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Combining Color and Spatial Color Distribution Information in a Fuzzy Rule Based Compact Composite Descriptor

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Abstract. In this paper, a novel low level feature for content based image retrieval is presented. The proposed feature structure combines color and spatial color distribution information. The combination of these two features in one vector classifies the proposed descriptor to the family of Composite Descriptors. In order to extract the color information, a fuzzy system is being used, which is mapping the number of colors that are included in the image into a custom palette of 8 colors. The way by which the vector of the proposed descriptor is being formed, describes the color spatial information contained in images. To be applicable in the design of large image databases, the proposed descriptor is compact, requiring only 48 bytes per image. Experiments presented in this paper demonstrate the effectiveness of the proposed technique especially for Hand-Drawn Sketches.

Keywords: Image retrieval, Compact composite descriptors, Spatial distribution, Hand-drawn sketches.

1 Introduction

As content based image retrieval (CBIR) is defined any technology, that in principle helps to organize digital image archives by their visual content. By this definition, anything ranging from an image similarity function to a robust image annotation engine falls under the purview of CBIR [1].

In CBIR systems, the visual content of the images is mapped into a new space named the feature space. The features, typically represented as vectors in this space, have to be discriminative and sufficient for retrieval purposes like e.g. the description of the objects, finding of duplicates or retrieval of visually similar scenes. The key to attaining a successful retrieval system is to choose the right features that represent the images as "strong" as possible [2]. A feature is a set of characteristics of the image, such as color, texture, and shape. In addition, a feature can further be enriched with information about the spatial distribution of the characteristic, that it describes.

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Regarding CBIR schemes which rely on single features like color and/or color spatial information several schemes have been proposed. The algorithm proposed in [3] makes use of multiresolution wavelet decompositions of the images. In [4], each pixel as coherent or noncoherent based on whether the pixel and its neighbors have similar color. In [5][6][7] are presented the Spatial Color Histograms in which, in addition to the statistics in the dimensions of a color space, the distribution state of each single color in the spatial dimension is also taken into account. In [8] a color distribution entropy (CDE) method is proposed, which takes account of the correlation of the color spatial distribution in an image. In [9] a color correlograms method is proposed, which collects statistics of the co-occurrence of two colors. A simplification of this feature is the autocorrelogram, which only captures the spatial correlation between identical colors. The MPEG-7 standard [10] includes the Color Layout Descriptor [11], which represents the spatial distribution of color of visual signals in a very compact form.

The schemes which include more than one features in a compact vector can be regarded that they belong to the family of Compact Composite Descriptors (CCD). In [12] and [13] 2 descriptors are presented, that contain color and texture information at the same time in a very compact representation. In [14] a descriptor is proposed, that includes brightness and texture information in a vector with size of 48 bytes.

In this paper a new CCD is proposed, which combines color and spatial color distribution information. The descriptors of this type can be used for image retrieval by using hand-drawn sketch queries, since this descriptor captures the layout information of color feature. In addition, the descriptors of this structure are considered to be suitable for colored graphics, since such images contain relatively small number of color and less texture regions than the natural color images.

The rest of the paper is organized as follows: Section 2 describes how to extract the color information, which is embedded in the proposed descriptor, while Section 3 describes in details the descriptor's formation. Section 4 contains the experimental results of an image retrieval system that uses either the proposed desciptor or the MPEG-7 CLD descriptor on two benchmarking databases. Finally, the conclusions are given in Section 5.

2 Color Information

An easy way to extract color features from an image is by linking the color space channels. Linking is defined as the combination of more than one histogram to a single one. An example of color linking methods is the Scalable Color Descriptor [10], which is included in the MPEG-7 standard.

In the literature several methods are mentioned, that perform the linking process by using Fuzzy systems. In [15] the extraction of a fuzzy-linking histogram is presented based on the color space *CIE-L*a*b**. Their 3-input fuzzy system uses the *L**, *a** and *b** values from each pixel in an image to classify that pixel into one of 10 preset colors, transforming the image into a palette of the 10 preset colors. In this method, the defuzzyfication algorithm classifies the input pixel into one and only one output bin (color) of the system (crisp classification). Additionally, the required conversion of an image from the *RGB* color space to *CIEXYZ* and finally to *CIE-L*a*b** color space