Color descriptors from compressed images

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Background

The representation of color is a very important issue in color image processing and image compression in particular. A lot of efforts have been devoted to this during the development of the still and moving picture standards such as *JPEG, MPEG* and *H.26x*. Color representation plays very important role in **lossy image compression** and **lossless image compression** efficiency, in image retrieval efficacy and in the required computational complexity (in lossy category of image compression, the original image cannot be exactly reconstructed from the compressed image, where as in the lossless, the original image can be exactly reconstructed. Lossy algorithms generally produce greater compression than lossless compression.). The *monochrome, RGB* and *YCrCb* color spaces are those supported by all coding standards. The conversion from the *RGB* to the *YCrCb* is a linear non-reversible (i.e. lossy) transformation. In order for the *JPEG2000* standard to achieve lossless compression of color images, a new reversible color transformation has been defined. In absence of quantisation errors this decorrelating transformation introduces no errors (reversible/lossless). Three goals are achieved by this transformation, namely color decorrelation for efficient compression, reasonable color space with respect to the human visual system for quantisation and ability of having lossless compression, i.e. exact reconstruction with finite integer precision.

While early *MPEG* standards *MPEG-1* and *MPEG-2* concentrated almost entirely on compression, *MPEG-4* moved to a higher level of abstraction in coding objects and using content-specific techniques for coding content. *MPEG-7* has moved to an even higher level of abstraction, i.e. to cognitive coding. *MPEG-7* allows the localization of the required content. Color is the main visual feature, along with texture, shape and motion, towards content localization **[1]**.

Color descriptors – *MPEG-7* approach

The way colors in an image should be characterized relating to its perception, coherency and spatial distribution, several approaches to its description have been proposed. *MPEG-7* has standardized a subset of these approaches in the form of color descriptors. *MPEG-7* is a content representation standard for information search.

MPEG-7 defines five color descriptors (generally speaking, there are 7 color descriptors but *color space* and *color quantization* are considered as basic blocks). These descriptors cover different aspects of color and application areas. These five color descriptors are as follows:

- *Dominant Color*
- *Scalable Color*
- *Color Structure*
- *Color Layout*
- *Group of Frames/Group of Pictures Color*

Besides the “proper” descriptors listed above, *MPEG-7* standard contains two basic blocks or data types: *Color Space* and *Color Quantization*. These are not descriptors in their own right; they mainly serve as a reference for the specification of color space and its quantization in other descriptors **[2]**.

- *Color Space*:

The *color space* data type is used to specify the color space that a given descriptor refers to. It defines four color spaces: *RGB, YCbCr, HVS* and *HMMD*. For flexibility, a new color space can be defined by specifying the linear transformation from the *RGB* color space **[2]**.[1]

	JPEG	**JPEG2000**	**MPEG-1,-2,-4**	**MPEG-7**
Monochrome	YES	YES	YES	YES
RGB	YES	YES	YES	YES
YCrCb	YES	YES	YES	YES
YUrVr		YES		YES
HSV				YES
HMMD				YES
Linear Matrix				YES

Table 1: Color Spaces supported by the coding standards **[1].**

- *Color Quantization:*

This data types defines a uniform quantization of the given color space. Quantisation is the reduction of the number of unique colors in an image. The linear, non-linear and lookup table quantisation types are supported. In the linear case the normalized color value range is divided into equal intervals. Each quantized color is represented by a color value in three components according to the quantisation type used. When a lookup table is used it can be done instantly, otherwise it has to be calculated from predefined formulas and the current index [1].[2]

Only the *dominant color* descriptor actually uses these two data types directly. All the other descriptors fix the *color space* and specify their own quantization, but refer to the *color space* for the definition of transformations **[2]**.

- *Dominant Color:*

This descriptor provides a compact description of the representative colors of an image or image region. Its main

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[1] Introduction to *RGB* & *Color Spaces*: RGB and Color Spaces.

[2] Introduction to *Color Quantization*: Color Quantization.

target applications are similarity retrieval in image databases and browsing of image databases based on single or several color values.

In its basic form, the *dominant color* descriptor consists of the number of *dominant colors* (N), and for each *dominant color* its value expressed as a vector of *color components* (c_i) and the *percentage of pixels* (p_i) in the image or image region in the cluster corresponding to c_i. Two additional fields, *spatial coherency* (s) and *color variance* (v_i), provide further characteristics of the color distribution in the spatial and color space domains **[2]**.

- *Scalable Color:*

The *scalable color* descriptor is a color histogram extracted in *HSV* color space, and encoded for storage efficiency. The descriptor extraction starts with the computation of the color histogram with 256 bins in the *HSV* color space with *hue* (H) component quantized to 16 bins, and *saturation* (S) and *value* (V) quantized to 4 bins each. This initial version is then passed through a series of 1-D Haar transforms, starting with H axis, followed by S, V and H. The result is a set of 16 low-pass coefficients and up 240 high-pass coefficients. Due to the redundancy of the original histogram, the high-pass coefficients tend to have low (positive and negative) values. Typical application of the descriptor include similarity search in multimedia databases and browsing of large databases. *scalable color* also forms the basis of the *group of frames/pictures color* descriptor.

- *Color Layout:*

The *color layout* descriptor compactly characterizes the spatial distribution of color within an image. The *color layout* uses an array of representative colors for the image, expressed in the *YCbCr* color space, as the starting point for the descriptor definition. The size of the array is fixed to 8x8 elements to ensure scale invariance of the descriptor **[2]**. Its similarity calculation process is simple enough to achieve very high-speed retrieval. This descriptor allows not only natural pictures but also sketches as queries. Any other *color descriptors* do not support the sketch queries, which is very useful for user friendly interface **[1]**. The *color layout* descriptor can be used for fast searching of databases as well as filtering in broadcasting applications **[2]**.

- *Color Structure:*

This descriptor is a generalization of the color histogram that captures some spatial characteristics of the color distribution in an image. The *color structure* descriptor is a color feature descriptor that captures both color content (similar to a color histogram) and information about the structure of this content. Its main functionality is image-to-image matching and its intended use is for still-image retrieval, where an image may consist of either a single rectangular frame or arbitrarily shaped, possibly disconnected, regions. The extraction method embeds *color structure* information into the descriptor by taking into account all colors in a structuring element of 8x8 pixels that slides over the image, instead of considering each pixel separately. 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. Color values are represented in the double-coned *HMMD* color space, which is quantized non-uniformly into 32, 64, 128 or 256 bins. Each bin amplitude value is represented by an 8-bit code. The *color structure* descriptor provides additional functionality and improved similarity-based image retrieval performance for natural images compared to the ordinary color histogram **[3]**.

As in the case of *scalable color, color structure* has the property of scalability in the sense that a descriptor with a larger number of bins can be reduced to one with a smaller number of bins. The main applications envisaged for it is image/video retrieval in multimedia databases, particularly when high accuracy is required **[1]**.

- *Group of Frames/Group of Pictures Color:*

This descriptor is an extension to the *scalable color* to a group of frames/pictures. The structure of the *GoF/GoP* Color descriptor is identical to that of *scalable color* with the exception of one additional field, aggregation, which specifies how the color pixels from the different pictures/frames were combined before the extraction of the color histogram. The possible values are average, median and intersection.

The average is obtained simply as the average of the color histograms for all the frames/pictures in the group. The median histogram is obtained by calculating the median value of each histogram bin over the frames/pictures and assigning this value to the resulting histogram bin. The use the median helps to eliminate the effect of outliers in the frames/picture groups. Therefore, it improves retrieval performance in cases of occlusion, lighting changes etc. The intersection histogram is obtained by calculating the minimum value of each histogram bin over the frames/pictures and assigning this value to the resulting histogram bin. The intersection finds the minimum common colors in the frames/pictures and can therefore be used in applications that require the detection of a high level of correlation in the color **[1]**.

References

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