReferenceFlag
This attribute indicates the presence of the RGB primaries and gamma specification. If colorReferenceFlag is set to 0, no reference RGB primaries or gamma value are available. Otherwise, the color values are normalized using the following specification.

The CIE tristimulus chromaticity values of the RGB primaries and the illuminant white point are specified in Table 8.

Table 8 — CIE chromaticities for reference RGB primaries and illuminant white.

	Red	Green	Blue	White point (D65)
x	0.6400	0.3000	0.1500	0.3127
y	0.3300	0.6000	0.0600	0.3290
z	0.0300	0.1000	0.7900	0.3583

The gamma correction used to obtain the color values is specified using the following formula, where V_L is the linear input value of any captured component (R_L, G_L, B_L) and V denotes the nonlinear resulting value.

$$if \quad V_L \leq 0.00304 \quad then \quad V = 12.92 \times V_L$$

$$otherwise \quad V = 1.055 \times V_L^{(1.0 \div 2.4)} - 0.055$$

type
This attribute specifies the color space.

- type "RGB" is an RGB color space with or without reference primaries (depending on colorReferenceFlag). As noted above the R, G and B values are in the range [0,1].
- type "YCbCr" is expressed by a linear transformation:

```
Y =   0.299*R + 0.587*G + 0.114*B
Cb = -0.169*R - 0.331*G + 0.500*B
Cr =  0.500*R - 0.419*G - 0.081*B
```

  It follows that the Y component values are in the range [0,1] and Cb and Cr component values are in the range [-0.5,0.5].

- type "HSV" specifies a nonlinear transformation. It consists of the Value representing the lightness of color, the Saturation indicating the degree of colorfulness, and the Hue (H) representing the dominant spectral tone of the color, denoted by an angle from 0 to 360 degrees. Their values are derived from the normalized RGB values (ranging from 0 to 1) as follows:

```
Max = max(R, G, B);
Min = min( R, G, B);
Value = max(R, G, B);
if( Max == 0 ) then
  Saturation = 0;
else
  Saturation = (Max-Min)÷Max;
if( Max == Min ) Hue=0; /* achromatic */
otherwise:
if( Max == R && G >= B )
  Hue = 60*(G-B) ÷(Max-Min)
else if( Max == R && G < B )
  Hue = 360 + 60*(G-B) ÷(Max-Min)
else if( G == Max )
  Hue = 60*(2.0 + (B-R) ÷(Max-Min))
else
  Hue = 60*(4.0 + (R-G) ÷(Max-Min))
```

  The Saturation component takes values in the range [0,1], the Value component has values in the range [0,1] and the Hue component has values in the range [0,360].

  The HSV color space can best be interpreted as a cylinder, where the Hue component approximately represents the angle in degrees, a shown in Figure 9.

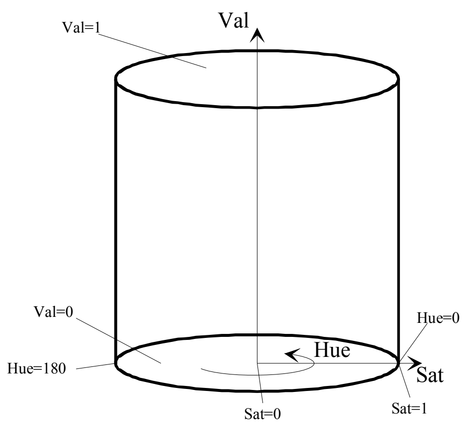


Figure 9 — Cylinder representing the limits of the HSV color space.

- type "HMMD" is defined by a nonlinear, reversible transformation from the RGB color space. There are five distinct attributes (components) in the HMMD color space, however only three of them (Hue, Max, Min, or Hue, Diff, Sum) are sufficient to define the color space. The five attributes can be characterized as follows:

  - Hue: the same as in HSV.
  - Max: indicates how much black color it has, giving a flavor of shade or blackness.
  - Min: indicates how much white color it has, giving a flavor of tint or whiteness.
  - Diff: indicates how much gray it contains and how close to the pure color, giving a flavor of tone or colorfulness.
  - Sum: simulates the brightness of the color.

  The transformations for Max, Min and Hue are the same as the equations for Min, Max and Hue in HSV color space. The transformations for Diff and Sum have the following form:

```
Diff = Max – Min;
Sum = (Max + Min)/2;
```

  The Max, Min and Sum components have values in the range [0,1] and the Diff component has values in the range [0,1]. The Hue component takes values in the range [0,360].

  The HMMD color space has a double cone appearance as shown in Figure 10.

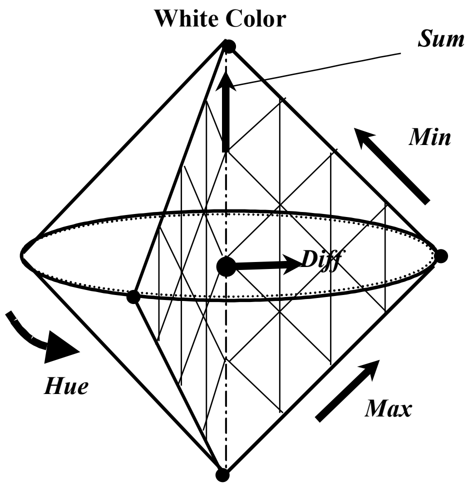


Figure 10 — Appearance of the HMMD color space.

- type "LinearMatrix" is specified by a linear matrix transformation from 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.
```

- type "Monochrome" is expressed by a linear transformation:

```
Y =   0.299*R + 0.587*G + 0.114*B
```

  from the components of the RGB color space. The resulting values lie in the range [0,1].

Within a description, the components of a color space must be ordered in a specific sequence. For the color spaces described, the sequence shown in Table 9 shall be valid.

Table 9 — Ordering of color components.

type	Component1	Component2	Component3	Component4	Component5
RGB	R	G	B	N/A	N/A
YCbCr	Y	Cb	Cr	N/A	N/A
HSV	H	S	V	N/A	N/A
HMMD	H	Max	Min	Diff	Sum
LinearMatrix	C1	C2	C3	N/A	N/A
Monochrome	Y	N/A	N/A	N/A	N/A

The binary representation of this attribute is specified in Table 10.

Table 10 — Meaning of type.

type	Meaning
0000	RGB
0001	YCbCr
0010	HSV
0011	HMMD
0100	LinearMatrix
0101	Monochrome
0110-1111	Reserved

ColorTransMat
This element specifies a color transformation matrix. If the color space is expressed by the linear matrix transformation, the values of this matrix define the transformation with reference to the RGB color space. Matrix values are within the range of -1 to 1, and are expressed as 16 bit signed integers. The scaling factor between the integer value and the floating point value (from –1 to 1) is defined by the following equation:

$$V_{fp} = V_{int} * 2^{-14}.$$

6.3 Color quantization

6.3.1 Introduction

This descriptor defines the uniform quantization of a color space. It provides a mapping from the floating point values specified in subclause 6.2 to an integer representation in which each component is linearly scaled to the integer range [0,NumOfBins-1], where NumOfBins is the number of quantization levels of each color component (see below).

6.3.2 DDL representation syntax

```
<complexType name="ColorQuantizationType" final="#all">
   <sequence minOccurs="1" maxOccurs="3">
      <element name="Component">
         <simpleType>
            <restriction base="string">
               <enumeration value="R"/>
               <enumeration value="G"/>
               <enumeration value="B"/>
               <enumeration value="Y"/>
               <enumeration value="Cb"/>
               <enumeration value="Cr"/>
               <enumeration value="H"/>
               <enumeration value="S"/>
               <enumeration value="V"/>
               <enumeration value="Max"/>
               <enumeration value="Min"/>
               <enumeration value="Diff"/>
               <enumeration value="Sum"/>
            </restriction>
         </simpleType>
      </element>
```



```
      <element name="NumOfBins" type="mpeg7:unsigned12"/>
   </sequence>
</complexType>
```

6.3.3 Binary representation syntax

ColorQuantization {	**Number of bits**	**Mnemonic**
for(k=0; k<NumOfComponents; k++) {		
Component[k]	5	bslbf
NumOfBins[k]	12	uimsbf
}		
}		

6.3.4 Descriptor components semantics

Component
This element specifies the color component to be quantized, allowing the components to be quantized in an arbitrary order. NumOfComponents is set to 1 when the color space quantized by this descriptor is monochrome and to 3 otherwise. The allowed color components combinations used for each color space are defined in Table 9. For the HMMD color space, the allowed combinations are {H,Max,Min} and {H,Diff,Sum}. In the binary representation, the meaning of the codes is specified in Table 11.

Table 11 — The meaning of Component.

Component	Meaning
00000	R
00001	G
00010	B
00011	Y
00100	Cb
00101	Cr
00110	H
00111	S
01000	V
01001	Max
01010	Min
01011	Diff
01100	Sum
01101-11111	Reserved

NumOfBins
This element specifies the number of bins for the color component. In the case of a uniform quantizer, the normalized value range *A* of the color component is divided into NumOfBins equal intervals of width *A/NumOfBins* each.

6.3.5 Decoding

The decoder decodes a color index that points to a specific color value.

Reconstruction of component *k* (*k*=0, …, NumOfComponents-1) with known **max_value** and **min_value** of each normalized component:

```
value_range = max_value - min_value;
comp_rec[k] = (comp_index[k]+0.5)*value_range÷NumOfBins[k] - min_value;
```

In the above, comp_index[k] is a quantized index of the *k*-th color component, which is an unsigned integer between 0 and 2^NumOfBins[k]-1. The color values residing on the boundaries between bins are assigned to the higher color index.

6.4 Dominant color

6.4.1 Introduction

This descriptor specifies a set of dominant colors in an arbitrarily shaped region. It targets content-based retrieval for color, either for the whole image or for an arbitrary region (rectangular or irregular).

6.4.2 DDL representation syntax

```
<complexType name="DominantColorType" final="#all">
   <complexContent>
      <extension base="mpeg7:VisualDType">
         <sequence>
            <element name="ColorSpace" type="mpeg7:ColorSpaceType"
                  minOccurs="0"/>
            <element name="ColorQuantization"
                  type="mpeg7:ColorQuantizationType" minOccurs="0"/>
            <element name="SpatialCoherency" type="mpeg7:unsigned5"/>
            <element name="Value" minOccurs="1" maxOccurs="8">
               <complexType>
                  <sequence>
                     <element name="Percentage" type="mpeg7:unsigned5"/>
                     <element name="Index">
                        <simpleType>
                           <restriction>
                              <simpleType>
                                 <list itemType="mpeg7:unsigned12"/>
                              </simpleType>
                              <length value="3"/>
                           </restriction>
                        </simpleType>
                     </element>
                     <element name="ColorVariance" minOccurs="0">
                        <simpleType>
                           <restriction>
                              <simpleType>
                                 <list itemType="mpeg7:unsigned1"/>
                              </simpleType>
                              <length value="3"/>
                           </restriction>
                        </simpleType>
                     </element>
                  </sequence>
               </complexType>
            </element>
         </sequence>
      </extension>
   </complexContent>
</complexType>
```


6.4.3 Binary representation syntax

DominantColor {	**Number of bits**	**Mnemonic**
Size	3	uimsbf
ColorSpacePresent	1	bslbf
if(ColorSpacePresent) {		
ColorSpace	See subclause 6.2.3	ColorSpaceType
}		
ColorQuantizationPresent	1	bslbf
if(ColorQuantizationPresent) {		
ColorQuantization	See subclause 6.3.3	ColorQuantizationType
}		
VariancePresent	1	bslbf
SpatialCoherency	5	uimsbf
for(k=0; k<Size; k++) {		
Percentage	5	uimsbf
for(m=0; m<3; m++) {		
Index	1-12	uimsbf
if(VariancePresent) {		
ColorVariance	1	uimsbf
}		
}		
}		
}		

6.4.4 Descriptor components semantics

Size
This field, which is only present in the binary representation, specifies the number of dominant colors in the region. The maximum allowed number of dominant colors is 8, the minimum number of dominant colors is 1. The following mapping of bit patterns is used: 000->1, …, 111->8.

ColorSpacePresent
This field, which is only present in the binary representation, indicates the presence of the ColorSpace element. If set to 0, ColorSpace is not present and RGB color space is used.

ColorSpace
This element is defined in subclause 6.2.

ColorQuantizationPresent
This element, which is only present in the binary representation, signals the presence of the ColorQuantization element. If set to 0, ColorQuantization is not present and uniform color quantization of the components to 5 bits is used.

ColorQuantization
This element is specified in subclause 6.3.

VariancePresent
This field, which is only present in the binary representation, indicates the presence of the color variances in the descriptor.

SpatialCoherency
This element specifies the spatial coherency of the dominant colors described by the descriptor. It is computed as a single value by the weighted sum of per-dominant-color spatial coherencies. The weight is proportional to the number of pixels corresponding to each dominant color. Spatial coherency per dominant color captures how coherent the pixels corresponding to the dominant color are and whether they appear to be a solid color in the given image region (See Figure 11, where red pixels in the left image have low spatial coherency and in the right image high spatial coherency).

Spatial coherency per dominant color is computed by the normalized average connectivity (8-connectedness) for the corresponding dominant color pixels.

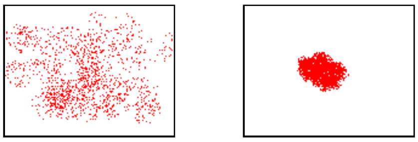


Figure 11 — Examples of low (a) and high (b) spatial coherency of color.

The weighted sum of per-dominant-color spatial coherencies is normalized from 0 to 1, then non-uniformly quantized to the range from 1 to 31 as follows. Normalized values less than 0.7 are set to 1, while values between 0.7 to 1 are uniformly quantized to the range 2 to 31. 0 is used to signal that this element is not computed (note that if it is not computed it does not mean that the spatial coherency is low).

Value
This element specifies an array of elements that hold percentages and values of colors in a visual item. The array elements consist of Percentage, ColorValueIndex and ColorVariance.

Percentage
This element specifies the percentage of pixels that have the associated color value. The percentage value is uniformly quantized to 5 bits with 0 corresponding to 0 percentage and 31 corresponding to 100%. Note that the sum of the Percentage values for a given visual item does not have to be equal to 100%.

Index
This element specifies the index of the dominant color in the selected color space as defined in ColorQuantization. The number of bits for each component is derived from the ColorQuantization element.

ColorVariance
This element specifies an integer array containing the value of the variance of color values of pixels corresponding to the dominant color in the selected color space, i.e.

$$CV_j = \frac{1}{N}\sum_{k=0}^{N-1}\left(m_j - p_{kj}\right)^2$$

where j indexes the color component, m_j is j-th component of the dominant color, p_{kj} is j-th component of the k-th pixel value, and the summation is over N pixels corresponding to the dominant color under consideration.

The dimension of this vector depends on the selected color space. Each component is quantized to 1 bit, with "0" corresponding to low variance and "1" corresponding to high variance. The quantization threshold is equal to 0.005 of the squared color component value range.

6.5 Scalable color

6.5.1 Introduction

This descriptor specifies a color histogram in the 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.

6.5.2 DDL representation syntax

```
<complexType name="ScalableColorType" final="#all">
   <complexContent>
      <extension base="mpeg7:VisualDType">
         <sequence>
            <element name="Coeff" type="mpeg7:integerVector"/>
         </sequence>
         <attribute name="numOfCoeff" use="required">
            <simpleType>
               <restriction base="integer">
                  <enumeration value="16"/>
                  <enumeration value="32"/>
                  <enumeration value="64"/>
                  <enumeration value="128"/>
```



```
                <enumeration value="256"/>
            </restriction>
         </simpleType>
      </attribute>
      <attribute name="numOfBitplanesDiscarded" use="required">
         <simpleType>
            <restriction base="integer">
               <enumeration value="0"/>
               <enumeration value="1"/>
               <enumeration value="2"/>
               <enumeration value="3"/>
               <enumeration value="4"/>
               <enumeration value="6"/>
               <enumeration value="8"/>
            </restriction>
         </simpleType>
      </attribute>
    </extension>
  </complexContent>
</complexType>
```

6.5.3 Binary representation syntax

ScalableColor {	Number of bits	Mnemonic
numOfCoeff	3	bslbf
numOfBitplanesDiscarded	3	bslbf
for(k=0; k<numOfCoeff; k++) {		
CoefficientSign	1	bslbf
}		
for(k=0; k<8-numOfBitplanesDiscarded; k++) {		
Bitplane[k]	BitplaneSize	bslbf
}		
}		

6.5.4 Descriptor components semantics

numOfCoeff
This attribute specifies the number of coefficients used in the scalable representation. Possible values are: 16, 32, 64, 128, and 256. Its binary semantics are specified in Table 12

Table 12 — The meaning of numOfCoeff.

numOfCoeff	Meaning
000	16
001	32
010	64
011	128
100	256
101-111	Reserved

numOfBitplanesDiscarded
This attribute specifies the number of bitplanes discarded in the scalable representation for each coefficient. Possible values are: 0, 1, 2, 3, 4, 6, 8. If the number of bits allocated to a specific coefficient is less than numOfBitplanesDiscarded, only the sign bit of this coefficient is retained. The binary semantics of this field are defined in Table 13

Table 13 — The meaning of numOfBitplanesDiscarded.

numOfBitplanesDiscarded	Meaning
000	0

001	1
010	2
011	3
100	4
101	6
110	8
111	Reserved

Coeff
This element specifies the Haar transform coefficients. In the DDL representation, coefficients are expressed as signed integers, where the precision of the quantized representation follows from the numOfBitplanesDiscarded value. In the binary representation, coefficients are expressed through their sign and optionally their amplitude.

CoefficientSign
This element specifies the sign of a Haar coefficient representing a component of a transformed color histogram in the HSV color space. The positive sign is encoded as “1” and the negative sign as “0”.

Bitplane[k]
This represents one bitplane of all the coefficients that are encoded in this specific bitplane. Because each coefficient is encoded with a different number of bits, the size of each bitplane increases starting from the most significant bits (MSB=8) to the least significant bits (LSB=1). The first bitplane contains the MSB of all coefficients encoded on 8 bits, while the last bitplane contains the LSB of all coefficients encoded. Table 14 shows the size in bits (or equivalently in number of coefficients represented) of each bitplane, depending on the NumberOfCoefficients retained in the scalable color representation. Note that following the notation of 6.5.3, Bitplane[0] is the most significant bitplane, while Bitplane[7] contains the least significant bit of each coefficient.

Table 14 — Sizes of successive bitplanes, depending on the NumberOfCoefficients.

Bitplanesize (significance)	Number Of Coefficients=16	Number Of Coefficients=32	Number Of Coefficients=64	Number Of Coefficients=128	Number Of Coefficients=256
Bitplane[0]	3	3	3	3	3
Bitplane[1]	5	5	5	5	5
Bitplane[2]	14	17	17	17	17
Bitplane[3]	16	24	25	25	25
Bitplane[4]	16	30	51	82	91
Bitplane[5]	16	31	63	102	138
Bitplane[6]	16	32	64	122	227
Bitplane[7]	16	32	64	128	256

Corresponding to Table 14, Bitplane[k] is assigned rank r=8-k. If for a coefficient BN<r in Table 15, the coefficient is skipped in Bitplane[k].

Within the bitplanes the coefficients, if present, are ordered as follows with respect to the coefficient index CI in Table 15:

- Coefficients 0-15:
  CI: 0, 4, 8, 12, 32, 36, 40, 44, 128, 132, 136, 140, 160, 164, 168, 172
- Coefficients 16-31:
  CI: 2, 6, 10, 14, 34, 38, 42, 46, 130, 134, 138, 142, 162, 166, 170, 174
- Coefficients 32-63:
  CI: 64, 66, 68, 70, 72, 74, 76, 78, 96, 98, 100, 102, 104, 106, 108, 110, 192, 194, 196, 198, 200, 202, 204, 206, 224, 226, 228, 230, 232, 234, 236, 238
- Coefficients 64-127:
  CI: 16, 18, 20, 22, 24, 26, 28, 30, 48, 50, 52, 54, 56, 58, 60, 62, 80, 82, 84, 86, 88, 90, 92, 94, 112, 114, 116, 118, 120, 122, 124, 126, 144, 146, 148, 150, 152, 154, 156, 158, 176, 178, 180, 182, 184, 186, 188, 190, 208, 210, 212, 214, 216, 218, 220, 222, 240, 242, 244, 246, 248, 250, 252, 254
- Coefficients 128-255:
  CI: 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33, 35, 37, 39, 41, 43, 45, 47, 49, 51, 53, 55, 57, 59, 61, 63, 65, 67, 69, 71, 73, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 119, 121, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157,

159, 161, 163, 165, 167, 169, 171, 173, 175, 177, 179, 181, 183, 185, 187, 189, 191, 193, 195, 197, 199, 201, 203, 205, 207, 209, 211, 213, 215, 217, 219, 221, 223, 225, 227, 229, 231, 233, 235, 237, 239, 241, 243, 245, 247, 249, 251, 253, 255.

For instance in Bitplane[1] with 16 coefficients, 5 bits expressing this bitplane for the coefficients (in sequence) CI=0, 4, 8, 12, 128 would be contained.

Bit representation of Coefficients
For each coefficient, what is encoded is the magnitude of a Haar coefficient representing a component of a transformed color histogram in the HSV color space. The Coefficient Index CI, the Number Of Bits allocated to the coefficients BN, as well as Offset values QO necessary for reconstruction of histograms, are given in Table 15. Reconstruction of one coefficient is defined as CR=QO+SIGN*AMPLITUDE. The AMPLITUDE value is constituted from all the bitplanes that are available, in their respective significance position. All bit values that are not available shall be supplemented by zero values.

Table 15 — Indexing, bit allocation and quantizer offsets of Haar coefficients.

CI	BN	QO	CI	BN	QO	CI	BN	QO	CI	BN	QO
0	8	217	64	4	3	128	7	-29	192	4	-5
1	3	-1	65	3	1	129	4	1	193	3	0
2	6	4	66	5	3	130	6	0	194	4	-4
3	2	0	67	3	0	131	3	-1	195	3	-1
4	8	-54	68	4	0	132	6	-22	196	4	-2
5	2	-1	69	2	-1	133	2	0	197	2	0
6	5	-1	70	4	-1	134	4	0	198	4	-1
7	2	0	71	2	0	135	2	0	199	2	0
8	8	-71	72	4	2	136	6	-14	200	4	-3
9	2	0	73	3	0	137	3	0	201	3	0
10	5	-5	74	4	0	138	5	-5	202	4	-1
11	2	0	75	2	0	139	2	0	203	2	0
12	7	-27	76	4	0	140	6	-8	204	3	-1
13	2	0	77	2	0	141	2	0	205	2	0
14	4	3	78	4	0	142	4	1	206	4	-1
15	2	0	79	2	0	143	2	0	207	2	0
16	4	-1	80	4	0	144	4	0	208	4	-1
17	3	1	81	4	2	145	4	2	209	3	1
18	4	1	82	4	-1	146	4	-2	210	4	-2
19	3	0	83	4	-1	147	4	-1	211	3	-1
20	4	0	84	4	-3	148	4	-3	212	4	-2
21	2	-1	85	3	-1	149	2	0	213	2	0
22	4	-1	86	4	-3	150	4	-3	214	4	-2
23	2	0	87	2	0	151	2	0	215	1	0
24	3	0	88	4	-1	152	4	-1	216	4	-1
25	3	0	89	4	1	153	4	1	217	3	1
26	3	-1	90	4	-2	154	4	-2	218	4	-2
27	2	0	91	2	-1	155	2	0	219	2	0
28	2	-1	92	3	-2	156	3	-1	220	3	-1
29	1	0	93	1	0	157	1	0	221	1	0
30	3	-1	94	4	-2	158	4	-2	222	3	-1
31	2	0	95	2	0	159	2	0	223	2	0
32	6	-22	96	4	0	160	6	-22	224	4	-2
33	3	1	97	4	1	161	3	1	225	2	0
34	6	0	98	4	-3	162	5	-2	226	4	-1
35	3	0	99	4	-1	163	3	0	227	2	0
36	6	-19	100	4	-3	164	5	-11	228	2	0
37	2	0	101	2	0	165	2	0	229	1	0
38	4	-2	102	4	-2	166	2	0	230	2	0
39	2	0	103	2	0	167	1	0	231	1	0
40	6	-14	104	4	-2	168	6	-13	232	4	-1
41	3	0	105	3	1	169	3	1	233	3	0

42	5	-2	106	4	-2	170	4	-1	234	2	0
43	2	-1	107	2	0	171	2	0	235	2	0
44	6	-9	108	2	0	172	5	-6	236	2	0
45	1	0	109	1	0	173	1	0	237	1	0
46	4	2	110	4	-1	174	3	0	238	2	0
47	2	0	111	2	0	175	2	0	239	1	0
48	3	0	112	4	-2	176	4	-1	240	3	-1
49	3	1	113	3	0	177	2	0	241	2	0
50	3	-1	114	4	-2	178	3	-1	242	2	0
51	2	0	115	3	0	179	2	0	243	2	0
52	3	0	116	2	0	180	2	0	244	1	0
53	2	0	117	2	0	181	1	0	245	1	0
54	2	0	118	2	0	182	1	0	246	1	0
55	2	0	119	1	0	183	1	0	247	1	0
56	3	-1	120	3	-1	184	3	-1	248	3	0
57	2	0	121	2	0	185	2	0	249	2	0
58	3	0	122	2	0	186	2	0	250	2	0
59	2	-1	123	2	0	187	2	0	251	2	0
60	2	0	124	2	0	188	1	0	252	1	0
61	1	0	125	1	0	189	1	0	253	1	0
62	3	1	126	2	0	190	2	0	254	1	0
63	2	1	127	2	0	191	2	0	255	1	0

The input to the transform is an HSV Color Histogram based on the definition of the uniform ColorQuantization descriptor with 16 bins in H, and 4 bins in each S and V (256 bins in total). The Index values of the input histogram bins equal the index values of the uniform ColorQuantization descriptor. Prior to the Haar transform, the histogram (probability) values are subject to a non-uniform mapping into a 4-bit index. Table 16 specifies the mapping function from a histogram with bin values of 11-bit integer precision into this 4-bit representation, which is used as the input to Figure 12(a). The flow diagram of the Haar transform is explained in Figure 12. The transform is performed in place, i.e. the indexing of the coefficients in Table 17 corresponds to the respective direct input path of the flow diagram. Figure 12(a) shows the first four levels of the transform, which has likewise to be applied with index offsets of 4, 8, 12, 32, 36, 40, 44, 128, 132, 136, 140, 160, 164, 168, 172. Figure 12(b) shows the remaining four levels, for which only the “intermediate lowpass” coefficients (to be found at the leading positions from the 16 index offsets) are used as inputs.

Table 16 — Equivalent quantization table of reconstructed HSV color histogram bin values.

Histogram value	4-bit index	Histogram value	4-bit index	Histogram value	4-bit index	Histogram value	4-bit index
0	0	40	4	…	8	422	12
1	1	41	5	197	8	…	12
2	1	…	5	198	9	519	12
3	2	66	5	…	9	520	13
…	2	67	6	261	9	…	13
9	2	…	6	262	10	629	13
10	3	101	6	…	10	630	14
…	3	102	7	335	10	…	14
21	3	…	7	336	11	752	14
22	4	144	7	…	11	753	15
…	4	145	8	421	11	…	15
						2047	15

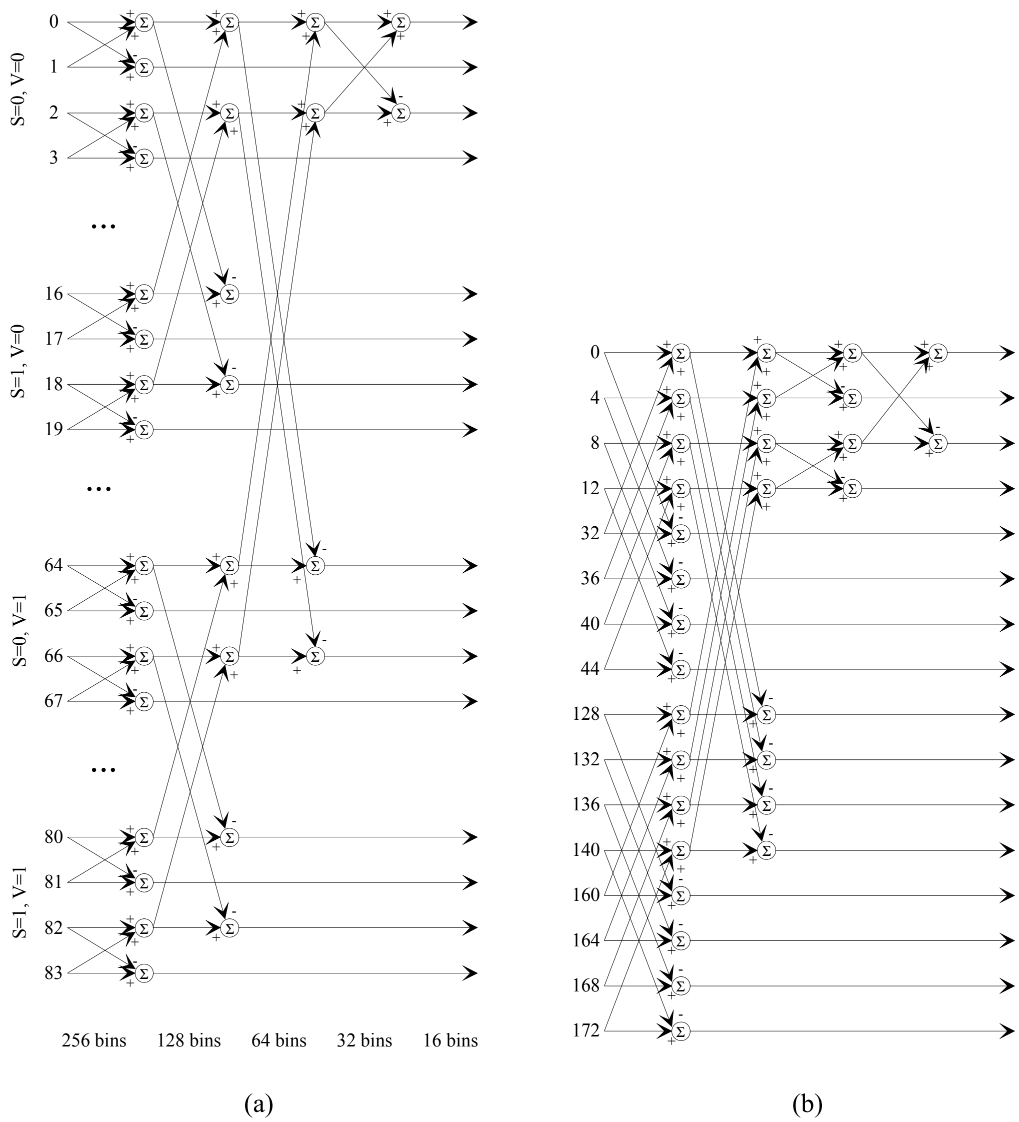


Figure 12 — Haar transform of 256-bin HSV color histogram (a) levels 1-4 (b) levels 5-8.

Table 17 — Bin numbers of reconstructed HSV color histograms.

Number of coefficients	Number of bins H	Number of bins S	Number of bins V
16	4	2	2
32	8	2	2
64	8	2	4
128	8	4	4
256	16	4	4

6.6 Color layout

6.6.1 Introduction

This descriptor specifies the spatial distribution of colors for high-speed retrieval and browsing. It targets image-to-image matching and sequence-to-sequence matching. It can also be used for color layout-based retrieval, such as sketch-to-image matching. This descriptor can be applied to images or arbitrarily shaped image regions. When applied to a video segment or a moving region, the descriptor specifies the spatial distribution of the color of a representative frame selected from the corresponding video segment or a representative region selected from the corresponding moving region.

The ColorLayout descriptor uses the YCbCr color space with quantization to 8 bits performed in the following way:

$$Y = 219 \cdot Y_{norm} + 16$$
$$Cb = 224 \cdot Cb_{norm} + 128$$
$$Cr = 224 \cdot Cr_{norm} + 128$$

Here, the Y_{norm}, Cb_{norm} and Cr_{norm} are the normalized YCbCr color values as defined in subclause 6.2.

6.6.2 DDL representation syntax

```
<complexType name="ColorLayoutType" final="#all">
   <complexContent>
      <extension base="mpeg7:VisualDType">
         <sequence>
            <element name="YDCCoeff" type="mpeg7:unsigned6"/>
            <element name="CbDCCoeff" type="mpeg7:unsigned6"/>
            <element name="CrDCCoeff" type="mpeg7:unsigned6"/>
            <choice>
               <element name="YACCoeff2">
                  <simpleType>
                     <restriction>
                        <simpleType>
                           <list itemType="mpeg7:unsigned5"/>
                        </simpleType>
                        <length value="2"/>
                     </restriction>
                  </simpleType>
               </element>
               <element name="YACCoeff5">
                  <simpleType>
                     <restriction>
                        <simpleType>
                           <list itemType="mpeg7:unsigned5"/>
                        </simpleType>
                        <length value="5"/>
                     </restriction>
                  </simpleType>
               </element>
               <element name="YACCoeff9">
                  <simpleType>
                     <restriction>
                        <simpleType>
                           <list itemType="mpeg7:unsigned5"/>
                        </simpleType>
                        <length value="9"/>
                     </restriction>
                  </simpleType>
               </element>
               <element name="YACCoeff14">
                  <simpleType>
                     <restriction>
                        <simpleType>
                           <list itemType="mpeg7:unsigned5"/>
                        </simpleType>
                        <length value="14"/>
                     </restriction>
                  </simpleType>
               </element>
               <element name="YACCoeff20">
                  <simpleType>
                     <restriction>
                        <simpleType>
                           <list itemType="mpeg7:unsigned5"/>
```



```
            </simpleType>
            <length value="20"/>
         </restriction>
      </simpleType>
   </element>
   <element name="YACCoeff27">
      <simpleType>
         <restriction>
            <simpleType>
               <list itemType="mpeg7:unsigned5"/>
            </simpleType>
            <length value="27"/>
         </restriction>
      </simpleType>
   </element>
   <element name="YACCoeff63">
      <simpleType>
         <restriction>
            <simpleType>
               <list itemType="mpeg7:unsigned5"/>
            </simpleType>
            <length value="63"/>
         </restriction>
      </simpleType>
   </element>
</choice>
<choice>
   <sequence>
      <element name="CbACCoeff2">
         <simpleType>
            <restriction>
               <simpleType>
                  <list itemType="mpeg7:unsigned5"/>
               </simpleType>
               <length value="2"/>
            </restriction>
         </simpleType>
      </element>
      <element name="CrACCoeff2">
         <simpleType>
            <restriction>
               <simpleType>
                  <list itemType="mpeg7:unsigned5"/>
               </simpleType>
               <length value="2"/>
            </restriction>
         </simpleType>
      </element>
   </sequence>
   <sequence>
      <element name="CbACCoeff5">
         <simpleType>
            <restriction>
               <simpleType>
                  <list itemType="mpeg7:unsigned5"/>
               </simpleType>
               <length value="5"/>
            </restriction>
         </simpleType>
      </element>
      <element name="CrACCoeff5">
```

```
                <simpleType>
                   <restriction>
                      <simpleType>
                         <list itemType=”mpeg7:unsigned5”/>
                      </simpleType>
                      <length value=”5”/>
                   </restriction>
                </simpleType>
             </element>
          </sequence>
          <sequence>
             <element name=”CbACCoeff9”>
                <simpleType>
                   <restriction>
                      <simpleType>
                         <list itemType=”mpeg7:unsigned5”/>
                      </simpleType>
                      <length value=”9”/>
                   </restriction>
                </simpleType>
             </element>
             <element name=”CrACCoeff9”>
                <simpleType>
                   <restriction>
                      <simpleType>
                         <list itemType=”mpeg7:unsigned5”/>
                      </simpleType>
                      <length value=”9”/>
                   </restriction>
                </simpleType>
             </element>
          </sequence>
          <sequence>
             <element name=”CbACCoeff14”>
                <simpleType>
                   <restriction>
                      <simpleType>
                         <list itemType=”mpeg7:unsigned5”/>
                      </simpleType>
                      <length value=”14”/>
                   </restriction>
                </simpleType>
             </element>
             <element name=”CrACCoeff14”>
                <simpleType>
                   <restriction>
                      <simpleType>
                         <list itemType=”mpeg7:unsigned5”/>
                      </simpleType>
                      <length value=”14”/>
                   </restriction>
                </simpleType>
             </element>
          </sequence>
          <sequence>
             <element name=”CbACCoeff20”>
                <simpleType>
                   <restriction>
                      <simpleType>
                         <list itemType=”mpeg7:unsigned5”/>
                      </simpleType>
```



```
                  <length value="20"/>
               </restriction>
            </simpleType>
         </element>
         <element name="CrACCoeff20">
            <simpleType>
               <restriction>
                  <simpleType>
                     <list itemType="mpeg7:unsigned5"/>
                  </simpleType>
                  <length value="20"/>
               </restriction>
            </simpleType>
         </element>
      </sequence>
      <sequence>
         <element name="CbACCoeff27">
            <simpleType>
               <restriction>
                  <simpleType>
                     <list itemType="mpeg7:unsigned5"/>
                  </simpleType>
                  <length value="27"/>
               </restriction>
            </simpleType>
         </element>
         <element name="CrACCoeff27">
            <simpleType>
               <restriction>
                  <simpleType>
                     <list itemType="mpeg7:unsigned5"/>
                  </simpleType>
                  <length value="27"/>
               </restriction>
            </simpleType>
         </element>
      </sequence>
      <sequence>
         <element name="CbACCoeff63">
            <simpleType>
               <restriction>
                  <simpleType>
                     <list itemType="mpeg7:unsigned5"/>
                  </simpleType>
                  <length value="63"/>
               </restriction>
            </simpleType>
         </element>
         <element name="CrACCoeff63">
            <simpleType>
               <restriction>
                  <simpleType>
                     <list itemType="mpeg7:unsigned5"/>
                  </simpleType>
                  <length value="63"/>
               </restriction>
            </simpleType>
         </element>
      </sequence>
   </choice>
</sequence>
```

```
      </extension>
   </complexContent>
</complexType>
```

6.6.3 Binary representation syntax

ColorLayout {	**Number of bits**	**Mnemonic**
CoeffPattern	1-2	vlclbf
if(CoeffPattern==11) {		
NumOfYCoeffIndex	3	bslbf
NumOfCCoeffIndex	3	bslbf
}		
YDCCoeff	6	uimsbf
CbDCCoeff	6	uimsbf
CrDCCoeff	6	uimsbf
for(k=1; k<NumOfYCoeff; k++) {		
YACCoeff	5	uimsbf
}		
for(k=1; k<NumOfCCoeff; k++) {		
CbACCoeff	5	uimsbf
}		
for(k=1; k<NumOfCCoeff; k++) {		
CrACCoeff	5	uimsbf
}		
}		

6.6.4 Descriptor components semantics

CoeffPattern
This field, which is only present in the binary representation, specifies the number of coefficients included in the descriptor. The meaning of the values is specified in Table 18.

It is forbidden to use CoeffPattern “11” to express the combinations of NumOfYCoeff and NumOfCCoeff that are specified by CoeffPattern “0” and “01”.

Table 18 — Meaning of CoeffPattern.

CoefficientPattern	**Meaning**	
	NumOfYCoeff	NumOfCCoeff
0	6	3
10	6	6
11	Specified by NumOfYCoeffIndex	Specified by NumOfCCoeffIndex

numOfYCoeffIndex, n**umOfCCoeffIndex**
These fields, which are only present in the binary representation, specify the NumOfYCoeff and NumOfCCoeff for the cases not covered by CoeffPattern. Their mapping to NumOfYCoeff and NumOfCCoeff is specified in Table 19.

Table 19 — Meaning of NumOfYCoeffIndex and NumOfCCoeffIndex.

NumOfYCoeffIndex/NumOfCCoeffIndex	**NumOfYCoeff, NumOfCCoeff**
000	reserved
001	3
010	6

011	10
100	15
101	21
110	28
111	64

YDCCoeff, **YACCoeff**, **CbDCCoeff**, **CbACCoeff**, **CrDCCoeff, CrACCoeff**
These elements specify the integer arrays that hold a series of zigzag-scanned DCT coefficient values.

YDCCoeff
The first quantized DCT coefficient of the Y component.

CbDCCoeff
The first quantized DCT coefficient of the Cb component.

CrDCCoeff
The first quantized DCT coefficient of the Cr component.

YACCoeff
The second and the successive quantized DCT coefficients of the Y component. In the DDL representation, separate elements (YACCoeff2, YACCoeff5, YACCoeff9, YACCoeff14, YACCoeff20, YACCoeff27 and YACCoeff63) are used to cover all valid array lengths.

CbACCoeff
The second and the successive quantized DCT coefficients of the Cb component. In the DDL representation, separate elements (CbACCoeff2, CbACCoeff5, CbACCoeff9, CbACCoeff14, CbACCoeff20, CbACCoeff27 and CbACCoeff63) are used to cover all valid array lengths.

CrACCoeff
The second and the successive quantized DCT coefficients of the Cr component. In the DDL representation, separate elements (CrACCoeff2, CrACCoeff5, CrACCoeff9, CrACCoeff14, CrACCoeff20, CrACCoeff27 and CrACCoeff63) are used to cover all valid array lengths.

These coefficients are derived as follows. It should be noted that the following process must be performed on each color component independently. The DCT coefficients of each color component are derived from the corresponding component of local representative colors. The selection algorithm of local representative colors is not normative.

1. **DCT transformation of an 8x8 array of local representative colors.**

The 8x8 DCT coefficient matrix, c[8][8], can be calculated from the 8x8 matrix of local representative colors, d[8][8], as follows

```
int i, j, k;
double s;
double tmp[64];
for( i=0; i<8; i++ ) {
  for( j=0; j<8; j++ ) {
    s = 0.0;
    for( k=0; k<8; k++ )
      s += m[j][k]*d[i][k];
    tmp[i][j] = s;
  }
}
for( j=0; j<8; j++ ) {
  for( i=0; i<8; i++ ) {
    s = 0.0;
    for( k=0; k<8; k++ )
      s += m[i][k]*tmp[k][j];
    c[i][j] = (int)trunc(s+0.499999);
  }
}
```

Here, the function trunc(x) drops the fractions of x for rounding to integer values. The matrix m[8][8] is defined as follows:

```
for( i=0; i<8; i++ ) {
  double s=(i==0) ? sqrt(0.125) : 0.5;
  for( j=0; j<8; j++ ) {
```



```
      m[i][j] = s*cos((M_PI/8.0)*i*(j+0.5));
    }
  }
```

It should be noted that the invalid locations in d[8][8] should be padded before the above process is performed using the average color of all valid representative colors.

In the following process, yc[8][8], cbc[8][8] and crc[8][8] denote the DCT coefficient matrix for the Y, Cb and Cr color components.

2. Quantization of DCT coefficients

The coefficient matrix c should be quantized as follows:

```
YC[i][j] = quant_Y_DC(yc[i][j]) for i=0,j=0
           quant_Y_AC(yc[i][j]) otherwise
CbC[i][j] = quant_CbCr_DC(cbc[i][j]) for i=0,j=0
            quant_CbCr_AC(cbc[i][j]) otherwise
CrC[i][j] = quant_CbCr_DC(crc[i][j]) for i=0,j=0
            quant_CbCr_AC(crc[i][j]) otherwise
```

The quantization functions should be implemented as follows:

```
int quant_Y_DC(int i) {
  int j;
  i = i/8;
  if(i>192) j=112+(i-192)/4;
  else if(i>160) j=96+(i-160)/2;
  else if(i>96) j=32+i-96;
  else if(i>64) j=16+(i-64)/2;
  else j=i/4;
  return j>>1;
}
int quant_CbCr_DC(int i) {
  int j;
  i = i/8;
  if(i>191) j=63;
  else if(i>160) j=56+(i-160)/4;
  else if(i>144) j=48+(i-144)/2;
  else if(i>112) j=16+i-112;
  else if(i>96) j=8+(i-96)/2;
  else if(i>64) j=(i-64)/4;
  else j=0;
  return j;
}
int quant_Y_AC(int i) {
  int j;
  i = i/2;
  if(i>255) i=255;
  if(i<-256) i=-256;
  if(abs(i)>127) j=64+abs(i)/4;
  else if(abs(i)>63) j=32+abs(i)/2;
  else j=abs(i);
  j = (i<0)?-j:j;
  return (int)trunc(((double)j+128.0)/8.0+0.5);
}
int quant_CbCr_AC(int i) {
  int j;
  if(i>255) i=255;
  if(i<-256) i=-256;
  if(abs(i)>127) j=64+abs(i)/4;
  else if(abs(i)>63) j=32+abs(i)/2;
  else j=abs(i);
  j = (i<0)?-j:j;
  return (int)trunc(((double)j+128.0)/8.0+0.5);
}
```

The quantized DC coefficients are encoded in 6 bits and the AC coefficients in 5 bits.

3. Zigzag scanning of quantized coefficients

The quantized coefficients YC, CbC, and CrC are scanned in a zigzag manner and the descriptor values, YCoeff, CbCoeff and CrCoeff, are derived as follows:

```
YCoeff[zigzag(i,j)] = YC[i][j]
CbCoeff[zigzag(i,j)] = CbC[i][j]
CrCoeff[zigzag(i,j)] = CrC[i][j]
```

where the function zigzag(i,j) returns the order of zigzag scanning at location (i,j) as shown in Table 20.

Table 20 — Zigzag scan order on an 8x8 matrix.

	i							
j	0	1	5	6	14	15	27	28
	2	4	7	13	16	26	29	42
	3	8	12	17	25	30	41	43
	9	11	18	24	31	40	44	53
	10	19	23	32	39	45	52	54
	20	22	33	38	46	51	55	60
	21	34	37	47	50	56	59	61
	35	36	48	49	57	58	62	63

As the result of step 3, YDCCoeff, YACCoeff, CbDCCoeff, CbACCoeff, CrDCCoeff and CrACCoeff are obtained from YCoeff, CbCoeff and CrCoeff as follows:

```
YDCCoeff = YCoeff[0], YACCoeff[k] = YCoeff[k+1] for k=0,…,62
CbDCCoeff = CbCoeff[0], CbACCoeff[k] = CbCoeff[k+1] for k=0,…,62
CrDCCoeff = CrCoeff[0], CrACCoeff[k] = CrCoeff[k+1] for k=0,…,62
```

6.7 Color structure

6.7.1 Introduction

This descriptor specifies both color content (similar to that of a color histogram) and the structure of this content. It does this via the use of a *structuring element*. Its main function is image-to-image matching and its intended use is for still-image retrieval, where an image may consist of either arbitrarily shaped, possibly disconnected, regions or a single rectangular frame.

The descriptor expresses local color structure in an image by means of a structuring element that is composed of several image samples. The semantics of the descriptor, though related to those of a color histogram, differ in the following way. Instead of characterizing the relative frequency of individual image samples with a particular color, this descriptor characterizes the relative frequency of structuring elements that contain an image sample with a particular color. Hence, unlike the color histogram, this descriptor can distinguish between two images in which a given color is present in identical amounts but where the structure of the groups of pixels having that color is different in the two images. Figure 13 depicts an example of this.

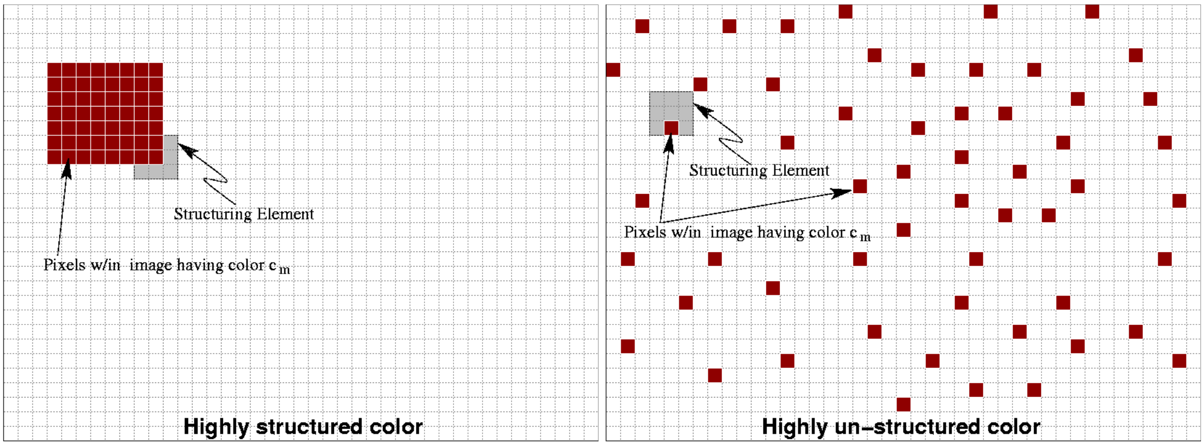


Figure 13 — Examples of structured and unstructured color.

6.7.2 DDL representation syntax

```
<complexType name="ColorStructureType" final="#all">
   <complexContent>
      <extension base="mpeg7:VisualDType">
         <sequence>
            <element name="Values">
               <simpleType>
                  <restriction>
                     <simpleType>
                        <list itemType="mpeg7:unsigned8"/>
                     </simpleType>
                     <minLength value="1"/>
                     <maxLength value="256"/>
                  </restriction>
               </simpleType>
            </element>
         </sequence>
         <attribute name="colorQuant" type="mpeg7:unsigned3" use="required"/>
      </extension>
   </complexContent>
</complexType>
```

6.7.3 Binary representation syntax

ColorStructure{	**Number of bits**	**Mnemonic**
colorQuant	3	uimsbf
NumOfValuesCode	8	uimsbf
for (m=0; m<M; m++) {		
Values[m]	8	uimsbf
}		
}		

6.7.4 Descriptor components semantics

colorQuant
This attribute specifies the color space and color quantization operating point and determines the number of ColorStructure values, *M*, used in the descriptor. Its semantics are specified in Table 21.

Table 21 — Semantics of colorQuant.

colorQuant	operating point
0	Forbidden

1	32 (HMMD)
2	64 (HMMD)
3	128 (HMMD)
4	256 (HMMD)
5-7	Reserved

NumOfValuesCode
This field, which is only present in the binary representation, specifies the number of ColorStructure values used in the descriptor. The number of ColorStructure values is determined as follows: M=NumOfValuesCode+1.

Values
This element specifies the ColorStructure descriptor data which is organized in an M element array of 8-bit integer values, $h(m)$ for $m \in \{0, 1, ..., M\text{-}1\}$. The array elements shall be referred to as *bins*. The number, M, of bins shall be chosen from the set {256, 128, 64, 32} associated allowable *operating points* as listed in Table 21. The bins of an M-bin descriptor are associated bijectively to the M quantized colors, c_0, c_1, c_2, …, c_{M-1}, of the M-cell color space, which is defined below. For the M=256 case, the value of $h(m)$ represents, in a non-linear manner to be described, the number of structuring elements in the image that contain one or more pixels with color c_m.

6.7.4.1 Extraction

The Color Structure descriptor containing 256 bins is extracted directly from the image based on a 256-cell quantization of the HMMD color space. Figure 14 depicts the extraction procedure. A "raw" 256-bin CS histogram is accumulated directly from the image, as described below. At this point, bin *amplitudes* are un-quantized and *linear*, i.e., linearly related to the number of structuring elements that containing the color associated with the bin.

Color Structure descriptors containing 128, 64, or 32 bins are computed based on unification of the bins of the 256-bin descriptor. For 256-bin descriptors no unification is performed. The unification is performed by adding the amplitudes contained in the appropriate bins and then clipping the sum to a maximum value of R_{max}, to be discussed below.

The mapping of the bins in the 256-bin descriptor to the bins in a smaller descriptor is defined by re-quantizing the color represented by each bin of the 256-bin descriptor into the more coarsely quantized color space as specified in Table 23, and then computing the bin index that represents each re-quantized color.

The final step of the extraction process is the non-uniform quantization of each bin amplitude to an 8-bit *code value*. The non-uniform nature of the quantization results in a non-linear relationship between code values and associated linear amplitudes. Non-uniform quantization proceeds as follows. Bin amplitudes are normalized by R_{max}. That is, the values $h(m)/R_{max}$ are computed for $m \in \{0, 1, ..., M\text{-}1\}$ so that the range of h is [0, 1]. This interval is divided into 6 regions each of which is subdivided into a specific number of uniform quantization levels. The first 5 of the 6 regions are of the form $[th_n, th_{n+1})$, $n \in \{0, ..., 4\}$ and the last is of the form $[th_5, 1.0]$ where values of th_n are given by: th_0=0, th_1=0.000000001, th_2=0.037, th_3=0.08, th_4=0.195, th_5=0.32. Table 22 contains the number of (uniform) quantization levels within each region.

Table 22 — Number of quantization levels in each region of the bin value range for non-uniform quantization.

Region	Number of levels
0	1
1	25
2	20
3	35
4	35
5	140

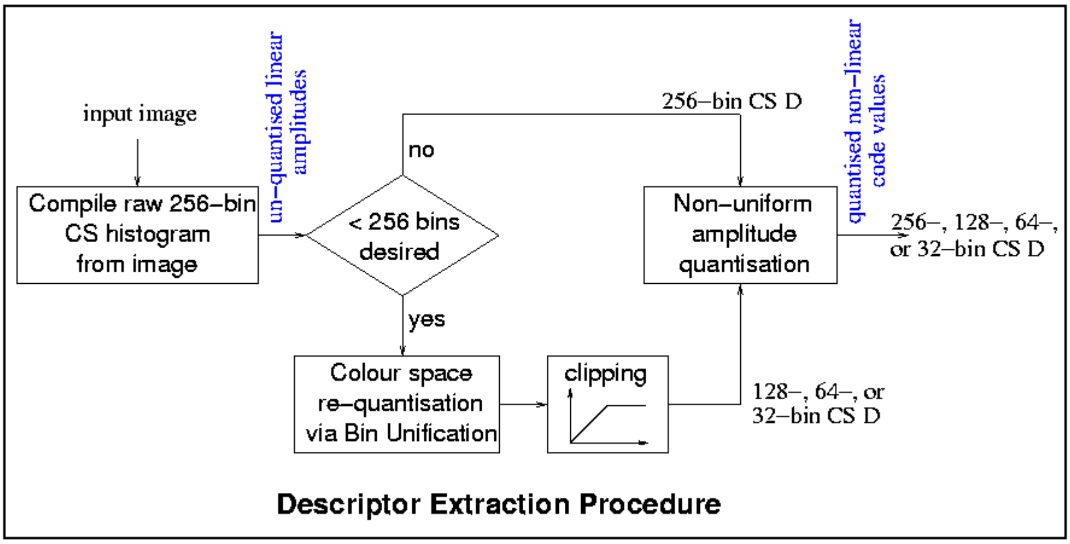


Figure 14 — ColorStructure descriptor extraction.

Both *query* and *database* descriptors are extracted by the preceding algorithm.

6.7.4.2 Descriptor re-quantization

When a query and a database descriptor are presented for comparison to a Similarity Measure their sizes must agree. Given a database descriptor of size M and a query descriptor of size N, the larger of the two descriptors must be reduced in size to match the smaller of the two. Figure 15 illustrates the method by which this reduction is performed. The code values of the descriptor to be reduced are first converted to (quantized) linear amplitudes. The conversion of code values to linear amplitudes shall have the following two properties: (i) there shall be a linear relationship between the resultant amplitudes and the mid-interval values of the non-uniform quantization intervals within [0,1] defined above, and (ii) these linear amplitude mid-interval values shall be represented by B bits, where B=20.

Next, bin unification is performed in the same manner as described above. In particular, if $M>N$, then the mapping of the bins in the M-bin descriptor to the bins in the N-bin descriptor is defined by re-quantizing the color represented by each bin of the M-bin descriptor into the N-cell color space as specified in Table 23, and then computing the bin index that represents each re-quantized color.

During bin unification the sum of two bins is clipped to the maximum possible linear amplitude, 2^B-1.

Last, the linear amplitudes of the reduced descriptor are converted back to non-linear 8-bit code values. It is to be noted that there is a bijective relationship between code values and (quantized) linear amplitudes.

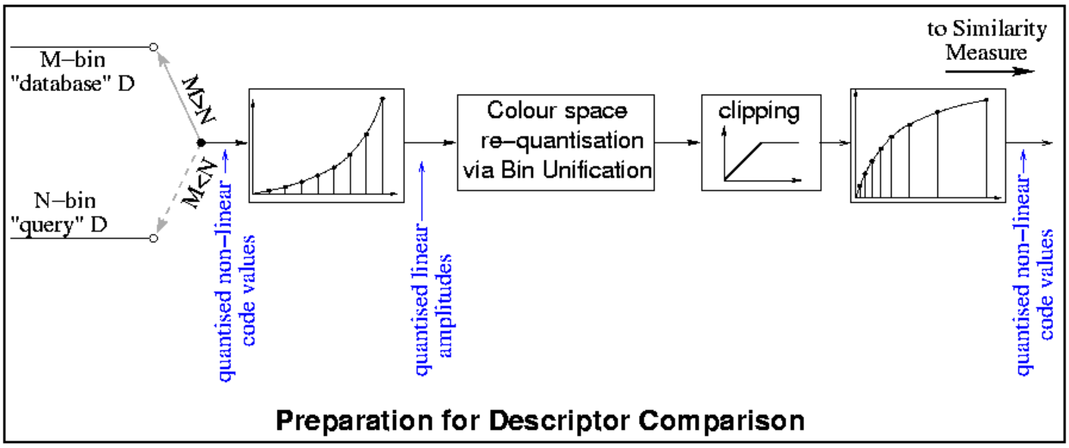


Figure 15 — ColorStructure descriptor re-quantization for similarity matching.

6.7.4.3 Color space and color quantization

The Color Structure descriptor shall be defined using the HMMD color space. The color pixels of incoming images in any other color space shall be converted to the HMMD color space. The Color Structure descriptor shall be defined using the following color space quantization operating points: 256, 128, 64, and 32 bins.

The 256-cell color space is quantized non-uniformly as follows (see Table 23). First, the HMMD color space is divided into 5 subspaces: subspaces 0, 1, 2, 3, and 4. This subspace division is defined along the Diff (colorfulness) axis of the HMMD color space, as shown in Figure 10. The subspaces are defined by cut-points which determine the following *diff*-axis intervals: [0,6), [6, 20), [20, 60), [60, 110) and [110, 255]. Second, each color subspace is uniformly quantized along the Hue and Sum axes, where the number of quantization levels along each axis is defined in Table 23 for each operating point.

Table 23 — HMMD color space quantization for ColorStructure descriptor.

<table>
<tr><td rowspan="3">Subspace</td><td colspan="8">Number of quantization levels for different numbers of histogram bins</td></tr>
<tr><td colspan="2">256</td><td colspan="2">128</td><td colspan="2">64</td><td colspan="2">32</td></tr>
<tr><td>Hue</td><td>Sum</td><td>Hue</td><td>Sum</td><td>Hue</td><td>Sum</td><td>Hue</td><td>Sum</td></tr>
<tr><td>0</td><td>1</td><td>32</td><td>1</td><td>16</td><td>1</td><td>8</td><td>1</td><td>8</td></tr>
<tr><td>1</td><td>4</td><td>8</td><td>4</td><td>4</td><td>4</td><td>4</td><td rowspan="2">4</td><td rowspan="2">4</td></tr>
<tr><td>2</td><td>16</td><td>4</td><td>8</td><td>4</td><td>4</td><td>4</td></tr>
<tr><td>3</td><td>16</td><td>4</td><td>8</td><td>4</td><td>8</td><td>2</td><td>4</td><td>1</td></tr>
<tr><td>4</td><td>16</td><td>4</td><td>8</td><td>4</td><td>8</td><td>1</td><td>4</td><td>1</td></tr>
</table>

Figure 16 shows a slice of the HMMD space in the *diff-sum* plane for zero hue angle and depicts the quantization cells for the 128-cell operating point. Cut-points defining the subspaces are indicated in the figure by vertical lines in the color plane. The *diff*-axis values that determine the cut-points are shown in black at the top of the dashed cut-point markers along the upper edge of the plane. Horizontal lines within each subspace depict the quantization along the *sum*-axis. The quantization of hue angle is indicated by the gray rotation arrows around each cut-point marker. The gray number to the right of a rotation arrow corresponds to the number of levels to which hue has been quantized in the subspace to the right of the cut-point. For example, Figure 16 states that the hue values associated with the subspace between *diff* = 60 and *diff* = 110 (i.e. subspace 3) are quantized to 8 levels. This agrees with the entry in Table 23.

The bijective mapping between color-space cells and descriptor bin indices is given explicitly by the numbers within the cells. The ordering of these numbers is first from bottom to top (parallel to the *sum*-axis), then from *diff-sum* plane to *diff-sum* plane (around the *hue*-axis) staying within a subspace, and finally from subspace to subspace. For example, the cells of Figure 16 closest to the bottom edge in subspaces 2 and 3 are numbered 32 and 64. The jump is due to the fact that there are four sum levels and 8 hue levels for this subspace. The numbers within the subspace, therefore, increase from 32 to 32 + 4*8 – 1 = 63.

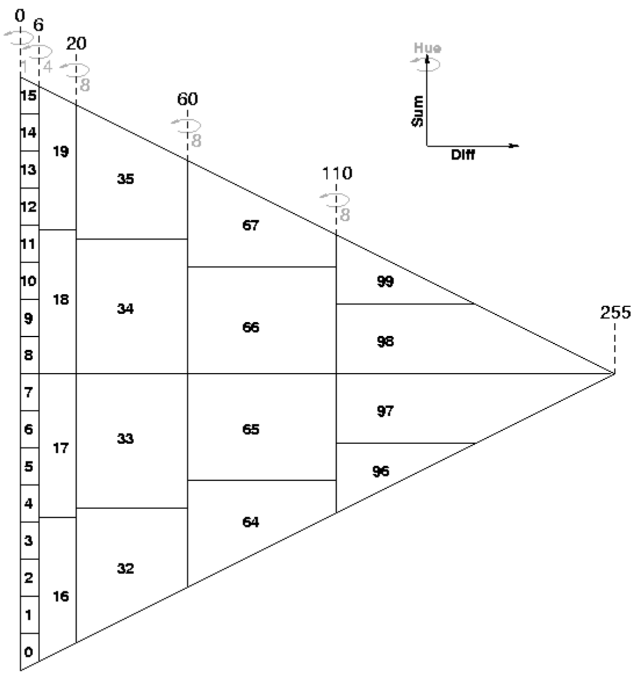


Figure 16 — Correspondence between 128-cell HMMD color space and bin indices.

6.7.4.4 Raw ColorStructure histogram accumulation

In the following, 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. An image in the usual sense is one in which all pixels in the rectangular array are classified as active. The dimensions of an 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 under all circumstances. In particular, passive pixels do not contribute to the accumulation of the bin values (defined below) of the CS histogram.

The accumulation of the raw Color Structure histogram is illustrated in Figure 17. Suppose that at a certain location in the image, the structuring element contains some pixels with color c_1, some pixels with color c_3 and some pixels with color c_7. Then, the bin labeled c_1, the bin labeled c_3 and the bin labeled c_7 would each be incremented once. So, in this location, the Color Structure histogram is incremented three times, once for each color present in the structuring element area.

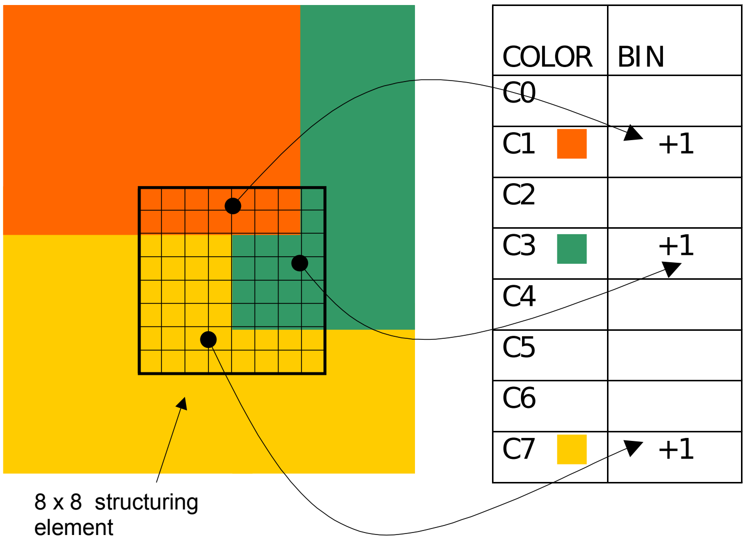
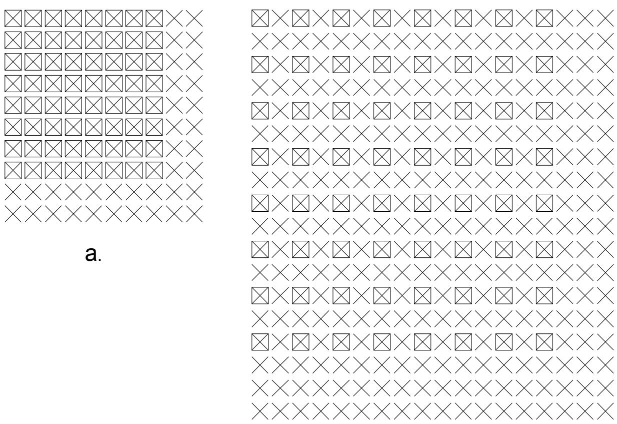


Figure 17 — Color structure histogram accumulation.

The spatial extent of the structuring element depends on the image size but the number of samples in the structuring element is held constant by subsampling the image and the structuring element at the same time. The number of samples in the structuring element is always 64, laid out in an 8x8 pattern, and the distance between two samples in this pattern increases with image size as shown in Figure 18. This method is equivalent to subsampling the image by a power of 2 and then using a structuring element of size 8x8 pixels. This can also be interpreted as resizing the image to a fixed base size and always using the same 8x8 structuring element.



a.

b.

Figure 18 — Structuring elements for images with different resolutions: a: 320x240, b: 640x480.

The subsampling factor and the structuring element width and height are defined as follows. Let E be the spatial extent of the structuring element in the original image, i.e., the spatial extent is ExE. Let K be the subsampling factor applied, i.e., K={1, 2, 4, 8, 16, …}, where K=1 implies no subsampling, K=2 implies subsampling by 2 horizontally and vertically, etc. K and E are defined as follows:

$$p = \max\{0, \mathrm{round}(0.5*\log_2(width*height)-8)\}$$
$$K = 2^p$$
$$E = 8*K$$

For example, an image of size 320x240 yields K=1 and E=8, in which case the structuring element is simply 8x8 pixels and no subsampling takes place. An image with sizes 640x480 yields K=2 and E=16, in which case the spatial extent of the structuring element is 16x16 and subsampling is 2x2, i.e. the structuring element of size 8x8 is applied to a subsampled image. Note that images smaller than 256x256 pixels are a special case in the sense that K=1 and E=8 in all cases. Images with width and/or height smaller than 8 pixels should be upsampled by the smallest power of 2 (in both directions) such that the minimum of the width and height of the resulting image is greater than or equal to 8.

Figure 18 (only a part of the images is shown) shows the structuring element in the initial location at the upper left corner of the image. The structuring element slides over the image and is shifted by one pixel in case (a) and by two pixels in case (b). Case (b) corresponds to subsampling of the image by 2 in both directions and subsequently applying the same 8x8 structuring element.

Each bin of the Color Structure descriptor $h(m)$ represents the number of locations of the structuring element at which a pixel with color c_m falls inside the element. The origin of the structure element is defined by its top-left sample. The locations of the structuring element over which the descriptor is accumulated are defined by the grid of pixels of the possibly subsampled input image.

The bin values $h(m)$ of the Color Structure descriptor are normalized by the number of positions within the (possibly subsampled) image that the structuring element can occupy if its origin is moved to every allowable location. The normalization factor is denoted by R_{max}. For example, for a 320x240 image the normalizing factor is (320-7)x(240-7). Normalized bin amplitude values lie in the range [0.0, 1.0].

6.8 GoF/GoP Color

6.8.1 Introduction

This descriptor specifies a structure required for representing the color features of a collection of (similar) images or video frames by means of the scalable color descriptor detailed in subclause 6.5. The collection of video frames can be a contiguous video segment or a non-contiguous collection of similar video frames.

6.8.2 DDL representation syntax

```
<complexType name="GoFGoPColorType" final="#all">
   <complexContent>
      <extension base="mpeg7:VisualDType">
         <sequence>
            <element name="ScalableColor" type="mpeg7:ScalableColorType"/>
         </sequence>
         <attribute name="aggregation" use="required">
            <simpleType>
               <restriction base="string">
                  <enumeration value="Average"/>
                  <enumeration value="Median"/>
                  <enumeration value="Intersection"/>
               </restriction>
            </simpleType>
         </attribute>
      </extension>
   </complexContent>
</complexType>
```

6.8.3 Binary representation syntax

GofGoPColor {	**Number of bits**	**Mnemonic**
aggregation	2	bslbf
ScalableColor	See subclause 6.5.3	ScalableColorType
}		

6.8.4 Descriptor components semantics

aggregation
This attribute specifies the kind of aggregation used, i.e. how the individual frame/picture histograms in the group are combined to obtain the group-of-frames/pictures histogram. The aggregation is performed over the histograms of the group of video frames or images, and the scalable descriptor is then computed on the aggregated histogram.

The individual histogram of a video frame or an image is an HSV color histogram based on the definition of uniform ColorQuantization descriptor with 16 bins in H, and 4 bins in each S and V (256 bins in total). The ColorQuantization of the HSV color space is the same as the one used in ScalableColor in subclause 6.5. After computing the individual frame or image histograms, one of the three types of aggregation presented below is performed. The mapping function from a histogram with bin values of 11-bit integer precision into a 4-bit representation presented in subclause 6.5 (Table 16) should be performed after the aggregation. Following this, the Haar transform is computed to obtain the ScalableColor descriptor.

The semantics of the binary representation of this attribute is specified in Table 24.

Table 24 — The meaning of aggregation.

aggregation	Meaning
00	Average
01	Median
10	Intersection
11	Reserved

The average histogram (Avg_Histogram) is computed by accumulating the frame/picture histograms in the group and subsequently normalizing each accumulated bin value by *N*, where *N* is the number of frames in the GoF or the number of pictures in the GoP. The value of bin *j* of the average histogram is computed as follows:

$$Avg\_Histogram\_value[j] = \frac{1}{N}\sum_{i=0}^{N-1} Histogram\_value_i[j];\ j = 0,...,255.$$

The median histogram (*Med_Histogram*) is obtained by constructing, for each bin, the ascending list of *N* frame/picture histogram values over the length of the GoF/GoP, and assigning the median of this list to the corresponding bin in the GoF/GoP histogram.

$$Med\_Histogram\_value[j] = \mathbf{median}(Histogram\_value_0[j],...,Histogram\_value_{N-1}[j]),\ j = 0,...,255.$$

The median histogram eliminates aberrant effects such as lighting changes, occlusion, text overlays, etc. which the average histogram is vulnerable to.

The intersection histogram (*Int_Histogram*) is obtained by computing for each bin *j* the minimum value over all the *N* frame/picture histograms in the group:

$$Int\_Histogram\_value[j] = \mathbf{min}_i(Histogram\_value_i[j]),\ j = 0,...,255.$$

For the average and median histograms, each bin of each of the *N* histograms should be normalized by the total number of pixels in the histogram before aggregation. For the intersection histogram, on the other hand, each bin should be normalized by the maximum bin value encountered before aggregation. After aggregation, the scalable color descriptor for the aggregated histogram is then computed as described in subclause 6.5.

ScalableColor
This element is specified in subclause 6.5.

7 Texture

7.1 Introduction

Pictures of water, grass, a bed of flowers, or a pattern on a fabric, contain strong examples of image texture. Many natural and man-made objects are distinguished by their texture. Texture is a region property, as is evidenced by these examples. While it is easy to visualize what one means by texture, there is no universally accepted formal definition of texture. One can think of a texture as consisting of some basic primitives (referred to as *textons*), whose spatial distribution in the image creates the appearance of a texture. The texture descriptors facilitate browsing and similarity retrieval using the texture feature in image and video databases. Note that the following texture descriptors are extracted from the luminance component only. All the texture descriptors can be extracted from arbitrarily shaped regions.

7.2 Homogeneous texture

7.2.1 Introduction

This descriptor characterizes the region texture using the energy and energy deviation in a set of frequency channels. This is applicable for similarity based search and retrieval applications.

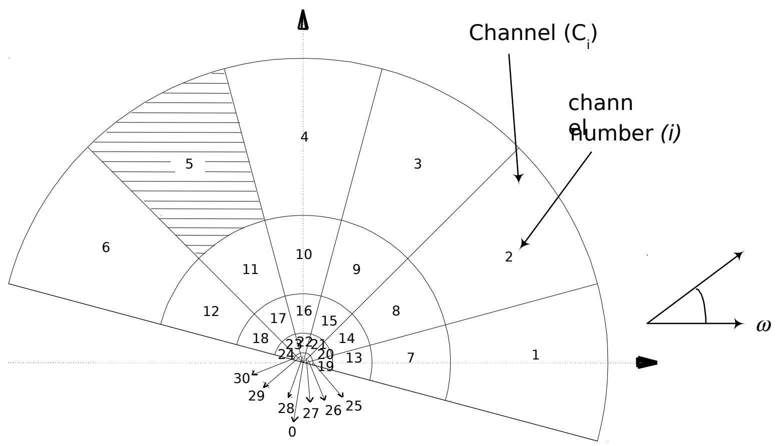


Figure 19 — Frequency layout for feature extraction.

The frequency space from which the texture features in the image are extracted is partitioned with equal angles of 30 degrees in the angular direction and with an octave division in the radial direction. The partitions in the frequency domain are called the feature channels (C_i). There are 30 feature channels as shown in Figure 19. In the normalized frequency space ($0 \leq \omega \leq 1$), the center frequencies of the feature channels are spaced equally by 30 degrees in angular direction such that $\theta_r = 30° \times r$, where *r* is angular index with $r \in \{0, 1, 2, 3, 4, 5\}$. The angular width of all feature channels is 30 degrees. In the radial direction, the center frequencies of the feature channels are spaced by an octave scale such that $\omega_s = \omega_0 \cdot 2^{-s}, s \in \{0,1,2,3,4\}$, where *s* is the radial index and ω_0 is the highest center frequency specified by ¾. The octave bandwidth of the feature channels in the radial direction is written as $B_s = B_0 \cdot 2^{-s}, s \in \{0,1,2,3,4\}$, where B_0 is the largest bandwidth specified by ½.

Each channel is numbered starting from the outermost band, from right to left, and from higher to lower frequency bands. Therefore, the feature channel indexes *i* in Figure 19 are expressed as $i = 6 \times s + r + 1$. Note that the DC term is denoted as C_0 .

On top of the feature channels, the following 2D Gabor function is applied:

$$G_{P_{s,r}}(\omega,\theta) = \exp\left[\frac{-(\omega-\omega_s)^2}{2\sigma_{\rho_s}^2}\right]\cdot\exp\left[\frac{-(\theta-\theta_r)^2}{2\sigma_{\theta_r}^2}\right], \quad [1]$$

The standard deviations of the Gabor function are determined by touching the Gabor function with its neighbor functions at half maximum (1/2) in both radial and angular directions. In the angular direction, σ_{θ_r} has a constant value of $15^\circ / \sqrt{2\ln 2}$. In the radial direction, σ_{ρ_s} depends on the octave bandwidth and is written as

$$\sigma_{\rho_s} = \frac{B_s}{2\sqrt{2\ln 2}} \quad [2]$$

The following tables show parameters in the feature channels and the Gabor functions.

Table 25 — Parameters of octave band in the radial direction.

Radial index (s)	0	1	2	3	4
Center frequency (ω_s)	$\frac{3}{4}$	$\frac{3}{8}$	$\frac{3}{16}$	$\frac{3}{32}$	$\frac{3}{64}$
Octave bandwidth (B_s)	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{16}$	$\frac{1}{32}$
σ_{ρ_s}	$\frac{1}{4\sqrt{2\ln 2}}$	$\frac{1}{8\sqrt{2\ln 2}}$	$\frac{1}{16\sqrt{2\ln 2}}$	$\frac{1}{32\sqrt{2\ln 2}}$	$\frac{1}{64\sqrt{2\ln 2}}$

Table 26 — Parameters of octave band in the angular direction.

Angular index (r)	0	1	2	3	4	5
Center frequency (θ_r)	0°	30°	60°	90°	120°	150°
Angular bandwidth	30°	30°	30°	30°	30°	30°
σ_{θ_r}	$\frac{30^\circ}{2\sqrt{2\ln 2}}$	$\frac{30^\circ}{2\sqrt{2\ln 2}}$	$\frac{30^\circ}{2\sqrt{2\ln 2}}$	$\frac{30^\circ}{2\sqrt{2\ln 2}}$	$\frac{30^\circ}{2\sqrt{2\ln 2}}$	$\frac{30^\circ}{2\sqrt{2\ln 2}}$

Based on the frequency layout and the Gabor functions, the energy e_i of the i^{th} feature channel is defined as the log-scaled sum of the square of the Gabor-filtered Fourier transform coefficients of an image:

$$e_i = \log_{10}[1 + p_i] \ , \quad [3]$$

where

$$p_i = \int_{\omega=0^+}^{1}\int_{\theta=(0^0)^+}^{360^0}[G_{P_{s,r}}(\omega,\theta)\cdot P(\omega,\theta)]^2 \ . \quad [4]$$

and $P(\omega,\theta)$ is the Fourier transform of an image represented in the polar frequency domain, i.e. $P(\omega,\theta) = F(\omega\cos\theta, \omega\sin\theta)$, where $F(x,y)$ is the Fourier transform in the Cartesian coordinate system. The integration is over the entire frequency layout (the radial direction is normalized to (0,1]) except the DC part which is represented by the "+" sign in the integral index (i.e. 0^+, $(0^0)^+$). Note that $i = 6\times s + r + 1$. The energy deviation d_i of the i^{th} feature channel is defined as the log-scaled standard deviation of the square of the Gabor-filtered Fourier transform coefficients of an image:

$$d_i = \log_{10}[1 + q_i] \ , \quad [5]$$

where

$$q_i = \sqrt{\int_{\omega=0^+}^{1} \int_{\theta=(0^0)^+}^{360^+} \left\{ \left[G_{P_{s,r}}(\omega,\theta) \cdot P(\omega,\theta) \right]^2 - p_i \right\}^2} \ . \quad [6]$$

Finally, the homogeneous texture descriptor consists of the mean and standard deviation of the image intensity, the energies e_i and (optionally) the energy deviations d_i of the feature channels.

7.2.2 DDL representation syntax

```
<complexType name=”HomogeneousTextureType” final=”#all”>
   <complexContent>
      <extension base=”mpeg7:VisualDType”>
         <sequence>
            <element name=”Average” type=”mpeg7:unsigned8”/>
            <element name=”StandardDeviation” type=”mpeg7:unsigned8”/>
            <element name=”Energy” type=”mpeg7:textureListType”/>
            <element name=”EnergyDeviation” type=”mpeg7:textureListType”
                  minOccurs=”0”/>
         </sequence>
      </extension>
   </complexContent>
</complexType>
<simpleType name="textureListType">
   <restriction>
      <simpleType>
         <list itemType="mpeg7:unsigned8"/>
      </simpleType>
      <length value="30"/>
   </restriction>
</simpleType>
```

7.2.3 Binary representation syntax

HomogeneousTexture {	**Number of bits**	**Mnemonic**
EnergyDeviationFlag	1	bslbf
Average	8	uimsbf
StandardDeviation	8	uimsbf
for(k=0; k<30; k++) {		
Energy[k]	8	uimsbf
}		
if (energyDeviationFlag) {		
for(k=0; k<30; k++) {		
EnergyDeviation[k]	8	uimsbf
}		
}		
}		

7.2.4 Descriptor components semantics

EnergyDeviationFlag
This field, which is only present in the binary representation, indicates the feature layers used for the texture description for similarity-based retrieval. The feature layers are base and enhancement layers. If the EnergyDeviationFlag is set to “0”, only a base layer consisting of the mean and standard deviation of the image intensity and energies of the 30 feature channels is used. If it is set to “1”, an enhancement layer containing additionally 30 energy deviation feature values is used.

Average
This element specifies the average image pixel intensity. Uniform quantization to 8 bits is applied with the following min/max values to obtain the representation.

Min	0
Max	255

StandardDeviation
This element specifies the standard deviation of the image pixel intensity. Uniform quantization to 8 bits is applied with the following min/max values to obtain the representation.

Min	1.31
Max	109.48

Energy
This element specifies a 1-D array that contains the energies computed from the feature channels. Since the number of feature channels is 30, the array has size 30. The elements (Energy [0], …, Energy [29]) represent energies from the 1st to the 30th feature channel accordingly. Uniform quantization to 8 bits is applied to each feature channel with the min/max values for each channel specified in Table 27.

Table 27 — Minimum and maximum energy values.

Channel	Min	Max	Channel	Min	Max	Channel	Min	Max
1	11.70	21.52	11	10.08	20.16	21	7.59	18.68
2	11.69	19.95	12	10.43	20.28	22	6.75	19.79
3	11.90	20.38	13	8.30	20.82	23	7.80	18.71
4	12.00	22.13	14	8.07	19.09	24	7.64	18.88
5	12.00	20.18	15	7.96	20.84	25	6.55	18.39
6	11.94	20.00	16	7.94	20.49	26	8.89	18.01
7	9.93	22.30	17	8.52	20.76	27	8.89	18.00
8	9.73	20.32	18	8.67	19.26	28	6.16	18.08
9	9.73	20.66	19	7.00	19.37	29	8.81	18.05
10	9.80	21.46	20	7.86	18.63	30	8.89	17.96

EnergyDeviation
This element specifies a 1-D array that contains the energy deviations computed from the feature channels. Since the number of feature channels is 30, the array has size 30. The elements (EnergyDeviation[0], …, EnergyDeviation[29]) represent energy deviations from the 1st to the 30th feature channel accordingly. Uniform quantization to 8 bits is applied to each feature channel with the min/max values for each channel specified in Table 28

Table 28 — Minimum and maximum energy deviation values.

Channel	Min	Max	Channel	Min	Max	Channel	Min	Max
1	13.30	24.69	11	11.90	22.33	21	10.07	21.28
2	13.31	22.98	12	12.25	22.23	22	8.91	22.62
3	13.45	23.89	13	10.39	24.32	23	10.29	21.77
4	13.61	25.24	14	10.20	21.62	24	10.15	21.70
5	13.55	24.28	15	10.21	24.40	25	9.05	21.10
6	13.44	22.70	16	10.11	23.80	26	11.75	20.75
7	11.74	25.64	17	10.65	24.33	27	11.78	20.79
8	11.56	24.10	18	10.80	21.69	28	8.65	20.85
9	11.55	22.69	19	9.28	22.66	29	11.67	20.77
10	11.61	25.22	20	10.39	21.33	30	11.74	20.75

7.3 Texture browsing

7.3.1 Introduction

This descriptor specifies the perceptual characterization of a texture, which is similar to a human characterization, in terms of regularity, coarseness and directionality. This representation is useful for browsing applications and coarse classification of textures.

7.3.2 DDL representation syntax

```
<complexType name="TextureBrowsingType" final="#all">
   <complexContent>
      <extension base="mpeg7:VisualDType">
         <sequence>
            <element name="Regularity">
               <simpleType>
                  <restriction base="string">
                     <enumeration value="irregular"/>
                     <enumeration value="slightlyRegular"/>
                     <enumeration value="regular"/>
                     <enumeration value="highlyRegular"/>
                  </restriction>
               </simpleType>
            </element>
            <sequence minOccurs="1" maxOccurs="2">
               <element name="Direction">
                  <simpleType>
                     <restriction base="string">
                        <enumeration value="noDirectionality"/>
                        <enumeration value="0Degree"/>
                        <enumeration value="30Degree"/>
                        <enumeration value="60Degree"/>
                        <enumeration value="90Degree"/>
                        <enumeration value="120Degree"/>
                        <enumeration value="150Degree"/>
                     </restriction>
                  </simpleType>
               </element>
               <element name="Scale">
                  <simpleType>
                     <restriction base="string">
                        <enumeration value="fine"/>
                        <enumeration value="medium"/>
                        <enumeration value="coarse"/>
                        <enumeration value="veryCoarse"/>
                     </restriction>
                  </simpleType>
               </element>
            </sequence>
         </sequence>
      </extension>
   </complexContent>
</complexType>
```

7.3.3 Binary representation syntax

TextureBrowsing {	**Number of bits**	**Mnemonic**
NumOfComponentsFlag	1	bslbf
Regularity	2	bslbf
for(k=0; k<=NumOfComponents; k++) {		
Direction	3	bslbf
Scale	2	bslbf
}		
}		

7.3.4 Descriptor components semantics

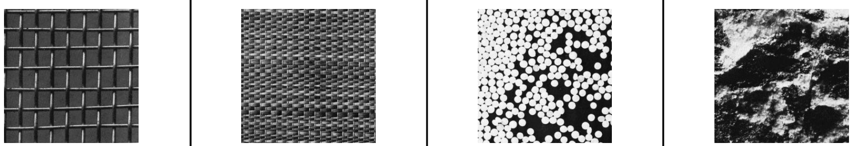
NumOfComponents

This field, which is only present in the binary representation, specifies the number of components in the descriptor. If it is 0 then one Direction element and one corresponding Scale element is present and NumOfComponents in the binary representation is 1, otherwise two of each are present and NumOfComponents in the binary representation is 2.

Regularity
This element specifies the periodicity of the underlying basic texture elements (textons). The mapping between binary representation and semantics is provided in Table 29 and image examples are provided in Figure 20.

Table 29 — Semantics of Regularity.

Regularity	Semantics
00	irregular
01	slightly regular
10	regular
11	highly regular



Regularity	11	10	01	00

Figure 20 — Examples of Regularity.

Direction
This element specifies the dominant direction(s) characterizing the texture directionality. 0 corresponds to a texture where no such direction can be assigned. Values between 1 and 6 indicate directions in steps of 30 degrees starting from 0, i.e. 0, 30, 60, 90, 120, 150 respectively as specified in Table 30.

Table 30 — Semantics of Direction.

Direction	Semantics
000	no directionality
001	0 degree
010	30 degree
011	60 degree
100	90 degree
101	120 degree
110	150 degree
111	Reserved

Scale
This element specifies the coarseness of the texture associated with the corresponding dominant orientation(s) specified in the Direction element. The lower the value of Scale, the less coarse the pattern is. It is extracted based on the frequency layout described in Figure 19. Note that logarithmic scaling is used. Table 31 specifies the semantics and the corresponding (approximate) scale *s* in the frequency layout.

Table 31 — Semantics of Scale.

Scale	Semantics
00	fine (0)
01	medium (1)
10	coarse (2)
11	very coarse (3,4)

7.4 Edge histogram

7.4.1 Introduction

This descriptor specifies the spatial distribution of five types of edges in local image regions. As shown in Figure 21, there are four directional edges and one non-directional edge in each local region called a *sub-image*. The *sub-image* is a part of the original image and each *sub-image* is defined by dividing the image space into 4x4 non-overlapping blocks as shown in Figure 22. More specifically, there are 16 non-overlapping *sub-images* as shown in Figure 22 and for each *sub-image* we generate a local edge histogram with 5 bins. Since there are five types of edges for each *sub-image*, we have a total of 16*5=80 histogram bins. As shown in Figure 22, by further dividing the *sub-image* into *image-blocks*, edge type information can be extracted from the *image-block*.

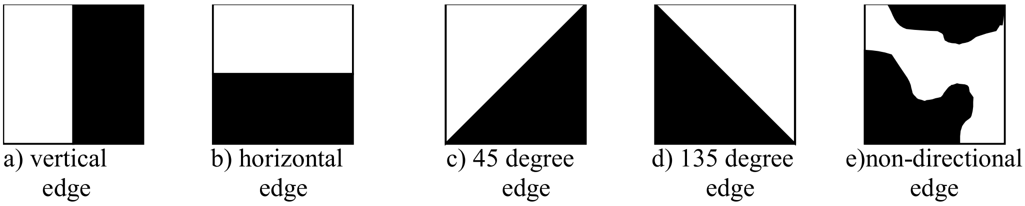


Figure 21 — Five types of edges.

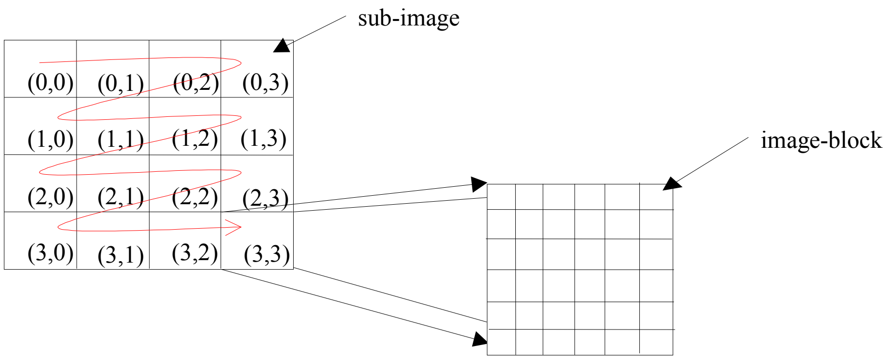


Figure 22 — Definition of sub-image and image-block.

7.4.2 DDL representation syntax

```
<complexType name=”EdgeHistogramType” final=”#all”>
   <complexContent>
      <extension base=”mpeg7:VisualDType”>
         <sequence>
            <element name=”BinCounts”>
               <simpleType>
                  <restriction>
                     <simpleType>
                        <list itemType=”mpeg7:unsigned3”/>
                     </simpleType>
                     <length value=”80”/>
                  </restriction>
               </simpleType>
            </element>
         </sequence>
      </extension>
   </complexContent>
</complexType>
```

7.4.3 Binary representation syntax

EdgeHistogram {	**Number of bits**	**Mnemonic**
for(k=0; k<80; k++) {		
BinCounts[k]	3	uimsbf
}		
}		

7.4.4 Descriptor components semantics

BinCounts
This element specifies the number of occurrences of each edge type in each sub-image. The local edge histogram represents the distribution of 5 types of edges in a local area called a sub-image. Since the number of sub-images is fixed to 16 and each sub-image generates 5 histogram bins, we have 80 histogram bins. By visiting the sub-images in raster scan order as shown in Figure 22, the semantics of each bin of BinCounts is defined as shown in Table 32.

Table 32 — Semantics of BinCounts.

BinCounts[k]	Semantics
BinCounts[0]	Vertical edges in sub-image (0,0)
BinCounts[1]	Horizontal edges in sub-image (0,0)
BinCounts[2]	45 degree edges in sub-image (0,0)
BinCounts[3]	135 degree edges in sub-image (0,0)
BinCounts[4]	Non-directional edges in sub-image (0,0)
BinCounts[5]	Vertical edges in sub-image (0,1)
•	•
BinCounts[74]	Non-directional edges in sub-image (3,2)
BinCounts[75]	Vertical edges in sub-image (3,3)
BinCounts[76]	Horizontal edges in sub-image (3,3)
BinCounts[77]	45 degree edges in sub-image (3,3)
BinCounts[78]	135 degree edges in sub-image (3,3)
BinCounts[79]	Non-directional edges in sub-image (3,3)

The value for each histogram bin in Table 32 is related to the total number of image blocks with the corresponding edge type for each sub-image. These bin values are normalized by the total number of image blocks in the sub-image and are non-linearly quantized by quantization tables. Five quantization tables for five different edge types are listed in Table 33, Table 34, Table 35, Table 36, and Table 37. Since 3 bits/bin are used, each quantization table has 8 levels.

Table 33 — Quantization table for vertical bins.

BinCounts	**Reconstruction value**
000	0.010867
001	0.057915
010	0.099526
011	0.144849
100	0.195573
101	0.260504
110	0.358031
111	0.530128

Table 34 — Quantization table for horizontal bins.

BinCounts	**Reconstruction value**
000	0.012266
001	0.069934
010	0.125879
011	0.182307
100	0.243396
101	0.314563
110	0.411728

111	0.564319

Table 35 — Quantization table for 45 degree bins.

BinCounts	Reconstruction value
000	0.004193
001	0.025852
010	0.046860
011	0.068519
100	0.093286
101	0.123490
110	0.161505
111	0.228960

Table 36 — Quantization table for 135 degree bins.

BinCounts	Reconstruction value
000	0.004174
001	0.025924
010	0.046232
011	0.067163
100	0.089655
101	0.115391
110	0.151904
111	0.217745

Table 37 — Quantization table for non-directional bins.

BinCounts	Reconstruction value
000	0.006778
001	0.051667
010	0.108650
011	0.166257
100	0.224226
101	0.285691
110	0.356375
111	0.450972

8 Shape

8.1.1 Introduction

Shape features relate to spatial arrangement of points (pixels) belonging to an object or a region. Shape descriptors can be divided into two broad classes: 2-dimensional (2D) and 3-dimensional (3D).

Two descriptors characterize the different shape features of a 2D object or region. The Region Shape descriptor captures the distribution of all pixels within a region. The Contour Shape descriptor characterizes the shape properties of a contour of an object.

The shape of a 3D object can be characterized in two ways. The Shape3D descriptor provides an intrinsic shape characterization of 3D mesh models. Alternatively, the MultipleView descriptor combined with a 2D shape descriptor can be used. The MultipleView representation is convenient when the 3D mesh model of the object is not known or when support for queries by 2D views of the 3D object is required.

8.2 Region shape

8.2.1 Introduction

This descriptor specifies the region-based shape of an object. The shape of an object may consist of either a single region or a set of regions, as well as some holes in the object as illustrated in Figure 23(c). Since the region-based shape descriptor makes use of all pixels constituting the shape, it can describe any shape, i.e. not only a simple shape with a single connected region but also a complex shape that consists of several disjoint regions as illustrated in Figure 23(d) and (e).

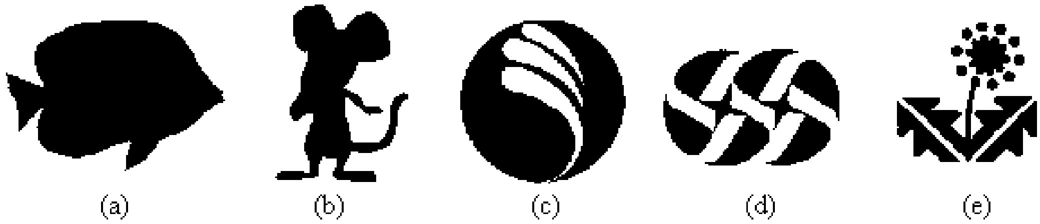


Figure 23 — Examples of various shapes.

The region-based shape descriptor utilizes a set of ART (Angular Radial Transform) coefficients. The ART is a 2-D complex transform defined on a unit disk in polar coordinates,

$$F_{nm} = \langle V_{nm}(\rho,\theta), f(\rho,\theta)\rangle = \int_0^{2\pi}\int_0^1 V_{nm}^{*}(\rho,\theta), f(\rho,\theta)\rho d\rho d\theta.$$

Here, F_{nm} is an ART coefficient of order n and m, $f(\rho,\theta)$ is an image function in polar coordinates, and $V_{nm}(\rho,\theta)$ is the ART basis function. The ART basis functions are separable along the angular and radial directions, i.e.,

$$V_{nm}(\rho,\theta) = A_m(\theta)R_n(\rho) .$$

The angular and radial basis functions are defined as follows:

$$A_m(\theta) = \frac{1}{2\pi}\exp(jm\theta) ,$$

$$R_n(\rho) = \begin{cases} 1 & n = 0 \\ 2\cos(\pi n\rho) & n \neq 0 \end{cases} .$$

Twelve angular and three radial functions are used.

Figure 24 shows the real parts of the 2-D basis functions whose origins are at the centers of each image. The imaginary parts have similar shape to the corresponding real parts but with different phases. Note that the brighter the region, the higher the value.

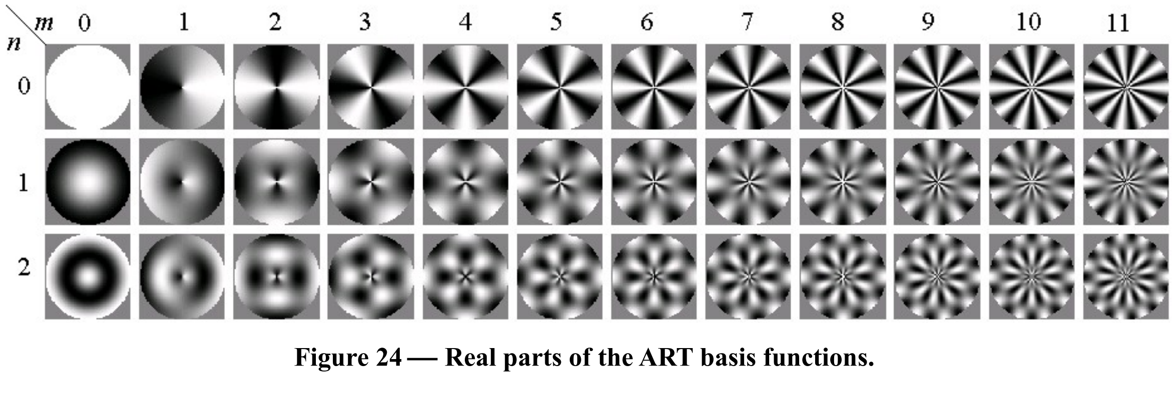


Figure 24 — Real parts of the ART basis functions.

8.2.2 DDL representation syntax

```
<complexType name="RegionShapeType" final="#all">
   <complexContent>
      <extension base="mpeg7:VisualDType">
         <sequence>
            <element name="MagnitudeOfART">
               <simpleType>
                  <restriction>
                     <simpleType>
```



```
                    <list itemType="mpeg7:unsigned4"/>
                  </simpleType>
                  <length value="35"/>
                </restriction>
              </simpleType>
            </element>
          </sequence>
        </extension>
      </complexContent>
</complexType>
```

8.2.3 Binary representation syntax

RegionShape {	**Number of bits**	**Mnemonic**
for(k=0; k<35; k++) {		
MagnitudeOfART[k]	4	uimsbf
}		
}		

8.2.4 Descriptor components semantics

MagnitudeOfART
This element specifies an array of 35 normalized and quantized magnitudes of the shape coefficients. The normalization is performed by dividing each of them by the magnitude of the largest coefficient. The relationship between the order of k and the order of radial and angular indices (n,m) is as follows:

k	0	1	2	3	4	…	30	31	32	33	34
n	1	2	0	1	2	…	1	2	0	1	2
m	0	0	1	1	1	…	10	10	11	11	11

The reconstruction values for dequantization of ART coefficients (inverse quantization table) are listed in Table 38.

Table 38 — Reconstruction value for ART coefficients.

ArtDE	Reconstruction value
0000	0.001763817
0001	0.005468893
0010	0.009438835
0011	0.013714449
0100	0.018346760
0101	0.023400748
0110	0.028960940
0111	0.035140141
1000	0.042093649
1001	0.050043696
1010	0.059324478
1011	0.070472849
1100	0.084434761
1101	0.103127662
1110	0.131506859
1111	0.192540857

8.3 Contour shape

8.3.1 Introduction

This descriptor specifies a closed contour of a 2D object or region in an image or video sequence (see Figure 25).

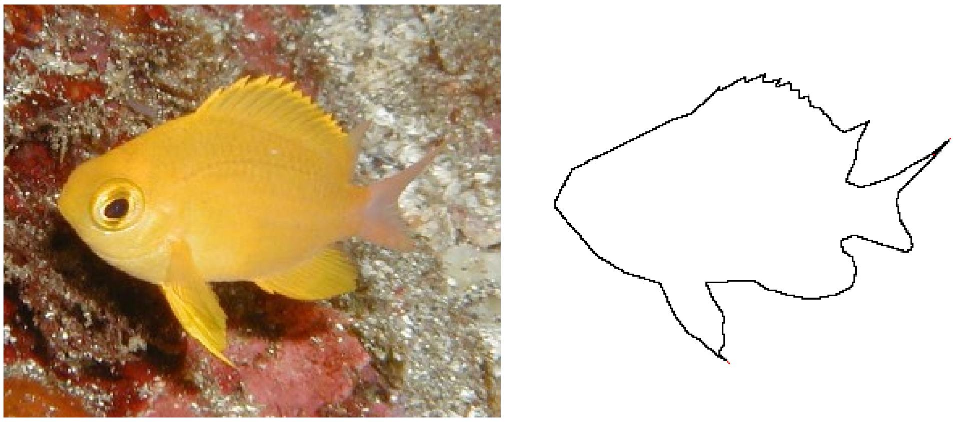


Figure 25 — A 2D visual object (region) and its corresponding shape

The object contour-based shape descriptor is based on the Curvature Scale Space (CSS) representation of the contour. This representation of contour shape is very compact, below 14 bytes in size on average.

In order to create a CSS description of a contour shape, *Nsamples* equidistant points are selected on the contour, starting from an arbitrary point on the contour and following the contour clockwise. The x-coordinates of the selected *Nsamples* points are grouped together and the y-coordinates are also grouped together into two series X, Y. The contour is then gradually smoothed by repetitive application of a low-pass filter with the kernel (0.25,0.5,0.25) to X and Y coordinates of the selected *Nsamples* equidistant contour points. As a result of the smoothing, the contour evolves and its concave parts gradually flatten-out, until the contour becomes convex. The filtering process is terminated when the contour becomes convex. A so-called CSS image can be associated with the contour evolution process. Figure 26 shows the evolution of a contour and the associated CSS image. The CSS image does not have to be explicitly extracted, but is useful to illustrate the CSS representation. It is a binary image in which horizontal coordinates (*x_css*) correspond to the indices of the contour points selected to represent the contour (1,…,*Nsamples*), and vertical-coordinates (*y_css*) correspond to the amount of filtering applied, defined as the number of passes of the filter. The CSS image is made up of horizontal lines, a line defined by *y_css=k* is computed from the smoothed contour resulting from *k*-passes of the filter. For each smoothed contour, the zero-crossings of its curvature function are computed. Contour curvature function zero-crossing points separate concave and convex parts of the contour. Each zero-crossing is marked on the horizontal line corresponding to the smoothed contour (*y_css=k*) and at the *x_css* location corresponding to the position of this zero-crossing along the contour. The CSS image has characteristic peaks. The coordinate values of the prominent peaks (*x_css*, *y_css*) in the CSS image are extracted. The peaks are ordered based on decreasing values of *y_css*, transformed using a non-linear transformation and quantized. In addition, the eccentricity and circularity of the contour are also calculated, quantized and stored.

In Figure 26, the left column shows the original contour and the contour at two different stages of the smoothing evolution process, after 20 and 80 passes of the filter. In the right column, the CSS image obtained from the evolution is shown. The contour smoothed by 20 passes of the filter has 8 curvature zero crossings (A, B, …, H), and these points are used to “construct” the CSS image at horizontal line *y_css=20*. The peaks in the CSS representation are shown in the figure.

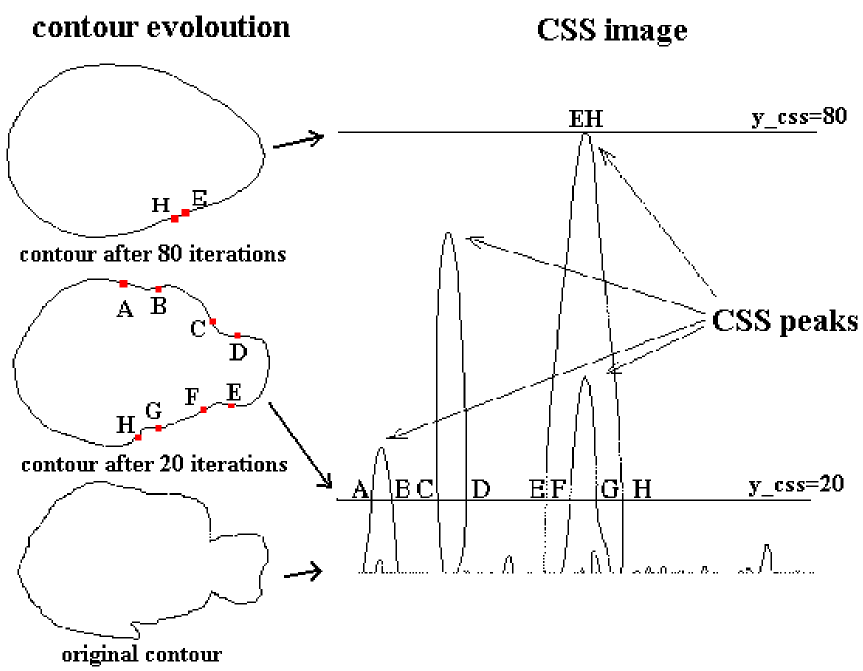


Figure 26 — CSS Image Formation.

8.3.2 DDL representation syntax

```
<complexType name="ContourShapeType" final="#all">
   <complexContent>
      <extension base="mpeg7:VisualDType">
         <sequence>
            <element name="GlobalCurvature"
                  type="mpeg7:curvatureType"/>
            <element name="PrototypeCurvature"
                  type="mpeg7:curvatureType" minOccurs="0"/>
            <element name="HighestPeakY" type="mpeg7:unsigned7"/>
            <element name="Peak" maxOccurs="62">
               <complexType>
                  <attribute name="peakX" type="mpeg7:unsigned6"/>
                  <attribute name="peakY" type="mpeg7:unsigned3"/>
               </complexType>
            </element>
         </sequence>
      </extension>
   </complexContent>
</complexType>
<simpleType name="curvatureType">
   <restriction>
      <simpleType>
         <list itemType="mpeg7:unsigned6"/>
      </simpleType>
      <length value="2"/> </restriction>
</simpleType>
```

8.3.3 Binary representation syntax

ContourShape {	**Number of bits**	**Mnemonic**
NumOfPeaks	6	uimsbf
GlobalCurvature	2*6	uimsbf
if (NumOfPeaks != 0) {		
PrototypeCurvature	2*6	uimsbf
}		
HighestPeakY	7	uimsbf
for (k=1; k<NumOfPeaks; k++) {		
peakX[k]	6	uimsbf
peakY[k]	3	uimsbf
}		
}		

8.3.4 Descriptor components semantics

NumOfPeaks
This field, which is only present in the binary representation, specifies the number of peaks in the CSS image used for the shape definition. For convex contours, there are no peaks in the CSS image and this attribute takes value 0.

GlobalCurvature
This element is a two-dimensional vector that specifies global parameters of the contour, namely the Eccentricity and Circularity.

- The calculation of Circularity is as follows:

$$circularity = \frac{perimeter^2}{area}.$$

For example, a circle has Circularity of

$$circularity_{circle} = \frac{(2\pi r)^2}{\pi r^2} = 4\pi.$$

GlobalCurvature[0] is obtained by uniformly quantizing the *circularity* to 6 bits in the range [12-110]. If the *circularity* value calculated is above 110, the value is clipped to 110.

- The calculation of Eccentricity is as follows:

$$i_{02} = \sum_{k=1}^{N} (y_k - y_c)^2$$

$$i_{11} = \sum_{k=1}^{N} (x_k - x_c)(y_k - y_c)$$

$$i_{20} = \sum_{k=1}^{N} (x_k - x_c)^2$$

where N is the number of points inside the contour shape, and (x_c,y_c) is the center of mass of the shape. From these equations, we then calculate the Eccentricity as:

$$eccentricity = \sqrt{\frac{i_{20} + i_{02} + \sqrt{i_{20}^2 + i_{02}^2 - 2i_{20}i_{02} + 4i_{11}^2}}{i_{20} + i_{02} - \sqrt{i_{20}^2 + i_{02}^2 - 2i_{20}i_{02} + 4i_{11}^2}}}$$

GlobalCurvature[1] is obtained by uniformly quantizing *eccentricity* to 6 bits in the range [1-10]. If the *eccentricity* value calculated is above 10, the value is clipped to 10.

PrototypeCurvature
This element is a two-dimensional vector that specifies the eccentricity and circularity of the so-called prototype contour. The prototype contour is defined as the curve smoothed by means of filtering until it becomes convex. A convex contour can be obtained by smoothing of the original contour by means of repetitive application of the normative filter, where the number of filter passes corresponds to the highest peak. Circularity and eccentricity are calculated from the convex contour and represented (quantized) in the same way as for the GlobalCurvature.

HighestPeakY
This element specifies the parameters of the filter corresponding to the highest peak (highest peak height). It is calculated using the following formula:

$$ypeak[0] = 3.8 * \left(\frac{y\_css[0]}{Nsamples^2} \right)^{0.6},$$

where *y_css[0]* is the number of passes of the binomial filter with the kernel (0.25,0.50,0.25) corresponding to the highest peak and *Nsamples* is the number of the equidistant points on the contour which were used as input to the filtering process. HighestPeakY is obtained by uniformly quantizing ypeak[0] to 7 bits in the range [0-1.7].

PeakX[k], **PeakY[k]**
These elements specify the parameters of the remaining prominent peaks (0<k<63). As a non-normative guidance, a peak can be considered prominent if its height after transformation is greater than *0.05*ypeak[0]*. The peaks are oriented in the decreasing order of the peak height component values. The precise semantics is as follows.

xpeak[k] is the normalized distance along the contour between two points on the contour P[0] and P[k], where point P[0] corresponds to the position on the contour of the highest peak and P[k] corresponds to the position of the k-th peak. The distance on the contour between P[0] and P[k] is measured clockwise and is normalized by the length of the contour. PeakX[k] is obtained by uniformly quantizing the normalized distance in the range [0-1] to 6 bits.

ypeak[k] represents the transformed height of the k-th peak. It is calculated using the following formula:

$$ypeak[k] = 3.8 * \left(\frac{y\_css[k]}{Nsamples^2} \right)^{0.6},$$

where *y_css[k]* is the number of passes of the binomial filter with the kernel (0.25, 0.5, 0.25) corresponding to the k-th peak, and *Nsamples* is the number of the equidistant points on the contour which were used as input to the filtering process. PeakY[k] is obtained by uniformly quantizing ypeak[k] in the range *[0, ypeak[k-1]]* to 3 bits.

8.4 Shape 3D

8.4.1 Introduction

This descriptor specifies an intrinsic shape description for 3D mesh models. It exploits some local attributes of the 3D surface.

The shape index, introduced by Koenderink, is defined as a function of the two principal curvatures. Let p be a point on the 3D surface. Let us denote by $\mathbf{k}_p^1$ and $\mathbf{k}_p^2$ the principal curvatures associated with point p. The shape index at point p, denoted by I_p, is defined as:

$$I_p = \frac{1}{2} - \frac{1}{\pi} \arctan \frac{k_p^1 + k_p^2}{k_p^1 - k_p^2}, \text{ with } \mathrm{k}_p^1 \geq \mathrm{k}_p^2 .$$

By definition, the shape index value is in the interval [0,1] and is not defined for planar surfaces. The shape spectrum of the 3D mesh is the histogram of the shape indices (I_p's) calculated over the entire mesh.

8.4.2 DDL representation syntax

```
<complexType name="Shape3DType" final="#all">
   <complexContent>
      <extension base="mpeg7:VisualDType">
```

```
         <sequence>
            <element name=”Spectrum”>
               <simpleType>
                  <restriction>
                     <simpleType>
                        <list itemType=”mpeg7:unsigned12”/>
                     </simpleType>
                     <maxLength value=”255”/>
                  </restriction>
               </simpleType>
            </element>
            <element name=”PlanarSurfaces” type=”mpeg7:unsigned12”/>
            <element name=”SingularSurfaces” type=”mpeg7:unsigned12”/>
         </sequence>
         <attribute name=”bitsPerBin” type=”mpeg7:unsigned4”
               use=”optional” default=”12”/>
      </extension>
   </complexContent>
</complexType>
```

8.4.3 Binary representation syntax

Shape3D {	**Number of bits**	**Mnemonic**
NumOfBins	8	uimsbf
bitsPerBin	4	uimsbf
for(k=0; k<NumOfBins; k++) {		
Spectrum[k]	1-12	uimsbf
}		
PlanarSurfaces	1-12	uimsbf
SingularSurfaces	1-12	uimsbf
}		

8.4.4 Descriptor components semantics

NumOfBins
This field, which is only present in the binary representation, specifies the number of bins of the Shape3D descriptor representation. The recommended value is 100 bins.

bitsPerBin
This attribute specifies the number of bits used for uniform quantization of the descriptor values. The recommended value is 12. The code “0000” and “1101” to “1111” are forbidden.

Spectrum
This element specifies the values of the 3D shape spectrum. Spectrum[k] contains the relative area of all the 3D mesh surface regions for which the shape index is in the interval [k/NumOfBins, (k+1)/NumOfBins) quantized uniformly to bitsPerBin bits.

PlanarSurfaces
This element specifies the relative area of planar surface regions of the mesh, with respect to the entire area of the 3D mesh. It is expressed as a ratio in the range between 0 and 1 with uniform quantization to bitsPerBin bits.

SingularSurfaces
This element specifies the relative area of all the singular polygonal components, with respect to the entire area of the 3D mesh. A face is said to be singular if reliable estimation of the descriptor is not possible (border polygons). It is expressed as a ratio in the range between 0 and 1 with uniform quantization to bitsPerBin bits.

9 Motion

9.1 Introduction

Motion in a sequence of 2D images can be induced by camera motion, one or several objects moving in the scene, or both. Four descriptors characterize various aspects of motion. The Camera Motion descriptor specifies a set of basic camera operations such as, for example, panning and tilting. Motion of a key point (pixel) from a moving object or region can be characterized by the Motion Trajectory descriptor. The Parametric Motion descriptor characterizes an evolution of an arbitrarily shaped region over time in terms of a 2D geometric transformation. Finally, the Motion Activity descriptor captures the pace of the motion in the sequence, as perceived by the viewer.

All motion descriptors with the exception of the Camera Motion descriptor can be applied to arbitrarily shaped regions.

9.2 Camera motion

9.2.1 Introduction

This descriptor specifies 3-D camera motion parameters. It is based on 3-D camera motion parameter information, which can be automatically extracted or generated by capture devices.

The camera motion descriptor supports the following well-known basic camera operations (see Figure 27): fixed, panning (horizontal rotation), tracking (horizontal transverse movement, also called traveling in the film industry), tilting (vertical rotation), booming (vertical transverse movement), zooming (change of the focal length), dollying (translation along the optical axis), and rolling (rotation around the optical axis).

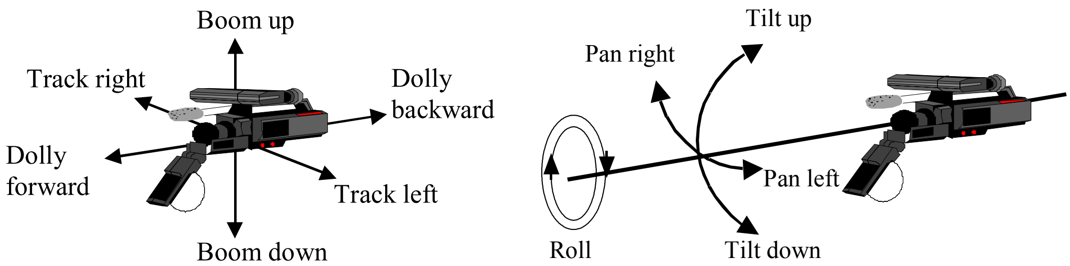


Figure 27 — (a) Camera track, boom, and dolly motion modes, (b) Camera pan, tilt and roll motion modes.

The sub-shots for which all frames are characterized by a particular type of camera motion, which can be single or mixed, determine the building blocks for the camera motion descriptor. Each building block is described by its start time, the duration, the speed of the induced image motion, the fraction of time of its duration compared with a given temporal window size, and the focus-of-expansion (FOE) (focus-of-contraction – FOC). The Descriptor represents the union of these building blocks, and it has the option of describing the mixture or non-mixture of different camera motion types.

The mixture mode captures global information about the camera motion parameters, disregarding detailed temporal information, by jointly describing multiple motion types, even if these motion types occur simultaneously. On the other hand, the non-mixture mode captures the notion of pure motion types and their union within a certain time interval. The situations where multiple motion types occur simultaneously are described as a union of the description of pure motion types. In this mode of description, the time window of a particular elementary segment can overlap with the time window of another elementary segment.

9.2.2 DDL representation syntax

```
<complexType name="CameraMotionType" final="#all">
   <complexContent>
      <extension base="mpeg7:VisualDType">
         <sequence>
            <element name="Segment" type="mpeg7:CameraMotionSegmentType"
                  minOccurs="0" maxOccurs="unbounded"/>
         </sequence>
      </extension>
   </complexContent>
```



```
</complexType>
<complexType name="CameraMotionSegmentType" abstract="true">
   <sequence>
      <element name="MediaTime" type="mpeg7:MediaTimeType"/>
      <element name="FocusOfExpansion" type="mpeg7:FocusOfExpansionType"
            minOccurs="0"/>
   </sequence>
</complexType>
<complexType name="MixtureCameraMotionSegmentType" final="#all">
   <complexContent>
      <extension base="mpeg7:CameraMotionSegmentType">
         <sequence>
            <element name="FractionalPresence"
                  type="mpeg7:FractionalPresenceType"/>
            <element name="AmountOfMotion"
                  type="mpeg7:MixtureAmountOfMotionType"/>
         </sequence>
      </extension>
   </complexContent>
</complexType>
<complexType name="NonMixtureCameraMotionSegmentType">
   <complexContent>
      <extension base="mpeg7:CameraMotionSegmentType">
         <sequence>
            <element name="AmountOfMotion"
                  type="mpeg7:NonMixtureAmountOfMotionType"/>
         </sequence>
      </extension>
   </complexContent>
</complexType>
<complexType name="FocusOfExpansionType">
   <sequence>
      <element name="HorizontalPosition" type="float"/>
      <element name="VerticalPosition" type="float"/>
   </sequence>
</complexType>
<complexType name="FractionalPresenceType" final="#all">
   <sequence>
      <element name="TrackLeft" type="mpeg7:unsigned7" minOccurs="0"/>
      <element name="TrackRight" type="mpeg7:unsigned7" minOccurs="0"/>
      <element name="BoomDown" type="mpeg7:unsigned7" minOccurs="0"/>
      <element name="BoomUp" type="mpeg7:unsigned7" minOccurs="0"/>
      <element name="DollyForward" type="mpeg7:unsigned7" minOccurs="0"/>
      <element name="DollyBackward" type="mpeg7:unsigned7" minOccurs="0"/>
      <element name="PanLeft" type="mpeg7:unsigned7" minOccurs="0"/>
      <element name="PanRight" type="mpeg7:unsigned7" minOccurs="0"/>
      <element name="TiltDown" type="mpeg7:unsigned7" minOccurs="0"/>
      <element name="TiltUp" type="mpeg7:unsigned7" minOccurs="0"/>
      <element name="RollClockwise" type="mpeg7:unsigned7" minOccurs="0"/>
      <element name="RollAnticlockwise" type="mpeg7:unsigned7"
            minOccurs="0"/>
      <element name="ZoomIn" type="mpeg7:unsigned7" minOccurs="0"/>
      <element name="ZoomOut" type="mpeg7:unsigned7" minOccurs="0"/>
      <element name="Fixed" type="mpeg7:unsigned7" minOccurs="0"/>
   </sequence>
</complexType>
<complexType name="MixtureAmountOfMotionType" final="#all">
   <sequence>
      <element name="TrackLeft" type="mpeg7:unsigned11" minOccurs="0"/>
      <element name="TrackRight" type="mpeg7:unsigned11" minOccurs="0"/>
      <element name="BoomDown" type="mpeg7:unsigned11" minOccurs="0"/>
```



```
      <element name="BoomUp" type="mpeg7:unsigned11" minOccurs="0"/>
      <element name="DollyForward" type="mpeg7:unsigned11" minOccurs="0"/>
      <element name="DollyBackward" type="mpeg7:unsigned11" minOccurs="0"/>
      <element name="PanLeft" type="mpeg7:unsigned11" minOccurs="0"/>
      <element name="PanRight" type="mpeg7:unsigned11" minOccurs="0"/>
      <element name="TiltDown" type="mpeg7:unsigned11" minOccurs="0"/>
      <element name="TiltUp" type="mpeg7:unsigned11" minOccurs="0"/>
      <element name="RollClockwise" type="mpeg7:unsigned11" minOccurs="0"/>
      <element name="RollAnticlockwise" type="mpeg7:unsigned11"
            minOccurs="0"/>
      <element name="ZoomIn" type="mpeg7:unsigned11" minOccurs="0"/>
      <element name="ZoomOut" type="mpeg7:unsigned11" minOccurs="0"/>
   </sequence>
</complexType>
<complexType name="NonMixtureAmountOfMotionType">
   <choice>
      <element name="TrackLeft" type="mpeg7:unsigned11"/>
      <element name="TrackRight" type="mpeg7:unsigned11"/>
      <element name="BoomDown" type="mpeg7:unsigned11"/>
      <element name="BoomUp" type="mpeg7:unsigned11"/>
      <element name="DollyForward" type="mpeg7:unsigned11"/>
      <element name="DollyBackward" type="mpeg7:unsigned11"/>
      <element name="PanLeft" type="mpeg7:unsigned11"/>
      <element name="PanRight" type="mpeg7:unsigned11"/>
      <element name="TiltDown" type="mpeg7:unsigned11"/>
      <element name="TiltUp" type="mpeg7:unsigned11"/>
      <element name="RollClockwise" type="mpeg7:unsigned11"/>
      <element name="RollAnticlockwise" type="mpeg7:unsigned11"/>
      <element name="ZoomIn" type="mpeg7:unsigned11"/>
      <element name="ZoomOut" type="mpeg7:unsigned11"/>
      <element name="Fixed">
         <complexType/>
      </element>
   </choice>
</complexType>
```

9.2.3 Binary representation syntax

CameraMotion {	**Number of bits**	**Mnemonic**
LoopSegments		vluimsbf5
for(k=0;k<loopSegments;k++) {		
Segment[k]		CameraMotionType_Polymorphism
}		
}		
CameraMotionType_Polymorphism {		
XsiTypeID	1	bslbf
if(!XsiTypeID) {		
CONTENTMODEL		MixtureCameraMotionSegmentType
}		
else if(XsiTypeID) {		
CONTENTMODEL		NonMixtureCameraMotionSegmentType
}		
}		
MixtureCameraMotionSegmentType {		
MediaTime	See annex B	MediaTimeType
FlagFOE	1	bslbf
if(FlagFOE) {		
FocusOfExpansion		FocusOfExpansionType
}		
FractionalPresence		FractionalPresenceType
AmountOfMotion		MixtureAmountOfMotionType
}		
NonMixtureCameraMotionSegmentType {		
MediaTime	See annex B	MediaTimeType
FlagFOE	1	bslbf
if(FlagFOE) {		
FocusOfExpansion		FocusOfExpansionType
}		
AmountOfMotion		NonMixtureAmountOfMotionType
}		
FocusOfExpansionType {		
HorizontalPosition	32	fsbf
VerticalPosition	32	fsbf
}		
FractionalPresenceType {		
FlagFP_TL	1	bslbf
if(FlagFP_TL) {		
TrackLeft	7	uimsbf
}		
FlagFP_TR	1	bslbf
if(FlagFP_TR) {		
TrackRight	7	uimsbf
}		

FlagFP_BD	1	bslbf
if(FlagFP_BD) {		
BoomDown	7	uimsbf
}		
FlagFP_BU	1	bslbf
if(FlagFP_BU) {		
BoomUp	7	uimsbf
}		
FlagFP_DF	1	bslbf
if(FlagFP_DF) {		
DollyForward	7	uimsbf
}		
FlagFP_DB	1	bslbf
if(FlagFP_DB) {		
DollyBackward	7	uimsbf
}		
FlagFP_PL	1	bslbf
if(FlagFP_PL) {		
PanLeft	7	uimsbf
}		
FlagFP_PR	1	bslbf
if(FlagFP_PR) {		
PanRight	7	uimsbf
}		
FlagFP_TD	1	bslbf
if(FlagFP_TD) {		
TiltDown	7	uimsbf
}		
FlagFP_TU	1	bslbf
if(FlagFP_TU) {		
TiltUp	7	uimsbf
}		
FlagFP_RC	1	bslbf
if(FlagFP_RC) {		
RollClockwise	7	uimsbf
}		
FlagFP_RU	1	bslbf
if(FlagFP_RA) {		
RollAnticlockwise	7	uimsbf
}		
FlagFP_ZI	1	bslbf
if(FlagFP_ZI) {		
ZoomIn	7	uimsbf
}		
FlagFP_ZO	1	bslbf
if(FlagFP_ZO) {		

ZoomOut	7	uimsbf
}		
FlagFP_FI	1	bslbf
if(FlagFP_FI) {		
Fixed	7	uimsbf
}		
}		
MixtureAmountOfMotionType {		
FlagAM_TL	1	bslbf
if(FlagAM_TL) {		
TrackLeft	11	uimsbf
}		
FlagAM_TR	1	bslbf
if(FlagAM_TR) {		
TrackRight	11	uimsbf
}		
FlagAM_BD	1	bslbf
if(FlagAM_BD) {		
BoomDown	11	uimsbf
}		
FlagAM_BU	1	bslbf
if(FlagAM_BU) {		
BoomUp	11	uimsbf
}		
FlagAM_DF	1	bslbf
if(FlagAM_DF) {		
DollyForward	11	uimsbf
}		
FlagAM_DB	1	bslbf
if(FlagAM_DB) {		
DollyBackward	11	uimsbf
}		
FlagAM_PL	1	bslbf
if(FlagAM_PL) {		
PanLeft	11	uimsbf
}		
FlagAM_PR	1	bslbf
if(FlagAM_PR) {		
PanRight	11	uimsbf
}		
FlagAM_TD	1	bslbf
if(FlagAM_TD) {		
TiltDown	11	uimsbf
}		
FlagAM_TU	1	bslbf
if(FlagAM_TU) {		

TiltUp	11	uimsbf
}		
FlagAM_RC	1	bslbf
if(FlagAM_RC) {		
RollClockwise	11	uimsbf
}		
FlagAM_RU	1	bslbf
if(FlagAM_RA) {		
RollAnticlockwise	11	uimsbf
}		
FlagAM_ZI	1	bslbf
if(FlagAM_ZI) {		
ZoomIn	11	uimsbf
}		
FlagAM_ZO	1	bslbf
if(FlagAM_ZO) {		
ZoomOut	11	uimsbf
}		
}		
NonMixtureAmountOfMotionType {		
FlagAM_TYPE	4	bslbf
if(FlagAM_TYPE==”0000”) {		
TrackLeft	11	uimsbf
} else if(FlagAM_TYPE==”0001”) {		
TrackRight	11	uimsbf
} else if(FlagAM_TYPE==”0010”) {		
BoomDown	11	uimsbf
} else if(FlagAM_TYPE==”0011”) {		
BoomUp	11	uimsbf
} else if(FlagAM_TYPE==”0100”) {		
DollyForward	11	uimsbf
} else if(FlagAM_TYPE==”0101”) {		
DollyBackward	11	uimsbf
} else if(FlagAM_TYPE==”0110”) {		
PanLeft	11	uimsbf
} else if(FlagAM_TYPE==”0111”) {		
PanRight	11	uimsbf
} else if(FlagAM_TYPE==”1000”) {		
TiltDown	11	uimsbf
} else if(FlagAM_TYPE==”1001”) {		
TiltUp	11	uimsbf
} else if(FlagAM_TYPE==”1010”) {		
RollClockwise	11	uimsbf
} else if(FlagAM_TYPE==”1011”) {		
RollAnticlockwise	11	uimsbf
} else if(FlagAM_TYPE==”1100”) {		

ZoomIn	11	uimsbf
} else if(FlagAM_TYPE==”1101”) {		
ZoomOut	11	uimsbf
}		
}		

9.2.4 Descriptor components semantics

LoopSegments
This field, which is only present in the binary representation, specifies the number of segments contained in the description.

XsiTypeID
This field, which is only present in the binary representation, indicates the description mode. If XsiTypeID is set to 1 then non-mixture mode is used, otherwise mixture mode is used.

MediaTime
This element specifies the time interval to which the Camera Motion descriptor applies.

FlagFOE
This field, which is only present in the binary representation, indicates whether the focus of expansion is present. If FlagFOE is set to 1 then focus of expansion is present, otherwise it is not present.

HorizontalPosition, VerticalPosition
These elements specify the coordinates of the focus of expansion (FOE) or focus of contraction (FOC), which is the point in the image from/to which all image velocity vectors diverge (FOE) or converge (FOC). The FOE (FOC) can be used to describe points in the scene on which the viewer should focus his attention, such as a news anchor person or an athlete. The FOE (FOC) makes sense when a zoom/dolly motion type is present. The coordinates of the focus of expansion/contraction are expressed using normalized coordinates.

FractionalPresence
In the mixture mode, for each camera motion type, this element specifies the length of time for which the given motion type occurs as a fraction of the total time of the video item being described. The values of the fields of FractionalPresence (TrackLeft, …) are real numbers between 0 and 1 quantized using a 7 bits uniform quantization (0 corresponds to 0.0, 127 corresponds to 1.0).

For each motion type, a binary flag (FlagFP_TL, …) specifies if the fractional presence of the given motion type is present (0=not present, 1=present).

AmountOfMotion
This element specifies the amount of track, boom, dolly, pan, tilt, roll and zoom there is in the image and depends on how the camera parameters vary with time. For each motion type, the amount of motion is defined as the average (over the total time of the video item described) fraction of the image (an area expressed in normalized coordinates) that was uncovered or covered due to the given camera motion type.

In the mixture mode, all fields in AmountOfMotion are optional. In non-mixture mode, only one field must be specified. One can note that in any mode, the amount of “fixed” motion is obligatorily equal to 0 and is thus not specified. The values of the fields of AmountOfMotion (TrackLeft, …) are real numbers between 0 and 1 quantized using 11 bits uniform quantization (0 corresponds to 0.0, 2047 corresponds to 1.0).

In the case of a mixture description (MixtureAmountOfMotion), for each motion type, a binary flag (FlagAM_TL, …) specifies if the amount of motion corresponding to the given motion type is present.

In the case of a non-mixture description, a single motion type is present and signaled by a 4-bit vector called **FlagAM_TYPE**, as defined in Table 39.

Table 39 — The meaning of FlagAM_TYPE.

FlagAM_TYPE	Motion type
0000	TrackLeft
0001	TrackRight
0010	BoomDown
0011	BoomUp
0100	DollyForward

0101	DollyBackward
0110	PanLeft
0111	PanRight
1000	TiltDown
1001	TiltUp
1010	RollClockwise
1011	RollAnticlockwise
1100	ZoomIn
1101	ZoomOut
1110	Fixed
1111	Reserved

9.3 Motion trajectory

9.3.1 Introduction

This descriptor specifies the motion trajectory of a moving object. The motion trajectory is a high-level feature associated with a moving region, defined as a spatio-temporal localization of one of its representative points (such as the centroid).

9.3.2 DDL representation syntax

```
<complexType name=”MotionTrajectoryType” final=”#all”>
   <complexContent>
      <extension base=”mpeg7:VisualDType”>
         <sequence>
            <choice>
               <element name=”CoordRef”>
                  <complexType>
                     <attribute name=”ref” type=”IDREF” use=”required”/>
                     <attribute name=”spatialRef” type=”boolean”
                           use=”required”/>
                  </complexType>
               </element>
               <element name=”CoordDef”>
                  <complexType>
                     <sequence>
                        <element name=”Repr” minOccurs=”0”>
                           <complexType>
                              <attribute name=”x” type=”mpeg7:unsigned8”
                                    use=”required”/>
                              <attribute name=”y” type=”mpeg7:unsigned8”
                                    use=”required”/>
                           </complexType>
                        </element>
                     </sequence>
                     <attribute name=”units” use=”required”>
                        <simpleType>
                           <restriction base=”string”>
                              <enumeration value=”pictureHeight”/>
                              <enumeration value=”pictureWidth”/>
                              <enumeration
                                    value=”pictureWidthAndHeight”/>
                              <enumeration value=”meter”/>
                           </restriction>
                        </simpleType>
                     </attribute>
                  </complexType>
               </element>
            </choice>
```



```
            <element name=”Params”
                  type=”mpeg7:TemporalInterpolationType”/>
         </sequence>
         <attribute name=”cameraFollows” type=”boolean” use=”optional”/>
      </extension>
   </complexContent>
</complexType>
```

9.3.3 Binary representation syntax

MotionTrajectory {	**Number of bits**	**Mnemonic**
cameraFollows	2	bslbf
CoordFlag	1	bslbf
if(CoordFlag) {		
ref		UTF-8
spatialRef	1	bslbf
}		
else {		
units	2	bslbf
CoordCodingLength	1	bslbf
if(CoordCodingLength) {		
xRepr	8	uimsbf
yRepr	8	uimsbf
}		
}		
Params	See subclause 5.6.3	TemporalInterpolationType
}		

9.3.4 Descriptor components semantics

cameraFollows
This attribute specifies whether the camera follows the object in situations where the moving region can be associated with a meaningful object. If it is not present in the DDL instantiation, the notion is not specified by the descriptor. For binary representation, the meaning of the bits is specified in Table 40.

Table 40 — The meaning of cameraFollows.

cameraFollows	Meaning
00	Information not specified
01	Reserved
10	Camera does not follow object
11	Camera follows object

CoordFlag
This field, which is only present in the binary representation, specifies whether coordinate system and units are specified by referencing a spatial coordinate system descriptor, or by instantiating a minimal set of fields in the trajectory description.

If CoordFlag is set to 1, reference to the adequate coordinate system descriptor instantiation follows (Spatial2DCoordinateSystem in the 2-D case), together with the spatialRef associated to it.

If CoordFlag is set to 0, the type of spatial units used for expressing the spatial coordinates of the keypoints follows together (optionally) with the binary coding lengths used for their instantiations. In the 3-D case, the unit of trajectory values is meter.

In addition, when CoordFlag is set to 0:

- when the trajectory is 2-dimensional, it is implicit and mandatory that the spatial coordinate system used for the coordinate values has its origin at the top left corner of the image, x-axis horizontal pointing right, y-axis vertical pointing down.
- when the trajectory is 3-dimensional, the coordinate system is local to the trajectory and is defined as follows:
    - its origin O is the first keypoint P_0 of the trajectory, which always has (0,0,0) coordinates.
    - the (Oz) axis is defined as the line going through P_0 and the next keypoint in the trajectory (different from P_0): P_1, which always has (0,0,dist(P_0 ,P_1)) as its coordinates, the distance being in meters. (Oz) is oriented from P_0 to P_1.
    - let H be the orthogonal projection of the next keypoint P_2 in the trajectory (not belonging to (Oz)) on the plane perpendicular to (Oz) passing through O. Axis (Ox) is defined as (OH), oriented from O to H. P_2 always has (x_2,0,z_2) as its coordinates, $x_2>0$.
    - axis (Oy) is finally uniquely determined to form a “direct” oriented coordinate axis.

ref
This attribute specifies a reference to a spatial coordinate system descriptor (the Spatial2DCoordinateSystem descriptor in the 2-D case) that defines the units and coordinate system used to express the coordinates values in the trajectory. The syntax and semantics of the Spatial2DCoordinateSystem are described in subclause 5.5.

If ref is used, the units attribute below is not used, and thus the trajectory coordinates units should be defined using the referenced spatial coordinate system. Note that subclause 5.5 proposes “pixel” as one possible unit, but it is not a recommended unit in this context as it makes trajectory depend on the scale of the images.

spatialRef
This attribute, which is required in cases where the Spatial2DCoordinateSystem is used, indicates if the coordinates values are given with respect to the local coordinate system (spatialRef is set to 1), or the integrated one (spatialRef is set to 0) (see subclause 5.5).

units
This attribute specifies the spatial units used to express the trajectory coordinates values, which are instantiated via TemporalInterpolation (see subclause 5.6). They can be either pixels normalized by picture width and height in horizontal and vertical dimensions respectively, or pixels normalized by picture height, or pixels normalized by picture width, or meters (for 3D applications).

The units specification is binary encoded as specified in Table 41.

Table 41 — The meaning of units.

units	Meaning
00	PictureWidth and Height
01	PictureHeight
10	PictureWidth
11	Meter

CoordCodingLength
This field, which is only present in the binary representation, is a 1-bit flag specifying in the 2-D case whether the length in bits of each coordinate value encoding should be different from the default 32 bits. If it is set to “1”, the specification of the bit length follows for each coordinate (x,y). If it is set to “0”, it means that 32 bits are used to encode all coordinate values in all dimensions (see subclauses 5.6.3 and 5.6.4).

xRepr, yRepr
These attributes specify the number of bits with which each x and y coordinate values are represented in the binary representation. All x-coordinate values are encoded using xRepr bits, and similarly for y.

Params
This element specifies the spatio-temporal key-points and interpolations used to express the trajectory data. Its syntax and semantics follow subclause 5.6.

The different elements of TemporalInterpolation should be used to express the MotionTrajectory parameters as follows (see subclause 5.6). The overall time interval on which TemporalInterpolation should be defined is the overall time interval on which the trajectory is defined. Dimension is its spatial dimension (2D or 3D). NumOfKeyPoints is the number of keypoints used to define the trajectory, KeyTimePoint being their temporal positions and KeyValue their spatial positions for each spatial dimension (f_a and f(t) in Table 42). DefaultFunction and Type characterize the type of interpolation done between the keypoints. Finally, the relation between speed, acceleration and the interpolation parameters is shown in Table 42 (see also Table 4).

Table 42 — Mapping between Temporal Interpolation and Motion Trajectory.

Trajectory Interpolation	Speed, Acceleration and Interpolation Parameters
(none)	N/A
$f(t) = f_a + v_a(t - t_a)$	$c_1 = v_a$
$f(t) = f_a + v_a(t - t_a) + \frac{1}{2}a_a(t - t_a)^2$	$c_1 = v_a$, $c_2 = 1/2a_a$

The following notation is used: t represents time, $f(t)$ the spatial position at time t, f_a the spatial position at time t_a, v_a and a_a the velocity and acceleration, considered constant between t_a and t. Such a trajectory model is applied to each trajectory dimension independently, on N intervals defined by N+1 key-points.

The dimensions used shall be 2 (for 2-D x,y trajectory) or 3 (for 3-D x,y,z trajectory).

9.4 Parametric motion

9.4.1 Introduction

This descriptor specifies the motion of objects in video sequences, as well as global motion. If it is associated with a region, it can be used to specify the relationship between two or more feature point motion trajectories according to the underlying motion model. The descriptor characterizes the evolution of arbitrarily shaped regions over time in terms of a 2-D geometric transform.

The parametric models the descriptor expresses are:

- Translational models: $v_x(x, y) = a_1$
  $v_y(x, y) = a_2$
- Rotation/scaling models: $v_x(x, y) = a_1 + a_3x + a_4y$
  $v_y(x, y) = a_2 - a_4x + a_3y$
- Affine models: $v_x(x, y) = a_1 + a_3x + a_4y$
  $v_y(x, y) = a_2 + a_5x + a_6y$
- Perspective models: $v_x(x, y) = (a_1 + a_3 x + a_4 y) / (1 + a_7 x + a_8 y)$
  $v_y(x, y) = (a_2 + a_5 x + a_6 y) / (1 + a_7 x + a_8 y)$
- Quadratic models: $v_x(x, y) = a_1 + a_3 x + a_4 y + a_7 xy + a_9 x^2 + a_{10} y^2$
  $v_y(x, y) = a_2 + a_5 x + a_6 y + a_8 xy + a_{11} x^2 + a_{12} y^2$

where $v_x(x, y)$ and $v_y(x, y)$ represent the x and y displacement components of the pixel at coordinates (x, y). The descriptor should be associated with a spatio-temporal region. Therefore, along with the motion parameters, spatial and temporal information is provided.

9.4.2 DDL representation syntax

```
<complexType name="ParametricMotionType" final="#all">
   <complexContent>
      <extension base="mpeg7:VisualDType">
         <sequence>
            <choice>
               <element name="CoordRef">
                  <complexType>
                     <attribute name="ref" type="IDREF"
                           use="required"/>
                     <attribute name="spatialRef" type="boolean"
```



```
                        use=”required”/>
               </complexType>
            </element>
            <element name=”CoordDef”>
               <complexType>
                  <attribute name=”originX” type=”float”
                        use=”required”/>
                  <attribute name=”originY” type=”float”
                        use=”required”/>
               </complexType>
            </element>
         </choice>
         <element name=”MediaDuration”
               type=”mpeg7:MediaIncrDurationType”/>
         <element name=”Params”>
            <simpleType>
               <restriction base=”mpeg7:floatVector”>
                  <maxLength value=”12”/>
               </restriction>
            </simpleType>
         </element>
      </sequence>
      <attribute name=”motionModel” use=”required”>
         <simpleType>
            <restriction base=”string”>
               <enumeration value=”translational”/>
               <enumeration value=”rotationOrScaling”/>
               <enumeration value=”affine”/>
               <enumeration value=”perspective”/>
               <enumeration value=”quadratic”/>
            </restriction>
         </simpleType>
      </attribute>
    </extension>
  </complexContent>
</complexType>
```


9.4.3 Binary representation syntax

ParametricMotion {	**Number of bits**	**Mnemonic**
motionModel	3	bslbf
CoordFlag	1	bslbf
if(CoordFlag) {		
ref		UTF-8
spatialRef	1	bslbf
} else {		
originX	32	fsbf
originY	32	fsbf
}		
MediaDuration	See annex B	MediaIncrDurationType
for(k=0; k<NumOfParams; k++) {		
Params[k]	32	fsbf
}		
}		

9.4.4 Descriptor components semantics

motionModel
This attribute specifies the model type used in the description. The possible values are specified in Table 43.

Table 43 — Relation between motionModel and NumOfParams.

motionModel	NumOfParams	Meaning
000	2	Translational
001	4	Rotation/scaling
010	6	Affine
011	8	Perspective
100	12	Quadratic
101-111	reserved	Reserved

CoordFlag
This field, which is only present in the binary representation, indicates if a coordinate system is specified either by referencing the Spatial2DCoordinateSystem descriptor, or by instantiating originX and originY in the ParametricMotion description.

If CoordFlag is set to 1, reference to the adequate Spatial2DCoordinateSystem follows. If CoordFlag is set to 0, coordinates origin instantiations are embedded (originX and originY).

ref
This attribute specifies a reference to the Spatial2DCoordinateSystem descriptor that defines the units and coordinate system used to express the motion parameters. Its syntax and semantics are described in subclause 5.5.

spatialRef
This attribute indicates if the motion parameter values are given with respect to the local coordinate system (spatialRef is set to 1), or the integrated one (spatialRef is set to 0) (see subclause 5.5).

originX, **originY**
These attributes specify the coordinates of the origin of the spatial reference, with respect to the image coordinates.

MediaDuration
This element specifies the length of the time interval associated with the descriptor.

Params
This element specifies an array of floating point numbers that contains the values of the model parameters. Its size depends on the considered motion model as specified by NumOfParams.

9.5 Motion activity

9.5.1 Introduction

This descriptor captures the notion of "intensity of motion" or "pace of action" in a video segment. A human watching a video or animation sequence perceives it as a slow sequence, fast paced sequence, action sequence etc. Examples of high activity include scenes such as "goal scoring in a soccer match", "scoring in a baseball game", "a high speed car chase", etc. On the other hand, scenes such as "news reader shot", "an interview scene", "a still shot" etc. are perceived as low action shots. Video content in general spans the gamut from high to low activity, therefore we need a descriptor that enables us to accurately express the activity of a given video sequence/shot and comprehensively covers the aforementioned gamut. The activity descriptor can be used in diverse applications such as content repurposing, surveillance, fast browsing, video abstracting, video editing, content based querying etc.

The activity descriptor includes the following five attributes:

- Intensity of Activity. A high value of intensity indicates high activity while a low value of intensity indicates low activity. For example, a still shot has a low intensity of activity while a "fast break" basketball shot has a high intensity of activity.
- Direction of Activity. While a video shot may have several objects with different activities, we can often identify a dominant direction. The direction element expresses the dominant direction of the activity if any.
- Spatial Distribution of Activity indicates whether the activity is spread across many regions or restricted to one large region. It is an indication of the number and size of "active" regions in a frame. For example, a talking head sequence would have one large active region, while an aerial shot of a busy street would have many small active regions.
- Spatial Localization of Activity expresses spatial distribution of motion intensities over the duration of the video segment/shot. For example, a video segment/shot that has high motion activity in the left side can be categorized/retrieved.
- Temporal Distribution of Activity expresses the variation of activity over the duration of the video segment/shot. In other words, whether the activity is sustained throughout the duration of the sequence or confined to a part of the duration.

9.5.2 DDL representation syntax

```
<complexType name="MotionActivityType" final="#all">
   <complexContent>
      <extension base="mpeg7:VisualDType">
         <sequence>
            <element name="Intensity">
               <simpleType>
                  <restriction base="mpeg7:unsigned3">
                     <minInclusive value="1"/>
                     <maxInclusive value="5"/>
                  </restriction>
               </simpleType>
            </element>
            <element name="DominantDirection" type="mpeg7:unsigned3"
                  minOccurs="0"/>
            <element name="SpatialDistributionParams" minOccurs="0">
               <complexType>
                  <attribute name="numOfShortRuns" type="mpeg7:unsigned6"
                        use="required"/>
                  <attribute name="numOfMediumRuns" type="mpeg7:unsigned5"
                        use="required"/>
                  <attribute name="numOfLongRuns" type="mpeg7:unsigned5"
                        use="required"/>
               </complexType>
            </element>
            <element name="SpatialLocalizationParams" minOccurs="0">
               <complexType>
```



```
            <choice>
               <element name="Vector4">
                  <simpleType>
                     <restriction>
                        <simpleType>
                           <list itemType="mpeg7:unsigned3"/>
                        </simpleType>
                        <length value="4"/>
                     </restriction>
                  </simpleType>
               </element>
               <element name="Vector16">
                  <simpleType>
                     <restriction>
                        <simpleType>
                           <list itemType="mpeg7:unsigned3"/>
                        </simpleType>
                        <length value="16"/>
                     </restriction>
                  </simpleType>
               </element>
               <element name="Vector64">
                  <simpleType>
                     <restriction>
                        <simpleType>
                           <list itemType="mpeg7:unsigned3"/>
                        </simpleType>
                        <length value="64"/>
                     </restriction>
                  </simpleType>
               </element>
               <element name="Vector256">
                  <simpleType>
                     <restriction>
                        <simpleType>
                           <list itemType="mpeg7:unsigned3"/>
                        </simpleType>
                        <length value="256"/>
                     </restriction>
                  </simpleType>
               </element>
            </choice>
         </complexType>
      </element>
      <element name="TemporalParams" minOccurs="0">
         <simpleType>
            <restriction>
               <simpleType>
                  <list itemType="mpeg7:unsigned6"/>
               </simpleType>
               <length value="5"/>
            </restriction>
         </simpleType>
      </element>
     </sequence>
    </extension>
   </complexContent>
</complexType>
```


9.5.3 Binary representation syntax

MotionActivity {	**Number of bits**	**Mnemonic**
Intensity	3	uimsbf
DirectionFlag	1	bslbf
SpatialDistributionFlag	1	bslbf
SpatialLocalizedDistributionFlag	1	bslbf
TemporalDistributionFlag	1	bslbf
if(DirectionFlag) {		
DominantDirection	3	uimsbf
}		
if(SpatialDistributionFlag) {		
NumOfShortRuns	6	uimsbf
NumOfMediumRuns	5	uimsbf
NumOfLongRuns	5	uimsbf
}		
if(SpatialLocalizedDistributionFlag) {		
SpaLocNumber	2	uimsbf
for(k=0; k<SpaLocNumber; k++) {		
SpatialLocalizationParams	3	uimsbf
}		
}		
if(TemporalDistributionFlag) {		
for(k=0; k<5; k++) {		
TemporalParams[k]	6	uimsbf
}		
}		
}		

9.5.4 Descriptor components semantics

Intensity
This element is expressed as a 3-bit integer lying in the range [1,5]. The value of 1 specifies the lowest intensity, whereas the value of 5 specifies the highest intensity. Intensity is defined as the standard deviation of motion vector magnitudes, appropriately normalized by the frame resolution and appropriately quantized as per frame resolution. This is illustrated in the pseudo-code below.

```
/* Pseudo-code to quantize standard deviation using thresholds optimised for
test set consisting of MPEG-1 footage. The quantization is to 5 levels as
follows:
1 – very low activity
2 – low activity
3 – medium activity
4 – high activity
5 – very high activity
*/


if(std_dev<t1)
 intensity = 1;
else if(std_dev<t2)
 intensity = 2;
else if(std_dev<t3)
 intensity = 3;
else if(std_dev<t4)
```

```
 intensity = 4;
else
 intensity = 5;

where the thresholds t1, t2, t3, t4 are calculated as follows:

t1 = 0.0857*l/F
t2 = 0.2353*l/F
t3 = 0.4267*l/F
t4 = 0.7037*l/F

where the diagonal length l is given by l=sqrt(frame_width*frame_width +
frame_height*frame_height), and F is the 'P' frame rate in frames/second, i.e.
the number of progressively motion compensated frames per second.
```

In the above pseudo-code, std_dev refers to the standard deviation of motion vector magnitudes. This measure indicates the coherence of motion vector magnitudes contained in the video sequences. It is calculated as follows:

```
w = frame_width;
h = frame_height;
mv_x[i] = horizontal_motion_vector (for i-th block);
mv_y[i] = vertical_motion_vector (for i-th block);

for(i=0; i<h*w; i++) {
 mv_mag = sqrt(mv_x[i]*mv_x[i] + mv_y[i]*mv_y[i]);
 mv_sum += mv_mag;
 mv_sqr += mv_mag*mv_mag;
}

avg = mv_sum/(h*w);
std_dev = sqrt((mv_sqr/(h*w)) - avg*avg);
```

DirectionFlag
This field, which is only present in the binary representation, indicates whether direction is specified. If DirectionFlag is set to 1 the direction is specified, otherwise it is not.

SpatialDistributionFlag
This field, which is only present in the binary representation, indicates whether spatial distribution is specified. If SpatialDistributionFlag is set to 1 then the spatial distribution is specified, otherwise it is not.

SpatialLocalizedDistributionFlag
This field, which is only present in the binary representation, indicates whether spatial localized activity distribution is specified. If SpatialLocalizedDistributionFlag is set to 1 then the spatially localized activity distribution is specified, otherwise it is not.

TemporalDistributionFlag
This field, which is only present in the binary representation, indicates whether temporal distribution is specified. If TemporalDistributionFlag is set to 1 then the temporal distribution is specified, otherwise it is not.

DominantDirection
This element specifies the dominant direction and is expressed as an angle between 0 and 360 degrees. It is defined as shown in the following pseudo-code:

```
int quantize_angle(float f_angle) {
  int direction;

  /* quantize angle using uniform 3 bit quantization
     over 0-360 degrees i.e. 0,45,90,135,180,225,270,315 */
  if((f_angle>=-22.5)&&(f_angle<22.5))       direction=0;
  else if((f_angle>=22.5)&&(f_angle<67.5))   direction=1;
  else if((f_angle>=67.5)&&(f_angle<112.5))  direction=2;
  else if((f_angle>=112.5)&&(f_angle<157.5)) direction=3;
  else if((f_angle>=157.5)&&(f_angle<202.5)) direction=4;
  else if((f_angle>=202.5)&&(f_angle<247.5)) direction=5;
  else if((f_angle>=247.5)&&(f_angle<292.5)) direction=6;
  else if((f_angle>=292.5)&&(f_angle<337.5)) direction=7;
```

```
    return direction;
  }
```

SpatialDistributionParams (numOfShortRuns, numOfMediumRuns, numOfLongRuns)
This element consists of three fields: numOfShortRuns, numOfMediumRuns and numOfLongRuns, which specify the numbers of short, medium and long runs of zeros, respectively.

Short, medium and long runs of zeros are elements of the motion activity descriptor that provide information about the number and size of active objects in the scene. Their values are extracted from the thresholded motion vector magnitude matrix, which has elements for each block indexed by (i,j). Each run is obtained by recording the length of zero runs in a raster scan order over this matrix. The thresholded motion vector magnitude matrix is given by:

$$C_{mv}^{thresh}(i,j) = \begin{cases} C_{mv}(i,j), \text{if } C_{mv}(i,j) \geq C_{mv}^{avg} \\ 0, \text{otherwise} \end{cases}$$

Let the horizontal and vertical motion vectors for block (i,j) be given by $v_{x,ij}$, and $v_{y,ij}$, respectively. Then, for each object or frame the "activity matrix" C_{mv} is defined as:

$$C_{mv} = \{v(i,j)\} \text{ where } v(i,j) = \sqrt{v_{x,ij}^2 + v_{y,ij}^2} \text{ for inter blocks and } v(i,j) = 0 \text{ for intra blocks}$$

and the average motion vector magnitude for an MxN frame is defined as:

$$C_{mv}^{avg} = \frac{1}{MN} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} C_{mv}(i,j)$$

From the thresholded motion vector magnitude matrix, the zero run-lengths are classified into three categories, short, medium and long, which are normalized with respect to the frame width. Short runs are defined as runs that are less than 1/3 of the frame width. Medium runs are defined to be greater than 1/3 of the frame width and less than 2/3 of the frame width. Long runs are defined to be greater than 2/3 of the frame width. If a long run is longer than the width of a frame, the number of long runs contained in it is equal to the integral part of the length of the run divided by the width of the frame.

The final normalization with respect to the image height is performed as follows. Let the height of the frame in pixels be *H* and the number of short, medium and long runs obtained in the previous step be *nsr*, *nmr* and *nlr*. Then, the normalized spatial distribution parameters are given by:

```
nsr_norm = (288÷H)*nsr;
if (nsr_norm>63)
    numOfShortRuns = 63;
else
    numOfShortRuns = (int)nsr_norm;

nmr_norm = (288÷H)*nmr;
if (nmr_norm>31)
    numOfMediumRuns = 31;
else
    numOfMediumRuns = (int)nmr_norm;

nlr_norm = (288÷H)*nlr;
if (nlr_norm>31)
    numOfLongRuns = 31;
else
    numOfLongRuns = (int)nlr_norm;
```

SpaLocNumber
This element specifies the number of spatially localized activity parameters and the associated grid divisions of the video frames. The encoding for the 2-bit binary representation is specified in Table 44.

Table 44 — The meaning of SpaLocNumber.

SpaLocNumber	Meaning
00	4 (=2x2)
01	16 (=4x4)
10	64 (=8x8)

11	256 (=16x16)

SpatialLocalizationParam(s)
This element specifies the relative activity of each rectangular region defined by SpaLocNumber. The activity for each region is defined as the average of motion sample magnitudes in each region. Relative activity is the ratio of activity of the region to the sum of activities in the shot. The relative activity is uniformly quantized with the step size Q=2/(SpaLocNumber*8), i.e. the value of 0 represents the range of [0,Q), the value of 6 represents the range of [6Q,7Q) and the value of 7 represents the range above 7Q. SpatialLocalizationParams are ordered from left to right and from top to bottom.

TemporalParams
This is a histogram consisting of 5 bins, where histogram bins with indexes 0, 1, 2, 3, and 4 correspond to Intensity value of 1, 2, 3, 4, and 5 respectively. The histogram expresses the relative frequency of different levels of activity in the sequence as defined by the intensity element above. Each value is the percentage of occurrences of the corresponding quantized intensity level uniformly quantized to 6 bits.

10 Localization

10.1 Introduction

This section provides localization tools to indicate regions of interest in the spatial (RegionLocator) and spatio-temporal (SpatioTemporalLocator) domains.

10.2 Region locator

10.2.1 Introduction

This descriptor enables localization of regions within images or frames by specifying them with a brief and scalable representation of a Box or a Polygon.

10.2.2 DDL representation syntax

```
<complexType name="RegionLocatorType" final="#all">
   <sequence>
      <element name="CoordRef" minOccurs="0">
         <complexType>
            <attribute name="ref" type="IDREF" use="required"/>
            <attribute name="spatialRef" type="boolean"
                  use="optional" default="false"/>
         </complexType>
      </element>
      <element name="Box" minOccurs="0" maxOccurs="unbounded">
         <complexType>
            <simpleContent>
               <extension base="mpeg7:BoxListType">
                  <attribute name="unlocatedRegion" type="boolean"
                     use="optional" default="false"/>
               </extension>
            </simpleContent>
         </complexType>
      </element>
      <element name="Polygon" minOccurs="0" maxOccurs="unbounded">
         <complexType>
            <sequence>
               <element name="Coords" type="mpeg7:IntegerMatrixType"/>
            </sequence>
            <attribute name="unlocatedRegion" type="boolean"
                  use="optional" default="false"/>
         </complexType>
      </element>
   </sequence>
```

```
</complexType>
<complexType name="BoxListType">
   <simpleContent>
      <restriction base=”mpeg7:IntegerMatrixType”>
         <minLength value=”4”/>
         <maxLength value=”6”/>
      </restriction>
   </simpleContent>
</complexType>
```


10.2.3 Binary representation syntax

RegionLocator {	**Number of bits**	**Mnemonic**
CoordFlag	1	bslbf
if(CoordFlag) {		
ref	See ISO 10646	UTF-8
spatialRef	1	bslbf
} else {		
XRepr	8	uimsbf
YRepr	8	uimsbf
}		
ContainedLocatorTypes	2	bslbf
if(ContainedLocatorTypes&1) {		
NumOfBoxes		vluimsbf5
for(j=0;j<NumOfBoxes;j++) {		
unlocatedRegion	1	bslbf
Use3P	1	bslbf
for(k=0;k<2+Use3P;k++) {		
PixelX[k]	if(CoordFlag) ceil(ld(xSrcSize)) else XRepr	uimsbf
PixelY[k]	if(CoordFlag) ceil(ld(ySrcSize)) else YRepr	uimsbf
}		
}		
}		
if(ContainedLocatorTypes&2) {		
NumOfPolygons		vluimsbf5
for(j=0;j<NumOfPolygons;j++) {		
unlocatedRegion	1	bslbf
NumOfVertices		vluimsbf5
FirstVertexX	if(CoordFlag) ceil(ld(xSrcSize)) else XRepr	uimsbf
FirstVertexY	if(CoordFlag) ceil(ld(ySrcSize)) else YRepr	uimsbf
XDynamicRange	4	uimsbf
YDynamicRange	4	uimsbf
for(k=0;k<NumOfVertices;k++) {		
Octant	3	bslbf
MajorComponent[k]	XDynamicRange or YDynamicRange	uimsbf
MinorComponent[k]	ld(min(MajorComponent[k], DynamicRange(MinorComponent)))	uimsbf
}		
}		
}		
}		

10.2.4 Descriptor components semantics

CoordFlag
This field, which is only present in the binary representation, indicates the presence of a reference to a coordinate system. If CoordFlag is set to 1 then a reference to a coordinate system is present. If CoordFlag is set to 0 then the implicit pixel-based reference system is used and XRepr and YRepr are specified within this descriptor.

ref
This attribute specifies a reference to a 2D coordinate system. In the DDL representation the referencing is based on ID/IDREF. In the binary representation, IDREF is encoded using the UTF-8 standard. In this coordinate system, the values of xSrcSize and ySrcSize are specified. Only Spatial2DCoordinateSystem that instantiate xSrcSize and ySrcSize attributes can be used.

spatialRef
This attribute indicates if the Coords values are given either with respect to the local coordinate system (spatialReference is set to 1), or the integrated one (spatialReference is set to 0) (see subclause 5.5).

XRepr, YRepr
These fields, which are only present in the binary representation, specify the number of bits to code image width and height.

Coords
This element specifies the pixel based coordinates of the vertices by using the integer matrix datatype. The first row of this matrix contains the x, and the second row the y coordinates of the vertices. In the case of a box region, the specification of three points is estimated. If two points are specified, the edges of the box are assumed parallel to the edges of the image.

In the case of a polygon region, only the first coordinate in each row uses absolute x and y coordinate values. All following coordinates are specified by the values Δx and Δy, which are the differences from the x and y coordinates of the previous vertex.

The matrix is represented by the binary representation with:

- XRepr, YRepr to specify the binary coordinate representation if no CoordRef is present.
- The first value of each row of the matrix is encoded in FirstVertexX and FirstVertexY.
- The XDynamicRange is determined as follows:
    - o the largest Δx value of the first row of the Coords matrix is chosen. Then XDynamic range is specified by XDynamicRange=ceil(ld(Δx_{max})).
- The YDynamicRange is determined as follows:
    - o the largest Δy value of the second row of the Coords matrix is chosen. Then YDynamic range is specified by YDynamicRange=ceil(ld(Δy_{max})).
- The values of the first and second row excluding the first value of each row are binary encoded by the octant, MajorComponent and MinorComponent.

ContainedLocatorTypes
This field, which is only present in the binary representation, specifies what locator types are present: “00” is reserved, “01” for boxes, “10” for polygons, “11” for boxes and polygons.

Box
This element specifies a 2-D box.

NumOfBoxes
This field, which is only present in the binary representation, specifies the number of boxes this descriptor is composed of.

unlocatedRegion
If this attribute is set to “0”, the box or polygon locates the inner region including the pixels of the polygon. If it is set to “1”, the box or polygon locates a region which does not belong to the located region including the pixels of the polygon. If more than one box or polygon are specified, the regions are overlaid in the order in which they are stored in

the bitstream. Thus, a previously “unlocated” region can again be located by sending a polygon surrounding it and sending its “unlocatedRegion” flag to “0”.

Use3P
This field, which is only present in the binary representation, indicates if two or three points are used. If Use3P is set to 1 then three points are used, otherwise two points are used.

PixelX, PixelY
These fields, which are only present in the binary representation, specify the coordinate values of one point in X and Y dimension.

Polygon
This element specifies a 2-D polygon.

NumOfPolygons
This field, which is only present in the binary representation, specifies the number of polygons contained in this descriptor.

NumOfVertices
This field, which is only present in the binary representation, specifies the number of vertices in the polygon description.

FirstVertexX, FirstVertexY
These fields, which are only present in the binary representation, specify the absolute-addressed coordinates of first vertex.

XDynamicRange, YDynamicRange
These fields, which are only present in the binary representation, specify the number of bits used for the binary representation of the MajorComponent and the MinorComponent as specified below.

Octant
This field, which is only present in the binary representation, specifies the octant the encoded segment lies in. This is coded using three bits as specified in Table 45.

Table 45 — The meaning of Octant.

Octant	Meaning
0	(x>y) && (y>=0)
1	(x<=-y) && (y>0)
2	(x>=-y) && (y<0)
3	(x<y) && (y<=0)
4	(x>0) && (y>=x)
5	(x>=0) && (y<-x)
6	(x<=0) && (y>-x)
7	(x<0) && (y<=x)

MajorComponent
This field, which is only present in the binary representation, specifies the absolute value of the bigger coordinate component with respect to its absolute value. Which of the X and Y components is the major component and its sign is signaled by sending the octant in advance (MajorComponent is the X coordinate if octant ∈ {0,1,2,3}, else the Y coordinate is the MajorComponent). Depending on the coordinate, this representation is coded with X- or YDynamicRange bits.

MinorComponent
This field, which is only present in the binary representation, specifies the absolute value of the smaller coordinate component with respect to its absolute value. Which of the X and Y component is the minor component and its sign is also signaled by sending the octant in advance (MinorComponent is the X coordinate if octant ∈ {4,5,6,7}, else the Y coordinate is the MinorComponent). This representation is coded with the smaller number of bits necessary: the number of bits needed for the representation of the major component or the number of bits specified in the DynamicRange value of the minor component.

10.3 Spatio-temporal locator

10.3.1 Introduction

This descriptor specifies the spatio-temporal regions in a video sequence and provides localization functionality especially for hypermedia applications. It consists of FigureTrajectory and ParameterTrajectory.

The SpatioTemporalLocator describes moving regions in multiple frames by one or several sets of a reference region and its motion. FigureTrajectory and ParameterTrajectory describe a set of reference regions and their motions. The two description schemes are selected according to moving object conditions. In general, if a moving region is rigid and the motion model is known, ParameterTrajectory is preferable due to its compactness. On the other hand, if a moving region is non-rigid, FigureTrajectory with a polygon is suitable.

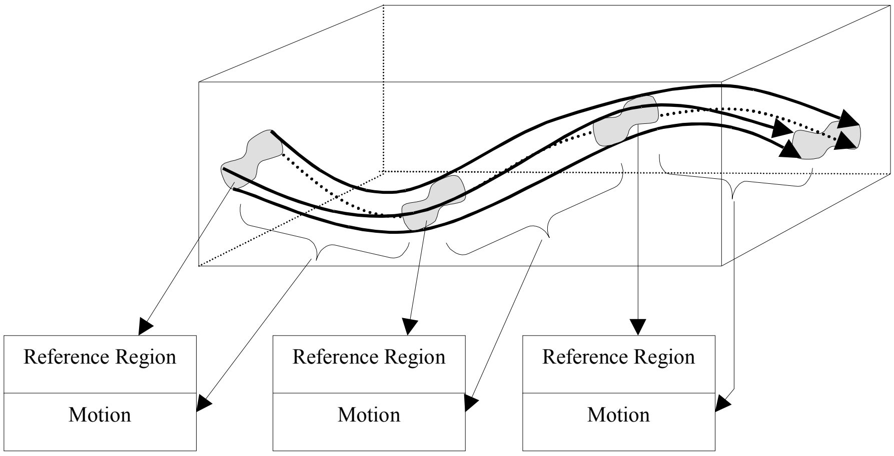


Figure 28 — Spatio-Temporal Region.

10.3.2 DDL representation syntax

```
<complexType name=”SpatioTemporalLocatorType” final=”#all”>
   <sequence>
      <element name=”CoordRef” minOccurs=”0”>
         <complexType>
            <attribute name=”ref” type=”IDREF” use=”required”/>
            <attribute name=”spatialRef” type=”boolean” use=”required”/>
         </complexType>
      </element>
      <choice minOccurs=”1” maxOccurs=”unbounded”>
         <element name=”FigureTrajectory” type=”mpeg7:FigureTrajectoryType”/>
         <element name=”ParameterTrajectory”
               type=”mpeg7:ParameterTrajectoryType”/>
         <element name=”MediaTime” type=”mpeg7:MediaTimeType”/>
      </choice>
   </sequence>
</complexType>
```

10.3.3 Binary representation syntax

SpatioTemporalLocator {	**Number of bits**	**Mnemonic**
CoordFlag	1	bslbf
if(CoordFlag) {		
ref	See ISO 10646	UTF-8
spatialRef	1	bslbf
}		
NumOfRefRegions		vluimsbf5
for(k=0; k<NumOfRefRegions; k++) {		
TypeOfTrajectory	2	bslbf
if(TypeOfTrajectory==”00”) {		
FigureTrajectory	See Clause 10.3.5.3	FigureTrajectoryType
} else if(TypeOfTrajectory==”01”) {		
ParameterTrajectory	See Clause 10.3.6.3	ParameterTrajectoryType
} else if(TypeOfTrajectory==”10”) {		
MediaTime	See annex B	MediaTimeType
}		
}		
}		

10.3.4 Datatype components semantics

CoordFlag
This field, which is only present in the binary representation, indicates if the coordinate system is specified by referencing the Spatial2DcoordinateSystem descriptor or the default coordinate system is used. If CoordFlag is set to 1, reference to the adequate Spatial2DCoordinateSystem follows. If CoordFlag is set to 0, the default coordinate system is used, in which the origin is the top-left corner of the image, the unit for both axes is pixel, and the type of the coordinate system is local.

CoordRef
This element specifies the coordinate system by referencing the Spatial2DCoordinateSystem descriptor.

ref
This attribute specifies a reference to the Spatial2DCoordinateSystem descriptor that defines the units and coordinate system used to express the coordinates. Its syntax and semantics are described in subclause 5.5.

It is mainly useful to specify an absolute reference taking into account global motion, in which the coordinates can be expressed. If it is present, units should be defined using the Spatial2DCoordinateSystem. If not present, local coordinate system is used.

spatialRef
This attribute indicates if the coordinate values are given either with respect to the local coordinate system (spatialReference is set to 1), or with respect to the integrated one (spatialReference is set to 0) (see subclause 5.5).

NumOfRefRegions

This field, which is only present in the binary representation, specifies the number of reference regions.

TypeOfTrajectory
This flag, which is only present in the binary representation, specifies the descriptor used to describe the trajectory. The mapping between the binary representation and the trajectory type is specified in Table 46.

Table 46 — The semantics of TypeOfTrajectory.

TypeOfTrajectory	Meaning
00	FigureTrajectoryType
01	ParameterTrajectoryType

10	MediaTimeType
11	Reserved

FigureTrajectory
This element is specified in subclause 10.3.5.

ParameterTrajectory
This element is specified in subclause 10.3.6.

MediaTime
This element specifies the temporal interval only using the MediaTimeType (see ISO/IEC 15938-5).

10.3.5 FigureTrajectoryType

10.3.5.1 Introduction

FigureTrajectoryType describes a spatio-temporal region by trajectories of the representative points of a reference region. Reference regions are represented by three kinds of figures: rectangles, ellipses and polygons. For rectangles and polygons, the representative points are their vertices. Although there are four vertices for a rectangle, only three of them are described because the fourth one can be easily calculated. For ellipses, three vertices of their circumscribing rectangles are selected as the representative points.

The trajectories are interpolated using the TemporalInterpolation descriptor. For this datatype, the reference region description is omitted because the TemporalInterpolation descriptor can directly express the representative points of figures.

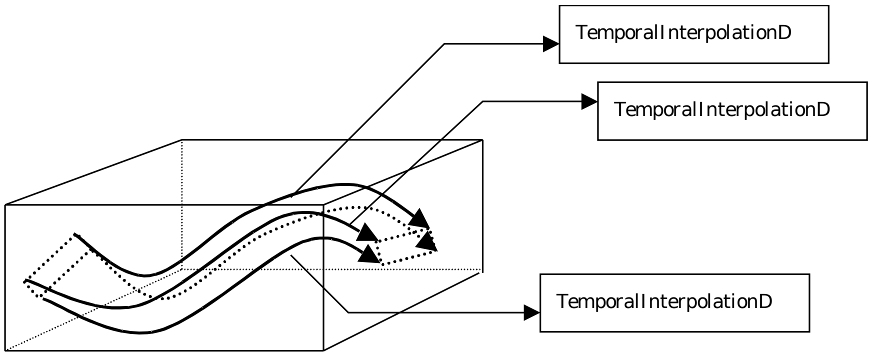


Figure 29 — Motion descriptions for FigureTrajectory.

10.3.5.2 DDL representation syntax

```
<complexType name="FigureTrajectoryType" final="#all">
   <sequence>
      <element name="MediaTime" type="mpeg7:MediaTimeType"/>
      <element name="Vertex" type="mpeg7:TemporalInterpolationType"
            minOccurs="3" maxOccurs="unbounded"/>
      <element name="Depth" type="mpeg7:TemporalInterpolationType"
            minOccurs="0"/>
   </sequence>
   <attribute name="type" use="required">
      <simpleType>
         <restriction base="string">
            <enumeration value="rectangle"/>
            <enumeration value="ellipse"/>
            <enumeration value="polygon"/>
         </restriction>
      </simpleType>
   </attribute>
</complexType>
```


10.3.5.3 Binary representation syntax

FigureTrajectory {	**Number of bits**	**Mnemonic**
MediaTime	See annex B	MediaTimeType
type	6	uimsbf
for(i=0;i<NumOfVertices;i++) {		
Vertex[i]	see subclause 5.6.3	TemporalInterpolationType
}		
DepthFlag	1	bslbf
if(DepthFlag) {		
Depth	See subclause 5.6.3	TemporalInterpolationType
}		
}		

10.3.5.4 Descriptor components semantics

MediaTime
This element specifies the start time and duration of a described spatio-temporal region. It is specified in ISO/IEC 15938-5.

type
This attribute is a 6-bit integer in the range [0-63] that specifies the type of the reference region. Table 47 shows the relations between the value of type, the type of the figure and NumOfVertices (the number of vertices described in the descriptor). Each vertex trajectory is described by the TemporalInterpolation descriptor. Vertices must be always continuous and ordered clockwise. For rectangle and ellipse, three vertices are specified as explained above. For polygon, the number of vertices is specified by the value of type (binary representation) or the number of Vertex elements (DDL representation).

Table 47 — Semantics of type.

type	Figure	NumOfVertices
0	Forbidden	-
1	Rectangle	3
2	Ellipse	3
3-63	polygon	Value of type

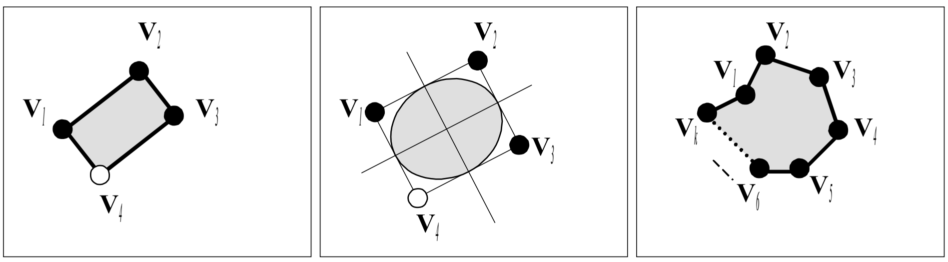


Figure 30 — Representative points of rectangle, ellipse and polygon.

Vertex
This element specifies a trajectory of each vertex using the TemporalInterpolation descriptor.

DepthFlag
This flag, which is only present in the binary representation, indicates the presence of Depth. If DepthFlag is set to 1, Depth is contained in the descriptor.

Depth
This element exists only when the depth information is available. Depth information is the distance between the focal point of the camera and the nearest surface point of the object. The unit of depth is meter. The sequence of depth values is described by the TemporalInterpolation descriptor.

10.3.6 ParameterTrajectoryType

10.3.6.1 Introduction

ParameterTrajectoryType specifies a spatio-temporal region by a reference region and trajectories of motion parameters. Reference regions are described using the RegionLocator descriptor. Motion parameters and parametric motion model specify a mapping from the reference region to a region of an arbitrary frame. The trajectories of the motion parameters are interpolated and are described using the TemporalInterpolation descriptor.

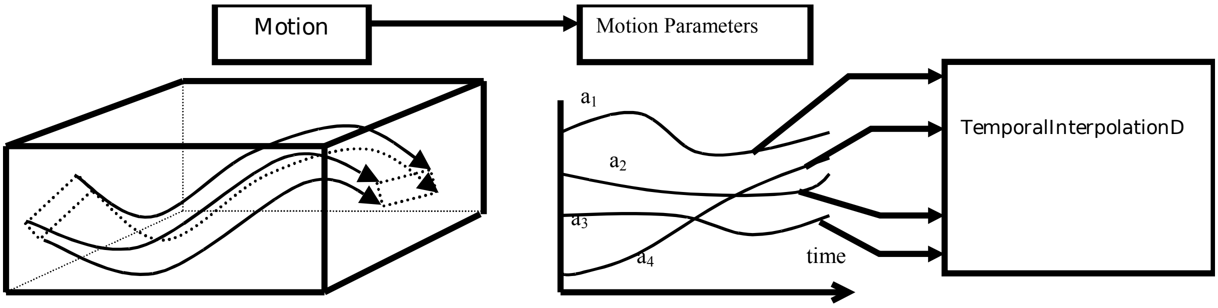


Figure 31 — Motion descriptions for ParameterTrajectory.

10.3.6.2 DDL representation syntax

```
<complexType name="ParameterTrajectoryType" final="#all">
   <sequence>
      <element name="MediaTime" type="mpeg7:MediaTimeType"/>
      <element name="InitialRegion" type="mpeg7:RegionLocatorType"/>
      <element name="Params" type="mpeg7:TemporalInterpolationType"
            minOccurs="0"/>
      <element name="Depth" type="mpeg7:TemporalInterpolationType"
            minOccurs="0"/>
   </sequence>
   <attribute name="motionModel" use="required">
      <simpleType>
         <restriction base="string">
            <enumeration value="still"/>
            <enumeration value="translation"/>
            <enumeration value="rotationAndScaling"/>
            <enumeration value="affine"/>
            <enumeration value="perspective"/>
            <enumeration value="parabolic"/>
         </restriction>
      </simpleType>
   </attribute>
   <attribute name="ellipseFlag" type="boolean" use="optional" default="false"/>
</complexType>
```

10.3.6.3 Binary representation syntax

ParameterTrajectory {	**Number of bits**	**Mnemonic**
motionModel	3	uimsbf
ellipseFlag	1	bslbf
MediaTime	See annex B	MediaTimeType
InitialRegion	See subclause 10.2.3	RegionLocatorType
Params	see subclause 5.6.3	TemporalInterpolationType
DepthFlag	1	bslbf
if(DepthFlag) {		
Depth	see subclause 5.6.3	TemporalInterpolationType
}		
}		

10.3.6.4 Datatype components semantics

motionModel
This attribute specifies the type of the motion model. Table 48 shows the relations between the value of motionModel, parametric motion model and the number of parameters described in the descriptor. If the model is still, the region does not move from the initial position and the Params element is not present. Otherwise, the number of parameters of the motion model specifies the dimension of the Params element. Definitions of motion models and their parameters are explained in subclause 9.4.

Table 48 — Semantics of motionModel.

MotionModel	Parametric motion model	Number of parameters
0	still	0
1	translation	2
2	rotationAndScaling	4
3	affine	6
4	perspective	8
5	parabolic	12
6-7	reserved	n/a

ellipseFlag
This attribute is meaningful only when a box is used in the RegionLocator. If ellipseFlag is set to 0, the reference region is a rectangle represented by the box. If ellipseFlag is set to 1, the reference region is an ellipse and the box specifies the circumscribing rectangle of the ellipse. When a polygon is used as a reference region, this flag does not carry any meaning.

MediaTime
This element specifies the start time and duration of a described spatio-temporal region. It is specified in ISO/IEC 15938-5.

InitialRegion
This element specifies a reference region and its structure as specified in subclause 10.2. When RegionLocator represents a box, the ellipseFlag should be referred. If ellipseFlag is set to 1, the box specifies a circumscribing rectangle of a reference region (ellipse).

Params
This element specifies the trajectory of the region locator using the parametric motion model. The time evolution of the motion parameters is described using the TemporalInterpolation descriptor (see subclause 5.6).

DepthFlag
This field, which is only present in the binary representation, indicates the presence of Depth. If it is equal to 1, Depth is contained in the descriptor.

Depth
This element exists only when the depth information is available. Depth information is the distance between the focal point of the camera and the nearest surface point of the object. The unit of depth is meter. The sequence of depth values is described by the TemporalInterpolation descriptor.

11 Others

11.1 Introduction

This clause defines other descriptors and consists of the face descriptor.

11.2 Face recognition

11.2.1 Introduction

This descriptor specifies the projection of a face vector onto a set of 48 basis vectors that span the space of possible face vectors.

11.2.2 DDL representation syntax

```
<complexType name="FaceRecognitionType" final="#all">
   <complexContent>
      <extension base="mpeg7:VisualDType">
         <sequence>
            <element name="Feature">
               <simpleType>
                  <restriction>
                     <simpleType>
                        <list itemType="mpeg7:unsigned5"/>
                     </simpleType>
                     <length value="48"/>
                  </restriction>
               </simpleType>
            </element>
         </sequence>
      </extension>
   </complexContent>
</complexType>
```

11.2.3 Binary representation syntax

FaceRecognition {	**Number of bits**	**Mnemonic**
for(k=0; k<48; k++)		
Feature[k]	5	uimsbf
}		

11.2.4 Descriptor components semantics

The FaceRecognition descriptor is extracted from a normalized face image. This normalized face image is obtained by scaling of the original image to 56 lines with 46 pixels in each line. The center of the two eyes in each face image should be located on the 24th row and the 16th and 31st column for the right and left eye respectively. This normalized image is then used to extract the face vector Λ which consists of the luminance values from the normalized face image arranged into a vector using a column-wise raster scan starting at the top-left corner of the image and finishing at the bottom-right corner of the image.

The FaceRecognition feature set is then calculated by projecting the one-dimensional face vector Λ onto the space defined by the basis matrix U which is specified in Annex A.1. The features are given by the vector W where $W = U^T(\mathbf{\Lambda} - \mathbf{\Psi})$ and Ψ is the mean face vector specified in Annex A.2.

The features are then normalized and clipped using the equation:

$$w_i = \begin{cases} 0, & if \quad w_i / Z < -16 \\ 31, & if \quad w_i / Z > 15 \\ round(w_i / Z + 16), & \text{otherwise} \end{cases}$$

where Z=16384*8 is the normalization constant.

Feature
The elements Feature[0], …, Feature[47] specify the projection of a face vector onto a space defined by the columns of the basis matrix *U*. Each element is stored as a 5-bit unsigned integer.

Annex A

(Normative)

Basis functions for FaceRecognition

A.1 Basis matrix

U[1][ ] = { -3, -6, -6, -7, -7, -7, -8, -8, -8, -8, -8, -8, -8, -8, -8, -8, -8, -8, -8, -8, -8, -9, -9, -9, -9, -8, -8, -8, -8, -9, -9, -9,
-9, -9, -9, -9, -9, -8, -9, -9, -9, -9, -9, -9, -9, -9, -9, -9, -8, -8, -8, -7, -7, -6, -5, -2, -6,-10,-11,-12,-12,-12,-12,-12,-13,-12,-
12,-12,-12,-12,-12,-12,-12,-12,-12,-12,-12,-13,-13,-13,-12,-12,-12,-12,-13,-13,-13,-13,-13,-14,-14,-14,-14,-14,-14,-14,-
15,-15,-15,-15,-15,-15,-15,-14,-14,-14,-13,-12,-11,-10, -8, -4, -6,-11,-11,-12,-12,-12,-12,-12,-11,-11,-10,-10, -9, -9, -9,
-9, -9, -9, -9, -9,-10, -9, -9, -9, -9, -9, -9,-10,-10,-11,-11,-12,-12,-13,-13,-13,-14,-14,-14,-15,-15,-15,-15,-15,-15,-15,-15,-
15,-15,-14,-14,-12,-11, -9, -7, -3, -7,-11,-11,-12,-12,-11,-10,-10, -9, -8, -7, -6, -6, -5, -5, -5, -5, -5, -5, -6, -6, -6, -6, -6,
-6, -6, -6, -6, -7, -8, -8, -9,-10,-11,-12,-12,-13,-14,-14,-15,-15,-16,-16,-16,-16,-16,-16,-16,-15,-14,-14,-12,-11, -9, -6, -3,
-7,-11,-11,-11, -9, -8, -7, -6, -4, -3, -2, -2, -1, -1, -1, -1, -1, -1, -2, -2, -2, -2, -2, -3, -3, -3, -3, -3, -4, -4, -5, -6, -7, -8, -9,-
10,-11,-13,-14,-14,-15,-15,-16,-16,-16,-16,-16,-16,-15,-14,-13,-12,-10, -7, -5, -3, -7,-10, -9, -8, -6, -5, -3, -2, 0, 0, 1,
1, 1, 2, 2, 2, 2, 2, 2, 2, 1, 1, 1, 0, 0, 0, 0, -1, -1, -1, -2, -3, -4, -5, -7, -8,-10,-11,-13,-14,-14,-15,-15,-16,-16,-16,-
16,-16,-15,-14,-13,-11, -9, -6, -5, -2, -6, -8, -7, -5, -3, -1, 0, 1, 2, 2, 3, 3, 3, 4, 4, 4, 4, 4, 4, 4, 3, 3, 2, 1, 1, 1,
1, 0, 0, 0, -1, -1, -2, -3, -4, -6, -7, -9,-11,-12,-13,-14,-15,-15,-16,-16,-16,-15,-14,-13,-12, -9, -7, -5, -4, -2, -5, -6, -4, -2,
-1, 1, 2, 2, 3, 4, 4, 4, 4, 4, 5, 5, 4, 4, 3, 3, 2, 2, 1, 0, 0, 0, 0, 0, 0, -1, -1, -1, -1, -2, -2, -3, -4, -5, -7, -9,-11,-
12,-14,-14,-15,-15,-15,-14,-13,-11,-10, -7, -6, -4, -3, -1, -3, -4, -2, 0, 1, 2, 3, 3, 4, 4, 4, 4, 4, 4, 4, 4, 3, 3, 2, 1,
1, 1, 0, -1, -1, -1, 0, 0, 0, 0, 0, 0, -1, -1, -1, -2, -2, -3, -4, -6, -8,-10,-11,-12,-13,-13,-12,-11, -9, -7, -6, -4, -3, -2,
-1, -2, -2, 0, 1, 2, 3, 3, 4, 4, 4, 4, 4, 4, 3, 3, 3, 2, 2, 1, 1, 1, 1, 0, -1, -1, -1, 0, 1, 1, 1, 1, 0, 0, 0, 0, -1, -1,
-1, -1, -2, -3, -4, -5, -6, -8, -9, -9, -9, -8, -6, -5, -3, -2, -2, -1, -1, -1, 0, 1, 3, 3, 3, 4, 4, 4, 4, 4, 4, 3, 3, 2, 2, 2, 2,
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U [16][ ] = {-19,-25,-18,-12,-10, -5, -8,-19,-16,-24,-26,-26,-28,-29,-26,-14,-11, -8, -7, -5, -9,-14, -5, 7, 4, 6, 11, 14, 14, 22, 33, 36, 37, 31, 27, 19, 17, 12, 0, -3,-14,-11, -4, -7,-12,-13,-17,-15,-12,-22,-39,-46,-66,-94,-102,-53, 1, -8, 5, 19, 21, 23, 19, 0,-23,-30,-38,-50,-51,-38,-22, -9,-13,-12, -3, 13, 17, 2,-10,-10,-25,-24,-22,-22,-18, 1, 25, 42, 54, 65, 71, 68, 75, 74, 54, 38, 25, 15, 8, 3, 0, -3, -2, 1, -9,-10,-35,-64,-108,-128,-128,-60, 3, 20, 36, 48, 48, 31, 3,-26,-36,-46,-56,-63,-58,-49,-53,-60,-43,-20, -3, 8, 21, 21, 2,-20,-39,-45,-59,-77,-82,-68,-42,-21, -8, 7, 27, 45, 77, 92, 83, 71, 59, 40, 24, 22, 22, 23, 28, 29, 19, 23, 0,-32,-78,-84,-74,-27, 18, 36, 51, 51, 33,-11,-51,-80,-87,-85,-73,-58,-50,-51,-59,-63,-57,-49,-42,-41,-32,-19,-17,-23,-40,-35,-30,-42,-61,-72,-83,-89,-89,-68,-36, -2, 44, 75, 84, 86, 75, 60, 41, 33, 33, 33, 34, 34, 40, 31, 4,-24,-42,-32,-23, 5, 29, 47, 44, 21,-14,-53,-70,-73,-54,-26, 7, 26, 26, 18, 10, 5, -1,-13,-32,-53,-58,-45,-43,-57,-71,-60,-38,-24,-21,-26,-46,-73,-100,-98,-80,-46, 5, 51, 76, 84, 89, 78, 56, 35, 28, 27, 30, 33, 39, 16,-16,-17, 2, 28, 28, 31, 40, 63, 41, 1,-17,-25,-17, 3, 27, 55, 77, 76, 63, 58, 56, 51, 43, 27, 7,-16,-33,-35,-50,-80,-59,-54,-40,-30,-26,-27,-40,-52,-61,-84,-101,-85,-45, 6, 47, 68, 84, 79, 58, 33, 32, 39, 41, 40, 33, -2,-27, 2, 43, 69, 68, 48, 61, 64, 37, 2, -5, -2, 13, 28, 53, 42, 31, 27, 31, 33, 22, 10, 11,-10,-17,-18,-18,-11,-15,-43,-54,-53,-49,-48,-44,-40,-44,-52,-64,-73,-101,-115,-110,-77,-29, 21, 49, 71, 70, 51, 42, 42, 37, 33, 11, -6, 18, 77,104,107,101, 53, 61, 57, 34, 13, 4, 3, 18, 32, 13, 6, 4, 5, 5, 4, 0, -3, -7,-20,-20,-21,-27,-27,-33,-55,-70,-57,-42,-33,-28,-23,-25,-29,-45,-49,-66,-72,-90,-108,-106,-82,-42, 2, 35,

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U [45][ ] = { -4,-47,-96,-81,-81,-93,-103,-99,-106,-75,-52,-75,-100,-104,-94,-78,-107,-108,-46, 48,115,122,102,118, 87,
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A.2 Mean face

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159, 160, 156, 151, 147, 144, 138, 133, 132, 131, 131, 131, 130, 126, 121, 114, 108, 102, 101, 99, 102, 103, 107, 110,
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142, 127, 106, 103, 113, 106, 91, 95, 114, 133, 148, 157, 158, 157, 156, 156, 153, 149, 145, 143, 142, 140, 138, 134,
131, 129, 125, 118, 111, 106, 105, 103, 101, 99, 101, 100, 102, 102, 65, 56, 81, 71, 63, 60, 59, 63, 69, 78, 89,
100, 108, 115, 122, 128, 132, 135, 136, 127, 108, 101, 110, 111, 102, 100, 119, 137, 147, 154, 155, 154, 153, 152, 149,
144, 141, 139, 138, 137, 135, 132, 129, 125, 120, 113, 107, 104, 103, 101, 99, 96, 98, 96, 98, 98, 63, 61, 86, 76,
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150, 151, 151, 151, 147, 144, 141, 138, 136, 135, 133, 131, 128, 123, 118, 112, 106, 104, 103, 101, 99, 97, 93, 94,
94, 95, 95, 60, 69, 96, 84, 74, 71, 66, 63, 62, 67, 72, 80, 87, 93, 99, 105, 110, 112, 114, 115, 109, 101, 102,
109, 115, 120, 129, 136, 140, 145, 147, 147, 147, 143, 141, 138, 136, 134, 131, 128, 126, 120, 115, 110, 108, 107, 108,
106, 103, 102, 100, 94, 91, 87, 89, 91, 58, 77, 109, 96, 82, 76, 70, 67, 63, 63, 65, 69, 74, 80, 84, 89, 92,
97, 99, 101, 101, 98, 98, 103, 109, 115, 123, 131, 135, 138, 140, 141, 140, 139, 135, 131, 128, 125, 121, 118, 116,
113, 114, 115, 117, 118, 119, 115, 110, 104, 99, 93, 91, 86, 87, 91, 58, 86, 123, 111, 96, 88, 78, 73, 68, 68, 66,
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117, 115, 116, 116, 119, 122, 125, 126, 127, 125, 123, 119, 111, 106, 99, 97, 92, 92, 95, 62, 95, 137, 125, 111, 105,
93, 84, 77, 74, 72, 70, 67, 66, 65, 66, 68, 68, 68, 69, 69, 70, 72, 75, 78, 81, 89, 98, 104, 109, 113, 115, 116,
118, 118, 120, 121, 120, 120, 122, 122, 124, 126, 127, 128, 128, 128, 126, 124, 121, 115, 107, 104, 99, 99, 102, 67,
101, 154, 140, 129, 120, 112, 102, 94, 85, 82, 78, 77, 74, 71, 69, 66, 66, 65, 64, 64, 63, 64, 68, 71, 76, 82,
91, 100, 107, 111, 115, 119, 123, 122, 123, 125, 125, 125, 126, 127, 125, 126, 127, 127, 125, 125, 125, 125, 127, 125,
120, 113, 108, 106, 108, 69, 103, 161, 153, 145, 137, 128, 120, 112, 105, 100, 95, 94, 92, 89, 84, 80, 77, 76, 75,
75, 73, 73, 76, 80, 84, 90, 98, 107, 114, 120, 124, 126, 125, 127, 128, 129, 129, 129, 130, 129, 127, 126, 125, 125,
124, 125, 128, 129, 129, 128, 125, 119, 113, 112, 113, 71, 109, 167, 162, 156, 149, 142, 135, 128, 124, 119, 114, 111,
109, 106, 103, 101, 97, 93, 90, 90, 89, 89, 91, 94, 99, 102, 107, 113, 120, 125, 128, 130, 130, 132, 132, 131, 132,
133, 132, 131, 130, 129, 130, 130, 131, 131, 132, 132, 131, 130, 129, 125, 121, 122, 121, 74, 112, 171, 168, 163, 158,
153, 148, 143, 137, 134, 130, 127, 124, 121, 119, 116, 114, 111, 107, 105, 106, 107, 109, 110, 114, 117, 121, 125, 129,
132, 133, 135, 135, 134, 134, 134, 135, 136, 137, 136, 136, 138, 139, 139, 138, 136, 136, 136, 135, 134, 133, 132, 129,
131, 127, 79, 123, 180, 176, 172, 169, 165, 161, 157, 151, 148, 145, 143, 141, 139, 136, 134, 132, 130, 127, 126, 126,
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144, 144, 143, 143, 143, 142, 142, 138, 137, 133, 87, 72, 122, 115, 114, 111, 109, 107, 104, 104, 102, 101, 99, 98,
97, 95, 94, 92, 91, 90, 90, 90, 90, 89, 88, 88, 89, 89, 89, 89, 89, 90, 90, 91, 92, 93, 95, 96, 96, 97, 97,
96, 97, 96, 96, 96, 95, 95, 95, 94, 95, 93, 95, 92, 89, 89, 50};

Annex B

(Normative)

Binary representation of media time tools

B.1 Introduction

In this annex the binary representation of the media time datatypes defined ISO/IEC 15938-5 are specified. The binary representation is applicable to several visual descriptors such as CameraMotion and TemporalInterpolation. The DDL representation syntax is specified in ISO/IEC 15938-5.

B.2 Binary representation syntax

MediaTimeType {	**Number of bits**	**Mnemonic**
MediaTimePointSelect	2	bslbf
if(MediaTimePointSelect==0) {		
MediaRelIncrTimePoint		MediaRelIncrTimePointType
}		
if(MediaTimePointSelect==1) {		
MediaRelTimePoint		MediaRelTimePointType
}		
if(MediaTimePointSelect==2) {		
MediaTimePoint	See ISO/IEC 15938-1	mediaTimePointType
}		
MediaDurationSelect	2	bslbf
if(MediaDurationSelect==2) {		
MediaDuration	See ISO/IEC 15938-1	mediaDurationType
}		
if(MediaDurationSelect==3) {		
MediaIncrDuration		MediaIncrDurationType
}		
}		
MediaRelTimePointType {		
IsMediaTimeBase	1	bslbf
if(IsMediaTimeBase) {		
mediaTimeBase		UTF-8
}		
mediaTimeOffset	See ISO/IEC 15938-1	mediaTimeOffsetType
}		
MediaRelIncrTimePointType {		
IsMediaTimeBase	1	bslbf
if(IsMediaTimeBase) {		
mediaTimeBase		UTF-8
}		
IsMediaTimeUnit	1	bslbf
if(IsMediaTimeUnit) {		
mediaTimeUnit		mediaDurationType
}		
increments		vluimsbf5
}		
MediaIncrDurationType {		
IsMediaTimeUnit	1	bslbf
if(IsMediaTimeUnit) {		
mediaTimeUnit		mediaDurationType
}		
increments		vluimsbf5

}		

B.3 Descriptor components semantics

MediaTimePointSelect
This element specifies the media time point representation. Possible media time point representations are MediaRelIncrTimePoint, MediaRelTimePoint and MediaTimePoint. These media time point representations are defined in ISO/IEC 15938-5.The meaning of the binary codes is specified in Table B.1.

Table B.1 — The meaning of MediaTimePointSelect.

Unit	Meaning
"00"	MediaRelIncrTimePoint
"01"	MediaRelTimePoint
"10"	MediaTimePoint
"11"	reserved

MediaDurationSelect
This element specifies the media duration representation. Possible media duration representations are MediaIncrDuration and MediaDuration. These media duration representations are defined in ISO/IEC 15938-5. The meaning of the binary codes is specified in Table B.2.

Table B.2 — The meaning of MediaDurationSelect.

Unit	Meaning
"00"	media duration not specified
"01"	media duration not specified
"10"	MediaDuration
"11"	MediaIncrDuration

IsMediaTimeBase
This field, which is only present in the binary representation, indicates the presence of mediaTimeBase attribute. If it is equal to 1, mediaTimeBase follows. If the field is set to 0 then the attribute is not present.

IsMediaTimeUnit
This field, which is only present in the binary representation, indicates the presence of mediaTimeUnit attribute. If it is equal to 1, mediaTimeUnit follows. If the field is set to 0 then the attribute is not present. The semantics of the remaining components is defined in ISO/IEC 15938-5.

The binary representation of mediaTimePointType is the same as for basicTimePointType (see ISO/IEC 15938-1). The binary representation of mediaDurationType and mediaTimeOffsetType is the same as for basicDurationType (see ISO/IEC 15938-1).

Annex C

(Informative)

Patent statements

The International Organization for Standardization and the International Electrotechnical Commission (IEC) draw attention to the fact that it is claimed that compliance with this part of ISO/IEC 15938 may involve the use of patents.
ISO and IEC take no position concerning the evidence, validity and scope of these patent rights.
The holders of these patent rights have assured the ISO and IEC that they are willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statements of the holders of these patents right are registered with ISO and IEC. Information may be obtained from the companies listed below.
Attention is drawn to the possibility that some of the elements of this part of ISO/IEC 15938 may be the subject of patent rights other than those identified in this annex. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

MPEG-7 Patent Statements							
		Sys	**DDL**	**Visual**	**Audio**	**MDS**	**Ref. Sof.**
	Canon				X		
	CIE	X	X	X	X	X	X
	Denso	X				X	
	ETRI	X	X	X	X	X	X
	Expway	X	X	X	X	X	X
	FhG				X		
	Fraunhofer				X		
	Geocast	X	X	X	X	X	
	HHI			X			X
	Hitachi	X	X	X	X	X	X
	Hyundai			X		X	X
	IBM	X	X	X	X	X	X
	JVC	X	X	X	X	X	X
	KDDI			X	X	X	X
	LG Electronics	X	X	X	X	X	X
	Matsushita	X	X	X	X	X	X
	Mitsubishi Electric	X	X	X	X	X	X
	NEC						
	NHK	X	X	X	X	X	X
	Philips	X	X	X	X	X	X
	Ricoh	X	X	X	X	X	X
	Samsung	X	X	X	X	X	X
	Sharp	X		X	X	X	X
	Siemens	X	X	X	X	X	X
	Sony	X	X	X	X	X	X
	Toshiba	X	X	X	X	X	X
	Vivcom					X	X