MPEG-7 based Color Temperature Customization

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Abstract

MPEG-7 is a new standard which addresses the multimedia content description problem at very different levels: description tools range from low-level features such as color and pitch to high-level features such as the name of the characters in a scene or the title of a movie.

This paper presents an MPEG-7 enabled application based on a low-level descriptor: the visual color temperature. The implemented application relates the human perception of color with low-level information, automatically extractable, thus allowing to customize the visual content according to the user color temperature preferences.

I. INTRODUCTION

MPEG-7 is a new standard [1] addressing the multimedia content description problem at very different levels: it offers a wide range of description tools that range from low-level features such as color and pitch to high-level features such as the name of the characters in a scene. Color temperature is one of the low-level visual characteristics that can be automatically extracted from the image and represented as an MPEG-7 content description.

Color temperature can be thought as the illuminating light color of the observed scene. Since illumination conditions is an important factor that affects the user's feeling of an image, each person feels differently on two images of the same content with different illuminations. Therefore, there exist personal preferences in terms of image color temperature.

In *Fig. 1*.a, the source image looks to be taken under twilight while in *Fig. 1*.b it looks to be taken under daylight. Some people prefer the first image because of the warm feeling while others may prefer the second image more with a cool and bright feeling. It is also known that there is a cultural factor involved since there is a considerable difference between the color temperature preferences for Oriental and European people. While Europeans usually prefer temperatures around 5,000 K, Oriental people prefer temperatures around 9,300 K [2].

Fig. 1 – Picture with (a) sunset illumination (T = 2,627 K) and with (b) day light illumination (T = 8,640 K).

This paper describes an MPEG-7 based application that customizes visual content according to the user preferred color temperature.

II. THE MPEG-7 STANDARD

MPEG-7 provides a set of description tools intended to characterize the audiovisual content using adequate features and targeting among others retrieval, and filtering applications. These description tools are independent of the content format; in fact, the content described can be in any format, e.g., analog, PCM, H.261, MPEG-1, -2 or –4, JPEG, etc. The content and the associated descriptions are independent streams but the standard provides linking mechanisms between them; these links must work in both directions.

The types of description tools specified by the MPEG-7 standard are:

- **Descriptors (D):** represent a feature, and define the syntax and semantics of the feature representation; examples are a color histogram, the average of the frequency components, a motion field, the text of the title, etc.
- **Description Schemes (DS):** specify the structure and semantics of the relationships between their components, which may be both Descriptors, and Description Schemes; as example is a movie, temporally structured as scenes and shots, including some textual descriptors at the scene level, and color, motion and audio descriptors at the shot level.
- **Description Definition Language (DDL):** allows the definition of new DSs, as well as the extension of existing DSs.
- **Systems tools:** support the multiplexing of descriptions, synchronization of descriptions with the associated content, binary representation for efficient storage and transmission, management and protection of intellectual property, etc.

Fig. 2 includes a block diagram showing how descriptions are generated and consumed in the application developed. After extracting or human annotating the features, they are coded in the MPEG-7 format so that they can be consumed later by any MPEG-7 enabled application. MPEG-7 descriptions do not need to be located in the same place as the content.

Having the content itself and the corresponding MPEG-7 descriptions, an application may use the descriptions to search or filter content, as well as to adapt (e.g. transcode) content to ease the information access.

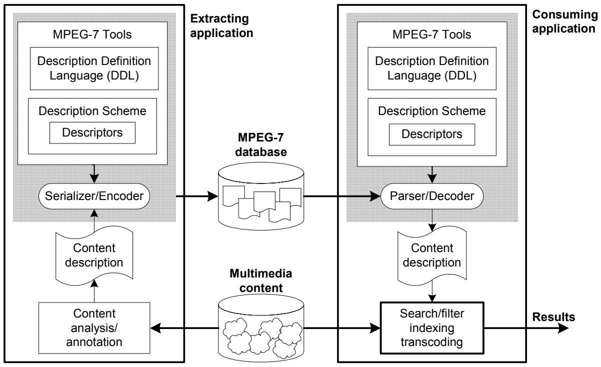

Fig. 2 – Abstract representation of MPEG-7 applications.

A. MPEG-7 Color Temperature Descriptor

MPEG has developed a low-level visual descriptor of color temperature [7] to describe images and videos and the corresponding user preference descriptor [8]. This low-level descriptor allows developing content customization applications with the capability to adapt visual content according to the user preferred color temperature.

The MPEG-7 descriptor is used to specify visual color temperatures and user color temperature preferences. The MPEG-7 color temperature descriptor semantics is quite simple: the *ColorTemperatureValue* parameter represents the color temperature of the given image/region. The range of the color temperature is [1,667; 25,000] in Kelvin units. The XML based descriptor syntax is as follows:

```
<!-- ######################################## -->
<!-- Definition of MPEG-7 ColorTemperatureType -->
<!-- ######################################## -->
<complexType name="ColorTemperatureType" final="#all">
  <complexContent>
       <extension base="mpeg7:VisualDType"/>
          <sequence>
             <element name=”ColorTemperatureValue”
                 type=”mpeg7:unsinged15”/>
          </sequence>
       </extension>
    </complexContent>
</complexType>
```

In a similar way, the user may specify his/her preference in terms of color temperature using this descriptor; in this case, the descriptor is used under the *UserPreferencesDS* that aggregates within MPEG-7 descriptions all user preferences related information.

III. BASICS ON COLOR TEMPERATURE

A light source, which is illuminating a scene, has several characteristics that can be measured. Such a light source is usually called the illuminant of a scene: one of the measures that can be taken is the color of that light, which is called the illuminant chromaticity. Another measure that can be taken from the scene illuminant is the color temperature of that light (the illuminant color temperature). The illuminant color temperature can be measured through the scene illuminant chromaticity. *Fig. 3* illustrates the described problem. In this paper, the term “color temperature” is used with the meaning of “scene illuminant color temperature”; see [3] for more details.

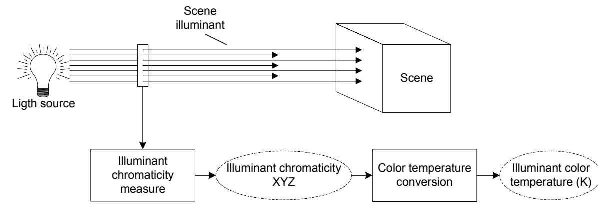

Fig. 3 – Light source, illuminant chromaticity and color temperature concepts.

Color temperature is a measure used to represent a property of light sources. In order to define color temperature, the concept of a blackbody radiator must be defined. A blackbody is a theoretical object, which is a perfect radiator – it absorbs all the incident radiation, and reradiates that energy with complete efficiency. As the temperature of a blackbody rises, it radiates energy in the visible range, first red, changing to orange, yellow, white and, finally, bluish. These colors plot as a curved line in the CIE chromaticity diagram, see *Fig. 4*. This curve is known as the blackbody locus.

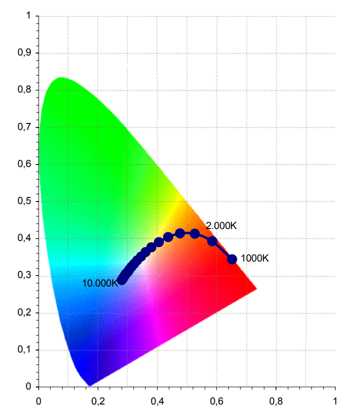

Fig. 4 – CIE-xy color system and blackbody locus.

The color temperature is not a measure of the physical temperature of the light source but rather of the temperature of the blackbody radiator when the color appearance is the same as the source being tested. Ironically, a low color temperature corresponds to what is considered a warm appearance (red and orange) while a high color temperature corresponds to a cool appearance (bluish light).

Color temperature is a measure, which humans can relate to a feeling of warm or cold from an image. This measure may be used in a content customization application to give the users more pleasant visual experiences [4]. In order to provide this functionality, it is required to have:

- a color temperature measurement algorithm [5];
- a color temperature transformation algorithm (to perform color temperature adaptations) [6].

These two types of algorithms are briefly described in the next sections.

IV. COLOR TEMPERATURE CUSTOMIZATION

The access to multimedia information by any terminal through any network is a new concept referred by the scientific community as *Universal Multimedia Access (UMA)*. The objective of UMA technology is to make available different presentations of the same information, more or less complex e.g. in terms of media types, suiting different terminals, networks and user preferences.

In the context of this paper, a UMA system has been implemented, where several content customization methods process information according to the user access conditions, and to the user preferences, in this case expressed in terms of color temperature. The major elements of the implemented system, see Fig. 5, are: (1) the *MPEG-7 Description* Tool, which is responsible for generating the MPEG-7 descriptions based on the content analysis results; (2) the *UMA Platform*, a content server that performs customizations according to the user environment characteristics; and (3) the *UMA browser*, a test tool acting like a Web terminal with the ability of supplying descriptions of the user environment characteristics (including color temperature preferences).

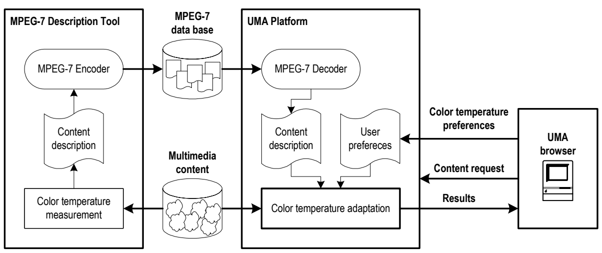

Fig. 5 – *The MPEG-7 based content customization system.*

There are several methods to transform the original image with a certain color temperature into another image with a different color temperature (following the user preference). To perform a color temperature customization, the following information is required:

- <u>Color temperature of the input image:</u> the color temperature can be directly extracted from the image or from an MPEG-7 description where the MPEG-7 color temperature descriptor is instantiated.
- <u>User preferred color temperature:</u> the user selects the pretended color temperature by example or value in the UMA browser. When selecting by example, the display device color temperature characteristics are already taken into account in the user selection.

Methods to measure the color temperature of an image and adapt it to the user preferences have been proposed to MPEG by the Samsung Advanced Institute of Technology [2]. Both algorithms have been implemented in [4]. It is important to notice that these algorithms are not standard; only the syntax and semantics of the color temperature descriptor are normative.

B. Measuring Color Temperature

Every physical body has two surface reflection characteristics: the diffuse and the specular reflection. When a surface is illuminated with a certain light source, part of that light is reflected with the same angle: this is the specular reflection. The other part of the light will initially penetrate into the object and will be after, partly absorbed and partly scattered back to the surface: this is the diffuse reflection.

Under certain conditions of direct illumination and viewing geometries, some surfaces show highlights (e.g. in the human skin this effect is easily observed corresponding to the white zones on the tip of the nose). Shafer's [9] proposes a method to measure the highlights; from this method, the illuminant chromaticity can be calculated. This is what is sometimes called the highlight method.

Self-luminous regions correspond to the areas in the scene that do not correspond to passive surface reflection areas. Self-luminous regions can also be thought of as active reflectors like a lamp itself, the light passing through an aperture in a wall or some specular reflection of an arbitrary surface. If these areas are excluded from the illuminant chromaticity calculation, the accuracy for the estimation will be increased.

Perceived illumination is a method to estimate the illuminant chromaticity from a color image by selectively excluding self-luminous regions. Humans can feel the global tone when looking at some arbitrary scene and exclude the light that is reflected by some surfaces. This tone information is proportional to the scene illuminant chromaticity. Since the measure pretended is a color temperature, the chromaticity coordinates are correlated with the blackbody locus coordinate corresponding to a certain color temperature, see [3].

The perceived illumination approach can provide a stable candidate range for the estimation of the illuminant chromaticity but the accuracy is not high and depends on the image content. The highlight method is not dependent on the image content and gives accurate values for the scene illuminant chromaticity, but it is difficult to select the final solution among those possible. The method proposed to MPEG by Samsung [2] allows estimating the illuminant chromaticity by combining both the perceived illumination and highlight algorithms.

C. Color Temperature Transformation

To faithfully reproduce the appearance of image colors (or to adapt to certain user preferences), a color temperature transformation system needs to apply a transform to the image that converts the input colors captured under the input illumination to the corresponding output colors under the relevant output illumination. This can be achieved using a chromatic adaptation transform in the XYZ domain (chromaticity domain), see [6] for details.

V. EXPERIMENTS AND TESTS

The color temperature customization tests used the color temperature extraction method presented in the previous section. Using the UMA browser to access the content, the user may select the pretended color temperature by example or value; it is the task of the content customization platform to transform the image to provide the user another image with the preferred color temperature. Qualitative results corresponding to this process can be observed in Figure 6.

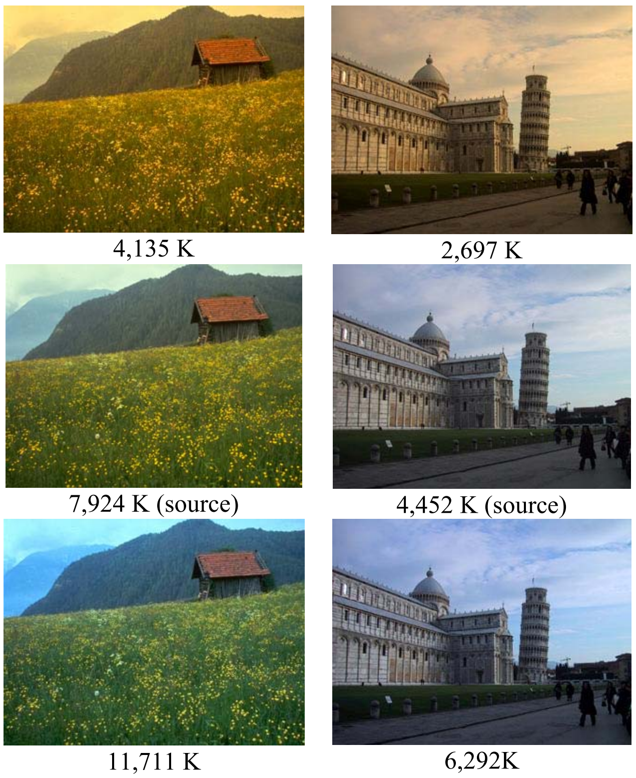

Fig. 6 – Color temperature customizations examples.

The UMA Platform was running in a content server with a Pentium III 850MHz / 256Mb RAM / SCSI disks. Table 1 presents some results of color temperature adaptations in terms of customization time (CPU costs in the content server) and required memory (memory costs in the content server).

Table 1 – Color temperature image customization measures.

Image characteristics	**Average customization time**	**Required buffer**
1600x1200 pixels; 24 bits	41410 ms	5625 kBytes
1024x768 pixels; 16 bits	14851 ms	1536 kBytes
640x480 pixels; 8 bits	5808 ms	300 kBytes
320x240 pixels; 8 bits	1552 ms	75 kBytes

To perform color temperature adaptations, two memory buffers are required: a buffer for the source image and a buffer of the same size for the output image. Moreover, the CPU costs for this customization task are also quite high (the processing time is in the order of thousands of milliseconds per image). It is trivial to note from the color temperature adaptation algorithm that the target color temperature does not affect the amount of transform calculations. Therefore, since the example image and the target color temperatures are irrelevant for the amount of calculations, the measures taken used an arbitrary target color temperature.

VI. FINAL REMARKS

This paper presents a color temperature customization system for which an algorithm to measure the image illuminant color temperature and an algorithm to transform the color temperature were implemented. Both algorithms were included in an MPEG-7 based application using a low-level MPEG-7 descriptor: the visual color temperature. The implemented application relates the human perception of color with low-level information, automatically extractable, thus allowing to customize the visual content according to the user color temperature preferences. This is today a rather rare capability since most of the MPEG-7 enabled applications still only use text based descriptors.

VII. REFERENCES

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