
**Information technology — Multimedia
content description interface —**

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

**AMENDMENT 1: Extensions of extraction
and use of MPEG-7 descriptions**

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

Partie 8: Extraction et utilisation des descriptions MPEG-7

*AMENDEMENT 1: Extensions d'extraction et utilisation des descriptions
MPEG-7*

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Amendment 1 to ISO/IEC TR 15938-8:2002 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information*.

NOTE This document preserves the sectioning of ISO/IEC TR 15938-8:2002. The text and figures given in this document are currently being considered as additions and/or modifications to those corresponding sections in ISO/IEC TR 15938-8:2002.

Information technology — Multimedia content description interface —

Part 8: Extraction and use of MPEG-7 descriptions

AMENDMENT 1: Extensions of extraction and use of MPEG-7 descriptions

Add after subclause 5.6:

5.7 GofGopFeature

This datatype is used to describe a certain visual feature representative of a series of video frames or collection of pictures. It is obtained by aggregating the visual descriptors extracted from each video frame or image in the collection.

5.7.1 Feature Extraction

First, the extraction algorithm computes a descriptor of the visual feature for each frame in the sequence or each image in the collection. The extraction is specified in the subclauses corresponding to the descriptor used (e.g. for HomogeneousTexture, subclause 4.3.1.1 is used). Once the values of the frame/image-based descriptors are computed, an instance of GofGopFeature is derived by the aggregation procedure corresponding to the descriptor used; as defined in ISO/IEC 15938-3.

There are three aggregation methods (i.e. Average, Median, SplitMerge) as follows:

- Average:

Each component of descriptors in the GOF or GOP is summed and then averaged to compose the aggregated description

- Median:

Each component of descriptors in the GOF or GOP is sorted and then the middle value is selected to compose the aggregated description.

- SplitMerge:

The DominantColor descriptors from different images are aggregated by merging of the clusters ("Value" elements) of different descriptors based on their proximity in colour space (the clusters within the same descriptor are also included as a special case, although if the extraction algorithm from 4.2.3.1 is followed, their distance will be greater than DISTANCE_MIN specified below). The merging procedure is performed iteratively, starting with the closest pair and repeating until only a small number of combined clusters remains. The outline of this algorithm is as follows:

closest_distance=0

While (number_of_clusters > MAX_NUM_OF_CLUSTERS or

closest_distance < DISTANCE_MIN) {

1. find two closest clusters
2. merge these two clusters

}

The distance between clusters is defined as the Euclidean distance between cluster centres, DISTANCE_MIN is the same as in 4.2.3.1 and MAX_NUM_OF_CLUSTERS is equal to 8.

Merging of the clusters is performed as follows. The representative colour value for the merged cluster is a weighted average of the colour values of the component clusters, where the weights are the *relative* pixel counts in the clusters.

$$m = w_1 m_1 + w_2 m_2$$

Merging of the colour variances is based on the assumption that each colour component is independent and for each component we assume that we are calculating the variance of a weighted sum of two Gaussian distributions. This leads to the following formula for the variance of the merged cluster σ^2 :

$$\sigma^2 = w_1 \sigma_1^2 + w_2 \sigma_2^2 + w_1 w_2 (m_1 - m_2)^2,$$

where σ_1^2, σ_2^2 are the variances of the component clusters, m_1, m_2 are their means and w_1, w_2 are

$$w_1 = W1/(W1+W2), w_2 = W2/(W1+W2)$$

where W1 and W2 are the unquantised weights for sub-descriptors.

5.7.2 Similarity Matching Criteria

Matching of GofGopFeature is performed using the descriptors' matching function appropriate to the descriptor used. Only GofGopFeature descriptors characterizing the same feature can be compared. For example, GofGopFeature using the HomogeneousTexture descriptor for two different sequences can be compared. Some descriptors allow multiple aggregation methods, for example, the Color Layout or Edge Histogram descriptors. Matching of GofGopFeature describing the same feature but derived with a different aggregation method is possible.

5.7.3 DDL instantiation examples

In the following two examples, an instance of ColorLayout is embedded in the GofGopFeature datatype.

In the first example, there is no specification of aggregation method.

```
<GofGopFeature>
  <Descriptor xsi:type="mpeg7:ColorLayoutType">
    <YDCCoeff>48</YDCCoeff>
    <CbDCCoeff>34</CbDCCoeff>
    <CrDCCoeff>32</CrDCCoeff>
    <YACCCoeff5>12 10 13 9 10</YACCCoeff5>
    <CbACCCoeff2>14 15</CbACCCoeff2>
    <CrACCCoeff2>16 12</CrACCCoeff2>
  </Descriptor>
</GofGopFeature>
```

In the second example, "Average" is used to aggregate descriptions.

```
<GofGopFeature>
  <Descriptor xsi:type="mpeg7:ColorLayoutType" aggregation="Average">
    <YDCCoeff>48</YDCCoeff>
    <CbDCCoeff>34</CbDCCoeff>
    <CrDCCoeff>32</CrDCCoeff>
    <YACCCoeff5>15 11 13 9 8</YACCCoeff5>
    <CbACCCoeff2>14 15</CbACCCoeff2>
    <CrACCCoeff2>16 12</CrACCCoeff2>
  </Descriptor>
</GofGopFeature>
```

In the following example, an instance of DominantColor is embedded in the GofGopFeature datatype.

```
<GofGopFeature>
  <Descriptor xsi:type="mpeg7:DominantColorType" aggregation="SplitMerge">
    <SpatialCoherency>0</SpatialCoherency>
    <Value>
      <Percentage>5</Percentage>
      <Index>0 89 203</Index>
      <ColorVariance>0 1 1</ColorVariance>
    </Value>
    <Value>
      <Percentage>14</Percentage>
      <Index>120 43 74</Index>
      <ColorVariance>0 1 0</ColorVariance>
    </Value>
    <Value>
      <Percentage>12</Percentage>
      <Index>243 212 27</Index>
      <ColorVariance>1 0 0</ColorVariance>
    </Value>
  </Descriptor>
</GofGopFeature>
```

In the following two examples, an instance of EdgeHistogram is embedded in the GofGopFeature datatype.

In the first example, there is no specification of aggregation method

```
<GofGopFeature>
  <Descriptor xsi:type="mpeg7:EdgeHistogramType">
    <BinCounts>
      2 6 4 4 2 1 7 5 3 2 1 6 4 2 2 2 5 4
      5 3 1 5 5 6 5 2 6 5 4 4 1 6 4 4 4 0 6 3 5
      2 1 5 5 6 6 4 2 3 6 7 3 2 5 5 7 3 2 4 4 7
      1 5 6 4 6 1 5 7 4 5 1 6 4 6 5 1 3 4 7 6
    </BinCounts>
  </Descriptor>
</GofGopFeature>
```

In the second example, "Average" is used to aggregate descriptions.

```

<GofGopFeature>
  <Descriptor xsi:type="mpeg7:EdgeHistogramType" aggregation="Average">
    <BinCounts>
      2  6  4  4  2  1  7  5  3  2  1  6  4  2  2  2  5  4  5  3  1
      5  5  6  5  2  6  5  4  4  1  6  4  4  4  0  6  3  5  2  1  5
      5  6  6  4  2  3  6  7  3  2  5  5  7  3  2  4  4  7  1  5  6
      4  6  1  5  7  4  5  1  6  4  6  5  1  3  4  7  6
    </BinCounts>
  </Descriptor>
</GofGopFeature>

```

In the following two examples, an instance of HomogeneousTexture is embedded in the GofGopFeature datatype.

In the first example, there is no specification of aggregation method.

```

<GofGopFeature>
  <Descriptor xsi:type="mpeg7:HomogeneousTextureType">
    <Average>19</Average>
    <StandardDeviation>20</StandardDeviation>
    <Energy>
      103  87  99  130  97  73  112  109  122  132  108  102  105  113
      106  141  103  111  78  76  82  117  88  70  69  61  48  68  48
      53
    </Energy>
    <EnergyDeviation>
      106  84  94  130  94  75  107  104  117  128  100  99  97  107  92
      132  90  106  76  64  78  110  83  65  64  52  39  72  35  47
    </EnergyDeviation>
  </Descriptor>
</GofGopFeature>

```

In the second example, "Median" is used to aggregate descriptions.

```

<GofGopFeature>
  <Descriptor xsi:type="mpeg7:HomogeneousTextureType" aggregation = "Median" >
    <Average>19</Average>
    <StandardDeviation>20</StandardDeviation>
    <Energy>
      103  87  99  130  97  73  112  109  122  132  108  102  105  113
      106  141  103  111  78  76  82  117  88  70  69  61  48  68  48
      53
    </Energy>
    <EnergyDeviation>
      106  84  94  130  94  75  107  104  117  128  100  99  97  107  92
      132  90  106  76  64  78  110  83  65  64  52  39  72  35  47
    </EnergyDeviation>
  </Descriptor>
</GofGopFeature>

```

5.7.3 Conditions of Usage

There are no specific conditions and limitations on the use of this container datatype.

Add after subclause 6.8:

6.9 Color Temperature

The color temperature of an image specifies the color of illumination in the scene of the image. It is expressed by Kelvin (K) temperature scale in the [1667K, 25000K] range. Using this, the color temperature descriptor describes the perceptual temperature feeling of an image. It targets the perception-based image browsing that enables viewers to navigate and match images based on the temperature perception (i.e. hot, warm, moderate, and cool) of the image.

This descriptor is also useful when a user would like to change the illumination of scene (i.e. still images or video) in favor of the user's preference. For example, some people might want to see warmer images (e.g. taken under incandescent lights) than original images while some people might want to see cooler images (e.g. taken under bright daylights). Those effects can be automatically achieved by adjusting the color temperature.

6.9.1 Color Temperature Browsing

6.9.1.1 Feature Extraction

The (correlated) color temperature of the scene-illumination in the image is extracted as follows.

Note: In this section, several references are made to sRGB, perceived illuminant, and (correlated) color temperature and its reciprocal scale. All information on these subjects can be found in [AMD1-1][AMD1-2][AMD1-3][AMD1-4][AMD1-5].

6.9.1.1.1 The Overall View of Color Temperature Extraction Algorithm

- 1) Linearizing input image: $RGB \rightarrow R_l G_l B_l$
- 2) Converting $R_l G_l B_l$ into XYZ
- 3) Removing pixels that have the pixel value smaller than the low luminance threshold(T_{ll})
- 4) Averaging XYZ value for all remained pixels: $X_a Y_a Z_a$
- 5) Calculating the self-luminous threshold: $X_{T_s}, Y_{T_s}, Z_{T_s}$ If $X_{T_s}, Y_{T_s}, Z_{T_s}$ have the same values with the previous values, go to procedure 7), else remove pixels that have the pixel value bigger than the self-luminous threshold and repeat procedure 4) to 6)
- 6) Averaging XYZ value for all pixels remained, estimating it as the illuminant tri-stimulus values, and computing the scene-illuminant chromaticity coordinates (x_s, y_s) in CIE 1931 diagram
- 7) Converting the scene-illuminant chromaticity (x_s, y_s) into color temperature T_c
 - (1) Calculating the chromaticity coordinates (u_s, v_s) in CIE 1960 UCS diagram from (x_s, y_s)
 - (2) Finding two adjacent isothermperature lines from (u_s, v_s) and obtaining the distance from those lines
 - (3) Computing the correlated color temperature using the distance ratio

6.9.1.1.2 The Detail of Extraction Algorithm

- 1) Linearizing input image: Obtain the linearized $R_l G_l B_l$ from the inverse gamma correction of the input RGB , which is the gamma-corrected for display devices

Note, it is assumed that an input image RGB is a gamma-corrected non-linear sR'G'B' in the range of 0~255(8bit) in the following equations.

if $R'_{sRGB}(i, j), G'_{sRGB}(i, j), B'_{sRGB}(i, j) \leq 0.03928 \times 255.0$,

$$R_{sRGB}(i, j) = \left(R'_{sRGB}(i, j) / 255 \right) \div 12.92$$

$$G_{sRGB}(i, j) = \left(G'_{sRGB}(i, j) / 255 \right) \div 12.92,$$

$$B_{sRGB}(i, j) = \left(B'_{sRGB}(i, j) / 255 \right) \div 12.92$$

else $R'_{sRGB}(i, j), G'_{sRGB}(i, j), B'_{sRGB}(i, j) > 0.03928 \times 255.0$,

$$R_l(i, j) = R_{sRGB}(i, j) = \left[\frac{\left(R'_{sRGB}(i, j) / 255 \right) + 0.055}{1.055} \right]^{2.4}$$

$$G_l(i, j) = G_{sRGB}(i, j) = \left[\frac{\left(G'_{sRGB}(i, j) / 255 \right) + 0.055}{1.055} \right]^{2.4},$$

$$B_l(i, j) = B_{sRGB}(i, j) = \left[\frac{\left(B'_{sRGB}(i, j) / 255 \right) + 0.055}{1.055} \right]^{2.4}$$

where (i, j) is the index for pixels

2) Converting linearized R_l, G_l, B_l into CIE 1931 tristimulus XYZ with conversion matrix M

$$\begin{bmatrix} X(i, j) \\ Y(i, j) \\ Z(i, j) \end{bmatrix} = M \bullet \begin{bmatrix} R_l(i, j) \\ G_l(i, j) \\ B_l(i, j) \end{bmatrix},$$

$$\text{where conversion matrix } M = \begin{bmatrix} 0.4124 & 0.3576 & 0.1805 \\ 0.2126 & 0.7152 & 0.0722 \\ 0.0193 & 0.1192 & 0.9505 \end{bmatrix}.$$

3) Removing pixels that have the pixel value smaller than the low luminance threshold(T_{ll})

$$\begin{cases} Y(i, j) < T_{ll}, & p(i, j) = 0 \\ \text{otherwise}, & p(i, j) = 255' \end{cases}$$

where $p(i, j)$ is the label for each pixel at the location (i, j) .

- 4) Averaging XYZ value for all pixels remained, which have $p(i, j) = 255$: $X_a Y_a Z_a$. $row * col$ intuitively means the number of all pixels remained.

$$X_a = \frac{1}{(row \times col)} \sum_{i=0}^{row-1} \sum_{j=0}^{col-1} X(i, j),$$

$$Y_a = \frac{1}{(row \times col)} \sum_{i=0}^{row-1} \sum_{j=0}^{col-1} Y(i, j),$$

$$Z_a = \frac{1}{(row \times col)} \sum_{i=0}^{row-1} \sum_{j=0}^{col-1} Z(i, j).$$

Calculating the self-luminous threshold: $X_{T_s}, Y_{T_s}, Z_{T_s}$

$$X_{T_s} = f \times k \times X_a,$$

$$Y_{T_s} = f \times k \times Y_a, \quad ,$$

$$Z_{T_s} = f \times k \times Z_a.$$

where $f \times k \times X_a Y_a Z_a$ means the estimated illuminant level [AMD1-4].

- 6) If $X_{T_s}, Y_{T_s}, Z_{T_s}$ have the same values with the previous values, go to procedure 7), else remove pixels that have the pixel value bigger than the self-luminous threshold and repeat procedure 4) to 6)

If $(X_{T_s}(t) = X_{T_s}(t-1), Y_{T_s}(t) = Y_{T_s}(t-1), Z_{T_s}(t) = Z_{T_s}(t-1)) \{ \text{go to 7) } \}$

else {

$$\begin{cases} X(i, j) > X_{T_s} \text{ or } Y(i, j) > Y_{T_s} \text{ or } Z(i, j) > Z_{T_s}, & p(i, j) = 0 \\ \text{otherwise,} & p(i, j) = 255 \end{cases}$$

}

repeat 4) ~ 6)

where t means the iteration time for the T_s and the initial values are set to

$$X_{T_s}(0) = 0, Y_{T_s}(0) = 0, Z_{T_s}(0) = 0.$$

- 7) Averaging the XYZ value for all pixels remained, estimating it as an illuminant tri-stimulus value, and computing the scene-illuminant chromaticity coordinates (x_s, y_s) in CIE 1931 diagram. Again, $row * col$ intuitively means the number of all pixels remained, which have $p(i, j) = 255$.

$$X_s = \frac{1}{(row \times col)} \sum_{i=0}^{row-1} \sum_{j=0}^{col-1} X(i, j),$$

$$Y_s = \frac{1}{(row \times col)} \sum_{i=0}^{row-1} \sum_{j=0}^{col-1} Y(i, j),$$

$$Z_s = \frac{1}{(row \times col)} \sum_{i=0}^{row-1} \sum_{j=0}^{col-1} Z(i, j).$$

$$x_s = \frac{X_s}{X_s + Y_s + Z_s},$$

$$y_s = \frac{Y_s}{X_s + Y_s + Z_s}.$$

8) Converting the scene-illuminant chromaticity (x_s, y_s) into color temperature T_c .

(1) Calculating the chromaticity coordinates (u_s, v_s) in CIE 1960 UCS diagram from (x_s, y_s).

$$u_s = \frac{4x_s}{-2x_s + 12y_s + 3},$$

$$v_s = \frac{6y_s}{-2x_s + 12y_s + 3}.$$

(2) Finding two adjacent isothermperature lines [Mori et al (1968)] from (u_s, v_s) and obtaining the distance from those lines: if (u_s, v_s) is located between i -th and $i+1$ -th isothermperature line then $d_i / d_{i+1} < 0$

$$d_i = \frac{(v_s - v_i) - t_i(u_s - u_i)}{(1 + t_i^2)^{1/2}},$$

where (u_i, v_i), t_i : chromaticity coordinates and slope for representing the i -th isothermperature line (Table AMD1-1 - Isothermperature lines: Calculated in accordance with the method proposed by Mori et al.(1968): The color temperatures between 1667K and 25000K and corresponding parameters(u_i, v_i, t_i) are marked with blue fonts) and d_i : distance between (u_s, v_s) and the i th isothermperature line.

(3) Calculating the correlated color temperature using the ratio of distance

$$T_c = \left[\frac{1}{T_i} + \frac{d_i}{d_i - d_{i+1}} \left(\frac{1}{T_{i+1}} - \frac{1}{T_i} \right) \right]^{-1},$$

where T_i is the color temperature for the cross point of the i -th isothermperature line with the daylight locus. The color temperatures less than 1667K and larger than 25000K are tuned to 1667K and 25000K, respectively.

Table AMD1-1 — Isotemperature lines: Calculated in accordance with the method proposed by Mori et al.(1968)

i	Reciprocal Megakelvin	Temperature T (K)	u_i	v_i	t_i
1	0	Infinity	0.18006	0.26352	-0.24341
2	10	100,000	0.18066	0.26589	-0.25479
3	20	50,000	0.18133	0.26846	-0.26876
4	30	33,333	0.18208	0.27119	-0.28539
5	40	25,000	0.18293	0.27407	-0.30470
6	50	20,000	0.18388	0.27709	-0.32675
7	60	16,667	0.18494	0.28021	-0.35156
8	70	14,286	0.18611	0.28342	-0.37915
9	80	12,500	0.18740	0.28668	-0.40955
10	90	11,111	0.18880	0.28997	-0.44278
11	100	10,000	0.19032	0.29326	-0.47888
12	125	8,000	0.19462	0.30141	-0.58204
13	150	6,667	0.19962	0.30921	-0.70471
14	175	5,714	0.20525	0.31647	-0.84901
15	200	5,000	0.21142	0.32312	-1.0182
16	225	4,444	0.21807	0.32909	-1.2168
17	250	4,000	0.22511	0.33439	-1.4512
18	275	3,636	0.23247	0.33904	-1.7298
19	300	3,333	0.24010	0.34308	-2.0637
20	325	3,077	0.24702	0.34655	-2.4681
21	350	2,857	0.25591	0.34951	-2.9641
22	375	2,677	0.26400	0.35200	-3.5814
23	400	2,500	0.27218	0.35407	-4.3633
24	425	2,353	0.28039	0.35577	-5.3762
25	450	2,222	0.28863	0.35714	-6.7262
26	475	2,105	0.29685	0.35823	-8.5955
27	500	2,000	0.30505	0.35907	-11.324
28	525	1,905	0.31320	0.35968	-15.628
29	550	1,818	0.32129	0.36011	-23.325
30	575	1,739	0.32931	0.36038	-40.770
31	600	1,667	0.33724	0.36051	-116.45

6.9.1.1.3 Optimal Interval Determination for Color Temperature Browsing Categories

To find the optimal range of color temperature values for each browsing category, interval classifiers for fuzzy categories based on rough information systems were used.

6.9.1.2 Browsing Method

1. For the hot image browsing, the browser starts displaying the images from the lowest sub-range in the hot color temperature range and continues displaying the images in the subsequent sub-ranges.
2. For the warm and moderate image browsing, the browser starts displaying images in the middle sub-range and continues displaying the images in the sub-ranges near the middle sub-ranges.

For the cool image browsing, the browser starts displaying the images from the highest sub-range in the cool color temperature range and continues displaying the images in the subsequent sub-ranges in a descending order.

The following is a pseudo-code in HTML format for color temperature browsing in the web browser using DOM and JavaScript. This code reads the XML document and generates corresponding DOM objects. Assume that the XML document of image DB is composed of image elements, which are again composed of an image link and its color temperature browsing type. This code produces category buttons on the web window. If one of the 4 category buttons is pushed, it will return the images belonging to the chosen category. Here, SortAscendingOrder(), SortDescendingOrder(), and RearrangeNearToFar() functions are left out to implementers where one can easily implement them.

```
<html>
<head>
  <title>color temperature browsing</title>
</head>

<script language="JavaScript"><!--Java script-->
function FindHot() {
  dom = ColorTemperature.XMLDocument; <!--DOM Object declaration-->
  node = dom.getElementsByTagName("Image") ;
  resulth = "";
  result.innerHTML = "";
  node = SortAscendingOrder(node); <!-- pseudo code: sort nodes
                                   in ascending order by its
                                   subRangeIndex value -->

  for (i=0;i< node.length-1; i++) {
    TitleString=node.item(i).lastChild.firstChild.firstChild.nodeValue;
    if (TitleString == "hot") {
      resulth=node.item(i).firstChild.firstChild.nodeValue+"\n\n";
      result.innerHTML += " <br />";
    }
  }
  if (resulth == "")
    result.innerHTML = "&lt;no hot image found&gt;";
}

function FindWarm(){
  dom = ColorTemperature.XMLDocument; <!--DOM Object declaration-->
  node = dom.getElementsByTagName("Image") ;
  node=RearrangeNearToFar(node); <!-- pseudo code: rearrange nodes
                                   with a middle value by
                                   its SubRangeIndex value -->

  resulth = "";
  result.innerHTML = "";
  for (i=0;i< node.length-1;i++) {
    TitleString=node.item(i).lastChild.firstChild.firstChild.nodeValue;
```

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6.9.2 Display Preference Control

People would often like to change the quality of the image or scene shown in display devices toward a way, which he/she prefers most. For example, people often control several buttons such as hue, brightness, and contrast to get the most natural and preferable scene for them. The color temperature provides the effective and efficient way to support the display preference control.

6.9.2.1 Decoding of Color Temperature

Color temperature of image could be obtained as follows:

Decode the first 2bits to identify the color temperature range of the category (e.g. 00: hot -> [1667K, 2250K], $T_{lb} = 1667$, $T_{ub} = 2250$).

- 1) $RT_{lb} = 10^6 / T_{lb}$, $RT_{ub} = 10^6 / T_{ub}$ (e.g. $RT_{lb} = 10^6 / 1667 = 599.88$, $RT_{ub} = 10^6 / 2250 = 444.444$).
- 2) Uniformly quantize [599.88, 444.444] into 64 sub-ranges.
- 3) Decode the last 6bits (e.g. 000001 -> 2nd sub-range) and pick the corresponding range (e.g. [597.0149, 595.0227]).
- 4) Calculate a mean $((597.0149 + 595.0227)/2 = 596.0188)$ and a representative color temperature of the range (i.e. $10^6 / 596.0188 \approx 1678K$).

6.9.2.1.1 Color Temperature Conversion for Display Preference Control

6.9.2.1.1.1 Color Temperature Conversion Overview

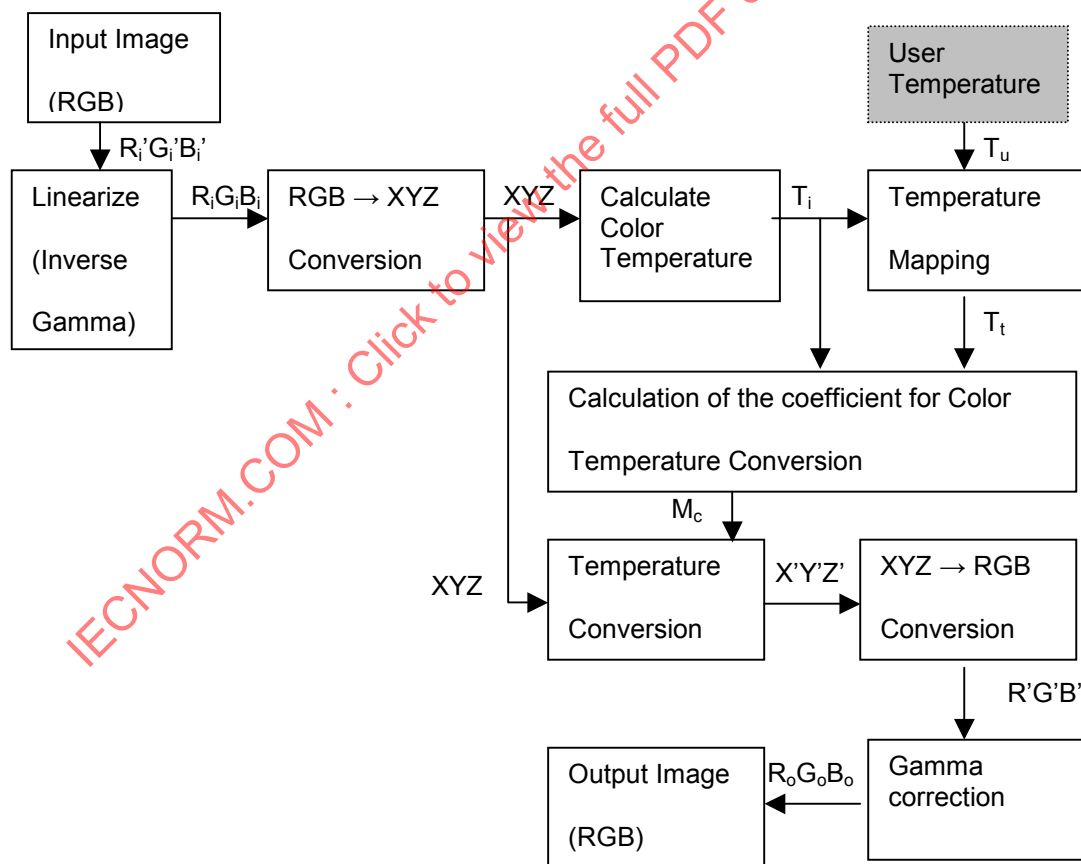


Figure AMD1-1 — Block diagram for the color temperature conversion

The overall flow of the color temperature conversion is shown in Figure AMD1-1 - Block diagram for the color temperature conversion. The color temperature mapping functions, calculation of the coefficient matrix, and image conversion are described in detail in the following subclauses.

6.9.2.1.2 Color Temperature Mapping Functions

When we obtain a user preferred color temperature against a training image (w/ a reference color temperature) through some user interface, we need to calculate a target color temperature against the input image on behalf of the relationship between the user preferred color temperature and the reference color temperature. The color temperature mapping indicates the mapping from the input color temperature to the output color temperature.

■ Input

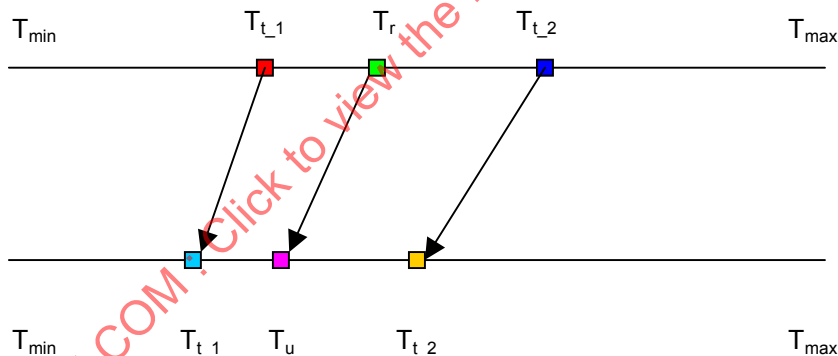
- T_i : Color temperature of input image
- T_u : User preferred color temperature

■ Output

- T_t : Target color temperature

■ Mapping Process

- 1) Get the color temperature of input image T_i , user preferred color temperature T_u , and target color temperature T_t .
- 2) Determine the reference color temperature T_r , e.g. D65 (6500K).
- 3) First of all, we can make T_r become T_u . Then, the color temperatures around T_r (i.e. bigger or smaller color temperatures around the reference color temperature) are converted in accordance with the mapping function. An example is shown in figure below.



When an observer wants to see cooler scenes, the images in moderate or cool category become cooler. The images in warm or hot category would move a little bit towards cooler temperature or change none. The opposite is also similar. When an observer wants to see warmer scenes, the images in moderate, warm, and hot category become warmer. On the other hand, the images in cool category would move towards warmer temperature or change none. We applied this scheme to the color temperature mapping method as follows.

Let the training image's color temperature be T_r , let T_u be the color temperature of the training image changed by the user's preference, and RT_r and RT_u are the reciprocal color temperature of them, respectively, then let $RT_{\text{delta}} = RT_r - RT_u$. Now the test image comes in with Color Temperature T_i and its reciprocal RT_i , then we will set the target temperature, denoted by T_t , using the following rule.

1) Calculate a weight Θ

When the color temperature chosen by a user is greater than the color temperature of the training image ($T_u > T_r$),

If ($T_i < T_{lctb}$) $\Theta = 0$,

else if ($T_{lctb} \leq T_i \leq T_r$)

$$T_{ni} = \frac{(T_i - T_{lctb})}{(T_r - T_{lctb})}, T_{ni} = [0, 1]$$

$$\Theta = T_{ni},$$

else

$$\Theta = 1.$$

T_{lctb} can be obtained as follows:

$$RT_{LCBT} = RT_r + (RT_{min} - RT_r) / 2 \text{ where } RT = 10^6 / T$$

$$T_{LCBT} = 10^6 / RT_{LCBT}.$$

When the color temperature chosen by a user is less than the color temperature of the training image ($T_u < T_r$),

If ($T_i \leq T_r$) $\Theta = 1$,

else if ($T_r < T_i \leq T_{uctb}$)

$$\Theta_{uctb} = \left(\frac{(T_{max} - T_{uctb})}{(T_{max} - T_r)} \right)^\alpha.$$

With two known points, (T_{uctb}, Θ_{uctb}) and ($T_r, 1$), a line equation $y=mx+c$ can be obtained.

$$m = (\Theta_{uctb} - 1) / (T_{uctb} - T_r), c = 1 - m * T_r,$$

$$\Theta = m * T_i + c,$$

else

$$T_{ni} = \frac{(T_{ri} - T_i)}{(T_{max} - T_{rr})}, T_{ni} = [0, 1],$$

$$\Theta = f_{pow}(T_{ni}, \alpha) = (T_{ni})^\alpha .$$

T_{uctb} can be obtained as follows:

$$RT_{UCBT} = RT_r - (RT_r - RT_{max}) / 2 \text{ where } RT = 10^6 / T$$

$$T_{UCBT} = 10^6 / RT_{UCBT}.$$

2) Calculate a target temperature, T_t .

$$RT_t = RT_l - (RT_{delta} \times \Theta),$$

$$T_t = 10^6 / RT_t.$$

6.9.2.1.3 Calculation of Coefficients of Color Temperature Conversion and Obtaining Converted Image

6.9.2.1.3.1 Color Temperature Conversion Coefficients

The color temperature conversion coefficients are members of the matrix that is used for converting between two different color temperatures. In order to calculate the coefficients, we need a color temperature of the input image (T_i) and a target color temperature (T_t) that is obtained from the mapping function. We can then make the coefficient matrix M_c for the color temperature conversion. We have used the Bradford chromatic adaptation transform for the color temperature conversion that is from CIE (commission Internationale de l'Eclairage).

The process to calculate the coefficients is as follows.

Calculate XYZ for T_l and T_t . We can transform a color temperature T_c to a chromaticity (x, y) with the following method. The chromaticity (x, y) can be transformed to tristimulus XYZ by giving 1 to the value of Y.

If ($1667 \leq T_c < 4000K$)

$$x_D = -0.2661239 \frac{10^9}{T_c^3} - 0.2343580 \frac{10^6}{T_c^2} + 0.8776956 \frac{10^3}{T_c} + 0.179910 ,$$

else if ($4000K \leq T_c \leq 25000K$)

$$x_D = -3.0258469 \frac{10^9}{T_c^3} + 2.1070379 \frac{10^6}{T_c^2} + 0.2226347 \frac{10^3}{T_c} + 0.24039 ,$$

if ($x_D \leq 0.38405$)

$$y_D = 3.0817580 x_D^3 - 5.8733867 x_D^2 + 3.75112997 x_D - 0.37001483 ,$$

else if ($x_D \leq 0.50338$)

$$y_D = -0.9549476 x_D^3 - 1.37418593 x_D^2 + 2.09137015 x_D - 0.16748867 ,$$

else

$$y_D = -1.1063814 x_D^3 - 1.34811020 x_D^2 + 2.18555832 x_D - 0.20219683 .$$

$$\begin{aligned} X_w &= (x_D/y_D) \\ Y_w &= (y_D/y_D) \\ Z_w &= (z_D/y_D) = ((1 - x_D - y_D)/y_D) \end{aligned} .$$

When T_l is transformed to (X_{lw}, Y_{lw}, Z_{lw}) and T_t is transformed to (X_{tw}, Y_{tw}, Z_{tw}) , we can use the Bradford chromatic adaptation transformation to define the conversion between two tristimulus values.

$$\begin{bmatrix} X_{tw} \\ Y_{tw} \\ Z_{tw} \end{bmatrix} = \begin{bmatrix} M_{BFD} \end{bmatrix}^{-1} \begin{bmatrix} D \end{bmatrix} \begin{bmatrix} M_{BFD} \end{bmatrix} \begin{bmatrix} X_{lw} \\ Y_{lw} \\ Z_{lw} \end{bmatrix} .$$

Here,

$$\begin{bmatrix} M_{BFD} \end{bmatrix} = \begin{bmatrix} 0.8951 & 0.2664 & -0.1614 \\ -0.7502 & 1.7135 & 0.0367 \\ 0.0389 & -0.0685 & 1.0296 \end{bmatrix}, \begin{bmatrix} M_{BFD} \end{bmatrix}^{-1} = \begin{bmatrix} 0.9870 & -0.1471 & 0.1600 \\ 0.4323 & 0.5184 & 0.0493 \\ -0.0085 & 0.0400 & 0.9685 \end{bmatrix},$$

$$\begin{bmatrix} D \end{bmatrix} = \begin{bmatrix} R_{tw}/R_{lw} & 0 & 0 \\ 0 & G_{tw}/G_{lw} & 0 \\ 0 & 0 & B_{tw}/B_{lw} \end{bmatrix}$$

In the matrix D , R_{lw} , G_{lw} , B_{lw} and R_{tw} , G_{tw} , B_{tw} are the cone responses of the each illuminant. We can calculate the con response as follows:

$$\begin{bmatrix} R_w \\ G_w \\ B_w \end{bmatrix} = \begin{bmatrix} M_{BFD} \end{bmatrix} \begin{bmatrix} X_w/Y_w \\ Y_w/Y_w \\ Z_w/Y_w \end{bmatrix} .$$

Finally, the coefficients of matrix M_{CT} can be obtained as follows:

$$\begin{bmatrix} M_{CT} \end{bmatrix} = \begin{bmatrix} M_{BFD} \end{bmatrix}^{-1} \begin{bmatrix} D \end{bmatrix} \begin{bmatrix} M_{BFD} \end{bmatrix}$$

6.9.2.1.3.2 Obtaining Converted Image from Input Image

Now, we can convert the input image to the output image with the target color temperature. First of all, we can calculate the tristimulus XYZ of each pixel in the input image. Then, we can calculate the converted $X'Y'Z'$ by multiplying the coefficient matrix M_{CT} to XYZ . We can calculate $R'G'B'$ from $X'Y'Z'$. Finally, the $R'G'B'$ is transformed to $R_oG_oB_o$ after applying the gamma correction process.

$$\begin{bmatrix} X'(i, j) \\ Y'(i, j) \\ Z'(i, j) \end{bmatrix} = \begin{bmatrix} M_{CT} \end{bmatrix} \begin{bmatrix} X(i, j) \\ Y(i, j) \\ Z(i, j) \end{bmatrix},$$

$$\begin{bmatrix} R'_l(i, j) \\ G'_l(i, j) \\ B'_l(i, j) \end{bmatrix} = \begin{bmatrix} M \end{bmatrix}^{-1} \begin{bmatrix} X'(i, j) \\ Y'(i, j) \\ Z'(i, j) \end{bmatrix},$$

if $(R'_l(i, j), G'_l(i, j), B'_l(i, j)) \leq 0.00304$,

$$R_o(i, j) = (R'_l(i, j) \times 12.92) \times 255$$

$$G_o(i, j) = (G'_l(i, j) \times 12.92) \times 255.$$

$$B_o(i, j) = (B'_l(i, j) \times 12.92) \times 255$$

if $(R'_l(i, j), G'_l(i, j), B'_l(i, j)) > 0.00304$,

$$R_o(i, j) = \left(1.055 \times (R'_l(i, j))^{\frac{1}{2.4}} - 0.055 \right) \times 255$$

$$G_o(i, j) = \left(1.055 \times (G'_l(i, j))^{\frac{1}{2.4}} - 0.055 \right) \times 255.$$

$$B_o(i, j) = \left(1.055 \times (B'_l(i, j))^{\frac{1}{2.4}} - 0.055 \right) \times 255$$

6.9.3 DDL Instantiation Examples

```
<ColorTemperature>
  <BrowsingCategory>hot</BrowsingCategory>
  <SubRangeIndex>1</SubRangeIndex>
</ColorTemperature>
```

6.9.4 Conditions of Usage

This descriptor is useful when user wants a coarse browsing of images or video segments with similar perceptual temperature feelings. Note that it can also be used in combination with the other descriptors in MPEG-7. For example, in looking for a preferred image, one can use the color temperature descriptor to find a set of candidates with the similar perceptual property or feeling without any query image and then use the

dominant color descriptor or the color layout descriptor to get a precise similarity match list among the candidate images. The case is similar for video segments. In this case, a representative color temperature descriptor value can be obtained by calculating the average color temperature descriptor values of all the frames or by selecting a color temperature descriptor of a representative frame in the video segment.

This descriptor is also useful when user wants to change the display quality of still images, video or TV signal in favor of the user's preference. User can automatically change the color temperature of video or TV signal. User can see a natural effect of changing illumination shone on the scene as long as maintaining the relative color temperature difference between consecutive scenes. In real-life application, we assume that there is an agent, in the form of software or hardware, to fulfil the functionality of display preference. The agent obtains user's preference for display through several possible interfaces and records it. The preferred color temperature value can be obtained through a direct input from a user or through a user's choice on given several examples of visual images.

6.10 Illumination Invariant Color

This descriptor provides means to achieve illumination invariance with existing color descriptors; Dominant Color, Scalable Color, Color Layout and Color Structure. This involves the preprocessing of the images to normalize their color temperatures to canonical illumination 6500K. Its main functionality is the similarity matching independent of illumination changes including the presence of shadow.

6.10.1 Feature Extraction

To achieve illumination invariance, the descriptors for both the query and database images are extracted from preprocessed images. The preprocessing consists of the Bradford chromatic adaptation transform defined in detail in the subclause 6.9.2.1.3.1. The transform converts the averaged chromaticity diagram of an image to the chromaticity diagram of canonical illumination corresponding to 6500K on the daylight locus. Once this preprocessing is applied, the color descriptors are extracted and matched as specified in the corresponding subclauses

Tool	Subclause
Dominant Color	4.2.3.1
Scalable Color	4.2.4.1
Color Layout	4.2.5.1
Color Structure	4.2.6.1

The algorithm for estimation of illumination (x, y) of an image is a combination of the color temperature extraction algorithm in the subclause 6.9.1.1.2 and the Grey-World algorithm. Its detailed procedure is as follows.

1) The preprocessing step.

This is the same as the first 2 steps of the color temperature extraction algorithm as described in the subclause 6.9.1.1.2. They consist of the following 3 steps.

- Convert image pixel RGB values to XYZ values.
- Remove the low luminance part.
- Remove the self luminance part by iterative manner.

2) The illumination (x, y) estimation step.

- Project the remaining XYZ values to x-y values.
- The bin counting step.

- Divide the x-y plane in 60 x 60 grids. We'll call the each cell as the 'bin'.
 - Index each bin 0 or 1 according to the presence of the (x, y) values in it, with a proper noise removal scheme. Specifically, there'll be a threshold value *alpha* depending on the image size and the total bin number that, for each bin, if the number of (x, y) values belonging to that bin is less than *alpha*, then the bin index is 0, otherwise the bin index is 1.
 - Average the center (x, y) values of each bin with index 1 to estimate the illumination (x, y). This is based on the Grey-World algorithm.
- 3) Image conversion step.

It is done in the same way as explained in the subclause 6.9.2.1.3. It consists of the following two steps.

- The image XYZ pixel value conversion by the Bradford transform calculated between the illumination (x, y) and the illumination (x, y) of the 6500K on the daylight locus lying in the x-y plane.
- Convert XYZ values to RGB values.

After converting the image to the canonical illumination 6500K, one can extract color descriptors (i.e. dominant color, scalable color, color layout, and color structure) from the converted image.

6.10.2 Similarity Matching

The similarity matching measurements from color descriptors for non illumination compensated pictures are equivalently applicable to the illumination compensated pictures.

6.10.3 DDL Instantiation Examples

```
<IlluminationInvariantColor>
  <ColorLayout>
    <YDCCoeff>50</YDCCoeff>
    <CbDCCoeff>34</CbDCCoeff>
    <CrDCCoeff>30</CrDCCoeff>
    <YACCCoeff5>16 12 15 12 17</YACCCoeff5>
    <CbACCCoeff2>12 17</CbACCCoeff2>
    <CrACCCoeff2>12 14</CrACCCoeff2>
  </ColorLayout>
</IlluminationInvariantColor>
```

6.10.4 Conditions of usage

This descriptor is useful when user wants to retrieve images with similar contents taken under different illumination conditions. In real-world, the illumination condition often changes due to varying weather conditions, different image acquisition times, presence of shadows, etc. The properties of the artificial illumination strongly depend on the lighting appliances used (e.g. bulbs, fluorescent lights). The color descriptors defined in ISO/IEC 15938-3 are mostly for the similarity search and retrieval functionality with no consideration of the illumination change in visual content. Illumination change can cause a great deal of change in the color distribution of the image and often makes two images with similar scene lie far apart in the color space. This descriptor acts as a container of the color descriptors so that any color descriptors can be extracted after applying the illumination invariant process and used for the illumination independent similarity matching. User will effectively retrieve images with this descriptor when the image database contains many similar scenes taken under different illumination conditions.

Add after subclause 8.4:

8.5 Shape Variation

This descriptor describes the variation of shape in a collection of binary images of objects. The collection of binary image includes a set of segmented images in sequence from a video. Its main functionality is to retrieve similar collection of shape images regardless of their sequence or the number of frames in each collection. When they are in sequences, it can be used for retrieval of Shape Variation represented by a set of frames in video segments – in terms of the similar shape variation due to the object movement.

8.5.1 Feature Extraction

8.5.1.1 The algorithm for extracting StaticShapeVariation and DynamicShapeVariation

- 1) Find the centroid of object regions in each frame.
- 2) Align the centroids of all frames.
- 3) Create SVM by accumulating object regions in each frame to create a two-dimensional histogram, and normalizing by the number of frames.

$$SVM(x, y) = \frac{1}{N} \sum_{k=1}^N V_k(x, y), \text{ where } \begin{cases} V_k(x, y) = 1 & \text{if } (x, y) \in \text{object region} \\ V_k(x, y) = 0 & \text{others} \end{cases}$$

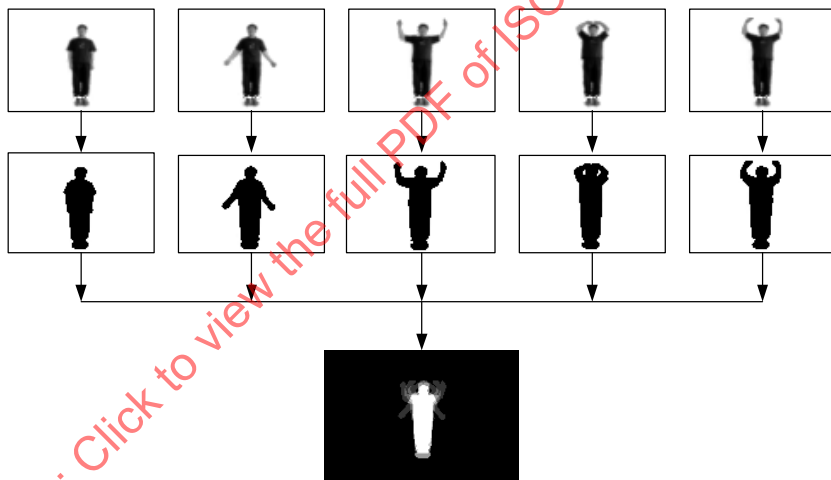


Figure AMD1-2 — Process of generating shape variation map.

- 4) Compute the ART coefficients of the SVM with angular order = 9 and radial order = 4 as described in the below.

a. Basis Function Generation: Construct a set of complex basis functions of ART in two 4-dimensional arrays, *BasisR*[9][4][LUT_SIZE][LUT_SIZE] and *BasisI*[9][4][LUT_SIZE][LUT_SIZE] for real and imaginary part, respectively. Here, *LUT_SIZE* is the size of Lookup table (typically *LUT_SIZE* = 101).

cx = *cy* = *LUT_SIZE*/2; // center of basis function

for(*y*=0 ; *y*< *LUT_SIZE* ; *y*++)

for(*x*=0 ; *x*< *LUT_SIZE* ; *x*++) {

radius = sqrt((*x*-*cx*)* (*x*-*cx*) + (*y*-*cy*)*(*y*-*cy*));

angle = atan2(*y*-*cy*, *x*-*cx*);


```

for(m=0 ; m<9 ; m++)
for(n=0 ; n< 4 ; n++) {
    temp = cos(radius * π * n/(LUT_SIZE/2));
    BasisR[m][n][x][y] = temp*cos(angle*m);
    BasisI[m][n][x][y] = temp*sin(angle*m);
}
}

```

- b. Size Normalization: The aligned centroid in the SVM is aligned to coincide with that of the lookup table. If the size of the image and that of lookup table are different, linear interpolation is applied to map the image onto the corresponding lookup table. Here, the size of the object is defined as twice the maximum distance from the centroid of the object.
- c. ART Transformation: The real and imaginary parts of ART coefficients are computed by summing up the multiplication of a pixel in an SVM to each corresponding pixel in the lookup table in raster scan order, respectively.
- d. Area Normalization: Compute each magnitude of ART coefficient and divide them by number of pixels in the object region for normalization.

5) StaticShapeVariation is obtained by a non-linear quantization of the magnitude of coefficients with 4 bits.

6) Invert the SVM excluding the background to generate a NSVM.

$$NSVM(x,y) = \begin{cases} 1 - SVM(x,y), & \text{if } SVM(x,y) \neq 0 \\ 0, & \text{otherwise} \end{cases}$$

7) Repeat the step 4) to get ART coefficients from the NSVM to obtain DynamicShapeVariation by a non-linear quantization of the magnitude of coefficients into 4 bits.

8.5.1.2 The algorithm for extracting StatisticalVariation

- 1) Generate ART coefficients with an angular order = 9 and radial order = 4 as described in the region shape descriptor.
- 2) Extract the ART coefficients of each object region in each frame.

$$\begin{aligned}
 ARTM_1 &= \{m_1(1), m_1(2), m_1(3), \dots, m_1(35)\} \\
 ARTM_2 &= \{m_2(1), m_2(2), m_2(3), \dots, m_2(35)\} \\
 &\vdots \\
 ARTM_N &= \{m_N(1), m_N(2), m_N(3), \dots, m_N(35)\}
 \end{aligned}$$

where, $ARTM_N$ and $m_N(k)$ denote the set of ART coefficients extracted from the N^{th} frame and k^{th} coefficient of the frame, respectively.

- 3) Calculate the standard deviation of the coefficient set STD.

$$STD = \{std(1), std(2), std(3), \dots, std(35)\}$$

$$std(k) = \sqrt{\frac{\sum_{n=1}^N (m_n(k) - \bar{m}(k))^2}{N-1}},$$

where, $\bar{m}(k)$ denotes the mean of k^{th} coefficients.

- 4) Multiply each standard deviation value by a weighting factor, 2. This is necessary to make use of the same quantization table for StaticShapeVariation, DynamicShapeVariation and StatisticalVariance as defined in the specification.
- 5) StatisticalVariation is obtained by a non-linear quantization of the standard deviation of the ART coefficients with 4 bits.

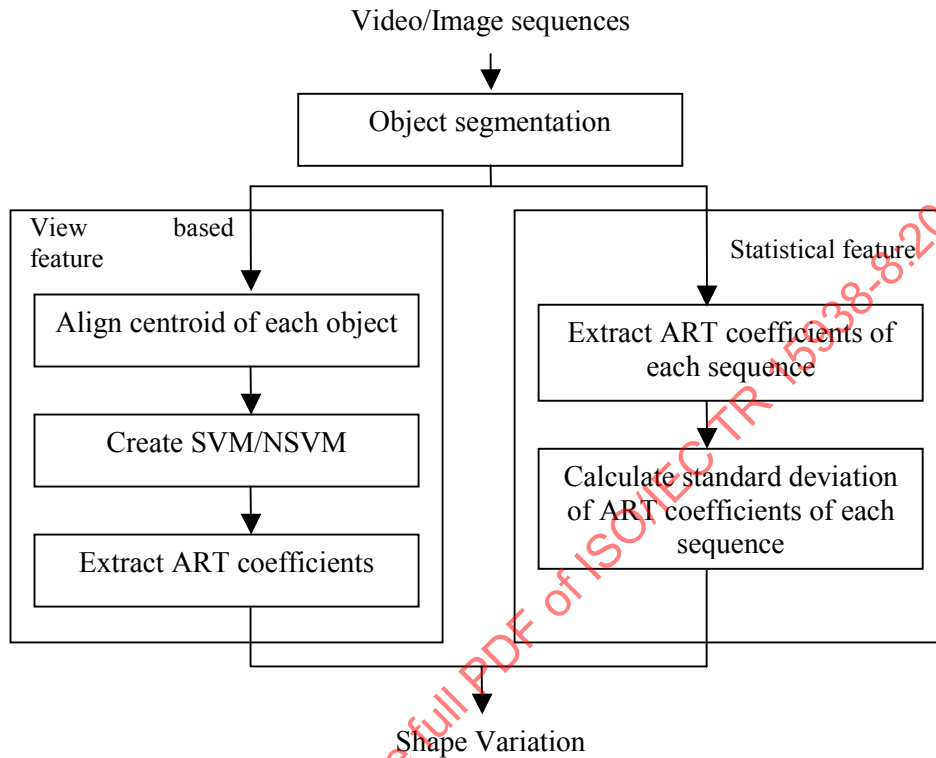


Figure AMD1- 3 — Procedure for computing Shape Variation

8.5.1.3 Matching method

The similarity distance between two Shape Variations is measured as follows:

$$\text{Distance}(Q, D) = D_{SSV}(Q, D) + D_{DSV}(Q, D) + D_{SV}(Q, D),$$

where,

$$D_{SSV}(Q, D) = \sum_{i=0}^{34} \left| \text{InverseQuantize}(\text{StaticShapeVariation}_Q[i]) - \text{InverseQuantize}(\text{StaticShapeVariation}_D[i]) \right|,$$

$$D_{DSV}(Q, D) = \sum_{i=0}^{34} \left| \text{InverseQuantize}(\text{DynamicShapeVariation}_Q[i]) - \text{InverseQuantize}(\text{DynamicShapeVariation}_D[i]) \right|,$$

$$D_{SV}(Q, D) = \sum_{i=0}^{34} \left| \text{InverseQuantize}(\text{StatisticalVariation}_Q[i]) - \text{InverseQuantize}(\text{StatisticalVariation}_D[i]) \right|.$$

8.5.2 DDL instantiation examples

```

<ShapeVariation>
  <StaticShapeVariation>
    15 15 13 3 8 2 10 15 12 15 4 11 8 3 7 15 12 12 10 13 8 5 6 12 10 1 9 11 7
  2 5 5 6 6 5
  </StaticShapeVariation>
  <DynamicShapeVariation>
    15 12 12 13 12 7 11 15 15 9 14 12 12 8 7 14 15 13 10 12 11 9 2 9 12 13 7 8
  9 8 8 3 7 9 10
  </DynamicShapeVariation>
  <StatisticalVariation>
    5 7 11 10 11 6 12 9 5 6 8 13 12 5 10 8 11 11 5 14 13 6 7 13 12 4 5 14 12 2
  3 10 9 8 3
  </StatisticalVariation>
</ShapeVariation>

```

8.5.3 Conditions of usage

This descriptor is useful when a user wants to find similar sequences in video or animation segments with the shape variation only of objects regardless of their size, color and texture. For example, in a sports video sequence of a diver jumping from the diving board, the number or the degree of rotation of the diver's body before splashing into water accounts for the points of game. This descriptor allows searching for video clips similar to the diver in terms of the body movement divers or the shape variation. The shape variation can be rotation invariant. Since the SVM is normalized by the number of frames in the sequence, video sequences with different number of frames can be retrieved, for example, a segment with slow video motion vs. a segment with normal speed. Although the size of each frame in sequence is assumed the same, a sequence of images with different size can also be compared.

This descriptor is computationally efficient and performs desired retrieval based on the variations of shapes from a database with images of various types of sequence images including character animations.

Add after subclause 11.1:

11.2 Advanced Face Recognition

11.2.1 Pose compensation for feature extraction

To extract CompositeFeature and CentralCompositeFeature, pose compensation is needed, and it is recommended to use the pose compensation method described as follows. It consists of two parts: pose estimation and pose alignment. The pose estimation classifies a normalized face image specified in the normative part into the nine poses, and the pose alignment transforms the face image into the frontal pose according to the estimated pose.

For pose estimation, the PCA-DFFS method is used, which is developed for face detection and face recognition. (PCA-DFFS stands for Principal Component Analysis followed by Distance From Feature Space.) When a normalized face image is given, it is projected onto the PCA subspaces of the projection matrices P_i ($i=1,2,\dots,9$) of the nine different poses. The definition for each pose class is presented in Table AMD1- 2 - Pose classes. Then, the distance of the image from pose i is computed by

$$d_i(\mathbf{x}) = \|\mathbf{x}\|^2 - \|\mathbf{P}_i(\mathbf{x} - \mathbf{M}_i)\|^2,$$

where $\mathbf{x}$ and $\mathbf{M}_i$ denote the column-wise raster scan of the normalized face image and the mean vector of the PCA subspace of pose i , respectively. The mean vectors and projection matrices are specified in Annex B. Note that the distance represents how much a face is described by the PCA subspace of a specific pose and it is called DFFS. The pose class with the minimum distance is selected as the most probable pose and it is computed by $i_{\min} = \min_i \{d_i(\mathbf{x})\}, i = 1, \dots, 9$.

Table AMD1- 2 — Pose classes

Pose ID	Definition
1	Up
2	Slightly Up
3	Left
4	Slightly Left
5	Frontal
6	Slightly Right
7	Right
8	Slightly Down
9	Down

Next, the pose alignment part warps the face image to the frontal pose according to the estimated pose classes. The normalized face image is geometrically warped into the frontal face image by using the Affine transformation matrix corresponding to the estimated pose class. The transformation of pose j is represented by a 6-dim vector $A_j = \{a, b, c, d, e, f\}$, which is specified in Table AMD1- 3 – Each row represents the affine transformation vector for each pose. The luminance of the warped face image at the position (x, y) is computed by

$$(1 - dy) \cdot \{(1 - dx) \cdot f(x', y') + dx \cdot f(x' + 1, y')\} + dy \cdot \{(1 - dx) \cdot f(x', y' + 1) + dx \cdot f(x' + 1, y' + 1)\},$$

where $x' = \text{ceil}(a \cdot x + b \cdot y + c)$, $y' = \text{ceil}(d \cdot x + e \cdot y + f)$, $dx = (a \cdot x + b \cdot y + c) - x'$, and $dy = (d \cdot x + e \cdot y + f) - y'$. Remind that $f(x', y')$ denotes the intensity of the normalized face image at the position (x', y') .

Table AMD1- 3 — Each row represents the affine transformation vector for each pose

Pose ID	A	B	C	E	D	f
1	0.991580	0.010128	0.074633	-0.003959	0.943660	1.515700
2	0.970768	-0.002972	0.881806	0.003942	0.887513	2.570872
3	1.037537	0.119828	-4.445840	-0.008323	1.242277	-5.354795
4	0.996640	-0.073498	1.742925	0.004347	1.033041	-0.724001
5	1.000000	0.000000	0.000000	0.000000	1.000000	0.000000
6	0.987388	0.086766	-1.807056	-0.003484	0.998318	0.264492
7	0.999838	-0.128101	3.728913	0.013586	1.185747	-4.659860
8	0.984965	-0.000953	0.423803	0.002269	0.970589	0.884239
9	0.978864	-0.003004	0.538113	0.011342	1.001916	-0.477181

11.2.2 Matching method

The distance between two face descriptors $\mathbf{w}$ and $\mathbf{w}'$ is defined by

$$\delta(\mathbf{w}, \mathbf{w}') = \sum_{i=0}^N a_i \|w_i - w'_i\|^2,$$

where N denotes the dimension of the descriptors. Smaller distance means more similar face.

It is recommended to use the recursive matching as shown in Figure AMD1- 4 - The block diagram of the joint retrieval scheme. When the Advanced Face Recognition descriptor is computed, the descriptor is influenced by environmental variations such as illumination and pose changes, and etc. Assuming that the first ranked retrieval image has the same identify with a query with different environmental variations, we use it as a new query image. This procedure is recursively done and it is called "the recursive matching."

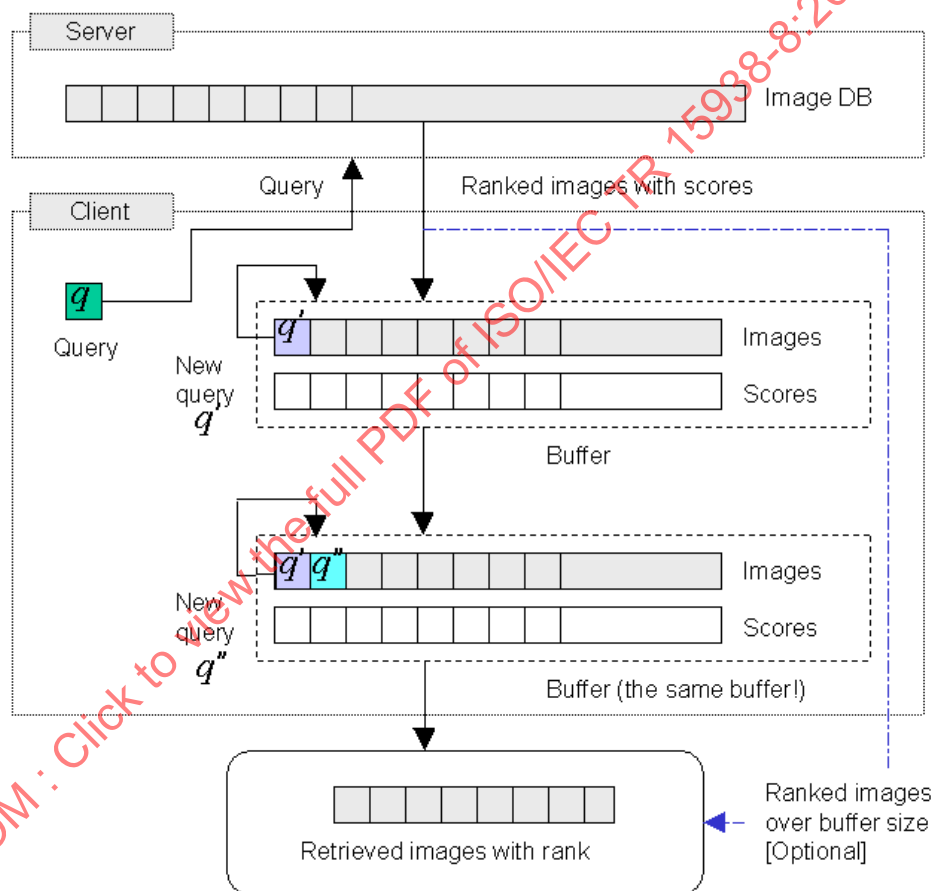


Figure AMD1- 4 — The block diagram of the joint retrieval scheme

Suppose that, given a query q , we would like to retrieve K images in ordered rank from an image database $\{I_i | i=1, \dots, N\}$ of size N . In the first step, from the query image, we can have sorted image set $\{q_i | i=1, \dots, M\}$ of size M from the image database, and they are stored into a buffer of size M . It includes its own corresponding score array $\{s(i) | i=1, \dots, M\}$, which is represented by $s(i) = \delta(q, q_i)$. In the next step, the first-ranked retrieval image q_1 is selected as a new query q' and the matching and sorting

procedure is repeated only within the buffer, not the whole database. As a result, we have the re-sorted image set $\{q'_i | i=1, \dots, M\}$ and the corresponding score array $\{s'(i) | i=1, \dots, M\}$. To reflect the matching by the new query, the score array is updated by

$$s'(i) = s(i) + b_1 \cdot \delta(q', q'_i),$$

where b_1 denotes a weighing constant. This procedure is performed recursively. In n -th step, we have a sorted data set $\{q_i^{(n-1)} | i=1, \dots, M\}$ with corresponding score array

$$\{s^{(n-1)}(i) | i=1, \dots, M\}, \text{ where } s^{(n-1)}(i) = s^{(n-2)}(i) + b_{n-1} \cdot \delta(q^{(n-1)}, q_i^{(n-1)}).$$

Based on experimental evidence, we recommend the parameter setting. The depth of additional iterations is 2, and $b_1 = 0.8$, $b_2 = (0.8)^2$.

11.2.3 DDL instantiation examples

```
<AdvancedFaceRecognition>
  <FourierFeature>
    24 14 21 13 10 31 21 24 10 1 19 18 11 8 21 9 12 20 19 19 23 15 10 22
  </FourierFeature>
  <CentralFourierFeature>
    18 10 2 0 22 19 18 29 6 17 10 12 15 14 20 17 19 13 17 31 11 20 11 20
  </CentralFourierFeature>
  <CompositeFeature>
    31 15 28 21 23 0 0 27 31 31 11 20 13 18 0 17 25 24 18 22 18 26 11 25 9 16
31 21 16 4 31 4 31 0 16 26 22 8 20 13 18 30 27 1 31 1 10 19 18 6 7 9 28 20 31 31
16 30 0 31 15 29
  </CompositeFeature>
  <SubregionCompositeFeature>
    22 20 0 31 0 31 15 0 31 15 5 23 25 14 10 26 20 22 11 31 31 0 0 24 22 15 17
0 31 22 31 14 23 24 31 0 10 25 22 20 24 29 31 0 1 9 10 16 0 0 1 18 12 15 22 0 31
31 7 31 31 31 7
  </SubregionCompositeFeature>
</AdvancedFaceRecognition>
```

11.2.4 Conditions of usage

Descriptor size versus accuracy

The descriptor provides an efficient description of a face image in a small descriptor size. When 24 components are respectively used in FourierFeature and CentralFourierFeature with extensionFlag = 0, the descriptor size becomes the minimum, which is 253 bits in binary representation. The minimum descriptor is recommended for applications under limited computer resources. To improve the recognition accuracy, it is recommended to increase the number of components in FourierFeature and CentralFourierFeature in most cases. CompositeFeature, and SubregionCompositeFeature are designed to provide more robust recognition to pose changes using pose compensation techniques.

Pose and illumination conditions

The descriptor is designed to identify faces robustly to variations in pose and illumination conditions. However, it becomes difficult to recognize faces with large pose variation such that one of eyes is not seen. In addition, larger pose variation and/or significant illumination changes may result in lower recognition accuracy.

Hair styles and backgrounds changes

FourierFeature and CompositeFeature are extracted from the full region of the normalized face image, which usually contains the hair of a head and/or backgrounds, while CentralFourierFeature and SubregionCompositeFeature are extracted from central part or subregions of the image which don't contain them. It is suggested to use mainly CentralFourierFeature and SubregionCompositeFeature in the applications where the change of hair styles and/or backgrounds may cause the degradation of recognition accuracy.

Add a new subclause 12:

12 Visual Description Schemes

12.1 Media-centric description schemes

12.1.1 DDL instantiation examples

In the following example, a photograph is described using ColorLayout, ColorTemperature and EdgeHistogram.

```
<StillRegionFeature>
  <ColorLayout>
    <YDCCoeff>40</YDCCoeff>
    <CbDCCoeff>34</CbDCCoeff>
    <CrDCCoeff>30</CrDCCoeff>
    <YACCCoeff5>16 12 15 12 17</YACCCoeff5>
    <CbACCCoeff2>12 17</CbACCCoeff2>
    <CrACCCoeff2>12 14</CrACCCoeff2>
  </ColorLayout>
  <ColorTemperature>
    <BrowsingCategory>hot</BrowsingCategory>
    <SubRangeIndex>1</SubRangeIndex>
  </ColorTemperature>
  <EdgeHistogram>
    <BinCounts>
      2 6 4 4 2 1 7 5 3 2 1 6 4 2 2 2 5 4
      5 3 1 5 5 6 5 2 6 5 4 4 1 6 4 4 4 0 6 3 5
      2 1 5 5 6 6 4 2 3 6 7 3 2 5 5 7 3 2 4 4 7
      1 5 6 4 6 1 5 7 4 5 1 6 4 6 5 1 3 4 7 6
    </BinCounts>
  </EdgeHistogram>
</StillRegionFeature>
```

In the following example, a video clip is described using RegularVisualTimeSeries and GofGopFeature that include ColorLayout and HomogeneousTexture instances.

```
<VideoSegmentFeature>
  <TemporalTransition
    offset="PT1N10F"
    <TimeIncr>PT3N10F</TimeIncr>
    <Descriptor xsi:type="ColorLayoutType">
      <YDCCoeff>50</YDCCoeff>
      <CbDCCoeff>34</CbDCCoeff>
      <CrDCCoeff>30</CrDCCoeff>
      <YACCCoeff5>16 12 15 12 17</YACCCoeff5>
```

```

        <CbACCCoeff2>12 17</CbACCCoeff2>
        <CrACCCoeff2>12 14</CrACCCoeff2>
    </Descriptor>
    <Descriptor xsi:type="ColorLayoutType">
        <YDCCoeff>48</YDCCoeff>
        <CbDCCoeff>34</CbDCCoeff>
        <CrDCCoeff>32</CrDCCoeff>
        <YACCCoeff5>12 10 13 9 10</YACCCoeff5>
        <CbACCCoeff2>14 15</CbACCCoeff2>
        <CrACCCoeff2>16 12</CrACCCoeff2>
    </Descriptor>
</TemporalTransition>
<RepresentativeFeature>
    <Descriptor xsi:type="mpeg7:HomogeneousTextureType">
        <Average>19</Average>
        <StandardDeviation>20</StandardDeviation>
        <Energy>
            103 87 99 130 97 73 112 109 122 132 108 102 105
            113 106 141 103 111 78 76 82 117 88 70 69 61 48
            68 48 53
        </Energy>
        <EnergyDeviation>
            106 84 94 130 94 75 107 104 117 128 100 99 97 107
            92 132 90 106 76 64 78 110 83 65 64 52 39 72 35
            47
        </EnergyDeviation>
    </Descriptor>
</RepresentativeFeature>
</VideoSegmentFeature>

```

Add the following to Bibliography:

- [AMD1-1] Michael Stokes, Matthew Anderson, Srinivasan Chandrasekar, Ricardo Motta, "A Standard Default Color Space for the Internet - sRGB, Version 1.10(<http://www.color.org>)", Nov. 5, 1996.
- [AMD1-2] Gunter Wyszecki and W. S. Stiles, Color Science, 2nd Edition, John Wiley & Sons, 1982.
- [AMD1-3] J.Y.Kim, D.S.Park, C.Y.Kim, Y.S.Seo, and Y.H.Ha, "New algorithm for detecting illuminant chromaticity from color images", Proceedings of SPIE(Electronic Imaging 2000) Vol. 3963, 2000.
- [AMD1-4] A.P.Petrov, Chang-Yeong Kim, Yang-Seok Seo, In-So Kweon, "Perceived illuminant measured," Color Research and Application, Vol.23, No.3, pp.159-168, 1998.
- [AMD1-5] Honam Lee, Hyungjin Choi, Bonggeun Lee, Sewoong Park, BongSoon Kang, "One dimensional conversion of color temperature in perceived illumination", IEEE Transaction on Consumer Electronics, Vol. 47, No. 3, AUGUST 2001.

Add a new Annex after Annex A:

Annex B (informative)

Model parameters for Advanced Face Recognition

Table B.1 — Renaming of model parameters

model parameter	Parameter name in the annex	related feature
basis matrix P_1	PCABasis1[27][1024]	PCA basis for Pose 1
mean vector M_1	PCAMean1 [1024]	Mean vector for Pose 1
basis matrix P_2	PCABasis2[27][1024]	PCA basis for Pose 2
mean vector M_2	PCAMean2 [1024]	Mean vector for Pose 2
basis matrix P_3	PCABasis3[27][1024]	PCA basis for Pose 3
basis matrix M_3	PCAMean3 [1024]	Mean vector for Pose 3
mean vector P_4	PCABasis4[27][1024]	PCA basis for Pose 4
basis matrix M_4	PCAMean4 [1024]	Mean vector for Pose 4
mean vector P_5	PCABasis5[27][1024]	PCA basis for Pose 5
basis matrix M_5	PCAMean5 [1024]	Mean vector for Pose 5
basis matrix P_6	PCABasis6[27][1024]	PCA basis for Pose 6
mean vector M_6	PCAMean6 [1024]	Mean vector for Pose 6
basis matrix P_7	PCABasis7[27][1024]	PCA basis for Pose 7
mean vector M_7	PCAMean7 [1024]	Mean vector for Pose 7
basis matrix P_8	PCABasis8[27][1024]	PCA basis for Pose 8
mean vector M_8	PCAMean8 [1024]	Mean vector for Pose 8
basis matrix P_9	PCABasis9[27][1024]	PCA basis for Pose 9
mean vector M_9	PCAMean9 [1024]	Mean vector for Pose 9

PCABasis1[27][1024]={

{1.501280e-002, 1.711993e-002, 2.045343e-002, 2.541499e-002, 2.834123e-002, 3.241811e-002, 3.556774e-002, 3.810931e-002, 4.221402e-002, 4.442059e-002, 4.258996e-002, 3.994420e-002, 3.960928e-002, 3.473797e-002, 3.472442e-002, 3.259166e-002, 3.023661e-002, 2.888217e-002, 2.779769e-002, 2.064468e-002, 1.523743e-002, 1.314148e-002, 1.251349e-002, 9.874586e-003, 9.407980e-003, 8.201608e-003, 8.238771e-003, 9.873762e-003, 8.641455e-003, 7.189462e-003, 1.402328e-003, -1.476796e-004, 1.899305e-002, 2.219543e-002, 2.718361e-002, 3.380050e-002, 4.241112e-002, 4.624950e-002, 5.134473e-002, 5.617701e-002, 5.794957e-002, 5.018131e-002, 4.411062e-002, 3.360100e-002, 3.266054e-002, 3.217387e-002, 2.980546e-002, 2.640419e-002, 2.053839e-002, 1.366599e-002, 6.007836e-003, 4.105663e-004, -5.478155e-003, -9.812378e-003, -1.153561e-002, -1.269306e-002, -1.312026e-002, -1.204642e-002, -1.288811e-002, -1.332431e-002, -1.341765e-002, -1.248715e-002, -1.358655e-002, -1.442529e-002, 2.259340e-002, 3.108548e-002, 3.897597e-002, 4.888060e-002, 5.451618e-002, 6.062703e-002, 6.602907e-002, 6.205995e-002, 5.298448e-002, 4.176735e-002, 2.937610e-002, 2.907123e-002, 2.804218e-002, 2.346646e-002, 1.724247e-002, 8.744371e-003, 4.549840e-004, -4.301922e-003, -8.982694e-003, -1.228540e-002, -1.152209e-002, -1.394879e-002, -1.574470e-002, -1.725454e-002, -1.855297e-002, -1.908937e-002, -1.939441e-002, -1.960759e-002, -2.018701e-002, -2.029153e-002, -1.935036e-002, -1.772156e-002, 3.260451e-002, 4.227271e-002, 5.461301e-002, 6.410075e-002, 6.712814e-002, 7.173623e-002, 6.570203e-002, 5.415150e-002, 4.076180e-002, 2.913318e-002, 2.240508e-002, 1.519957e-002, 9.094210e-003, 3.282224e-003, -4.163261e-004, -3.178633e-003, -5.332421e-003, -1.051423e-002, -1.487540e-002, -1.544030e-002, -1.562014e-002, -1.377530e-002, -1.591381e-002, -1.852644e-002, -2.006908e-002, -2.123198e-002, -2.140150e-002, -2.217307e-002, -2.355704e-002, -2.364714e-002, -2.370846e-002, -2.385855e-002, 4.501055e-002, 5.850433e-002, 6.854344e-002, 7.455156e-002, 7.745588e-002, 7.145905e-002, 5.501453e-002, 4.152745e-002, 2.357448e-002, 1.224095e-002, 3.240776e-003, -3.927175e-003, -7.650309e-003, -6.792873e-003, -6.569436e-003, -6.016485e-003, -7.628737e-003, -1.413319e-002, -1.701724e-002, -1.612302e-002, -1.675262e-002, -1.367796e-002, -1.707163e-002, -1.995959e-002, -2.136057e-002, -2.266919e-002, -2.265928e-002, -2.282888e-002, -2.297266e-002, -2.320781e-002, -2.452824e-002, -2.447923e-002, 6.028676e-002, 7.232880e-002, 7.981762e-002, 8.165475e-002, 7.501111e-002, 5.805129e-002, 3.489553e-002, 1.978307e-002, 3.829753e-003, -1.281069e-004, -1.066366e-002, -1.846237e-002, -1.457675e-002, -7.618879e-003, -4.580744e-003, -1.006707e-002, -1.400373e-002, -1.768734e-002, -1.964592e-002, -1.808136e-002, -1.760321e-002, -1.522850e-002, -1.790190e-002, -2.157977e-002, -2.400574e-002, -2.384993e-002, -2.391018e-002, -2.433765e-002, -2.392664e-002, -2.414283e-002, -2.492209e-002, -2.640692e-002,

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