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REGULAR PAPER

A novel local mesh color texture pattern for image retrieval system

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ABSTRACT

This manuscript contributes a new feature descriptor local mesh color texture pattern (LMCTP) by merging color and local spatial information for image retrieval system. The intended method combines the various features from a mixture of color spaces, the local mesh patterns of the input image. LMCTP descriptor discriminates information between the spatial color textural patterns of multi-spectral channels within the local region. It determines the relationship between surrounding neighbors of the opponent color channel. Beside this, a merged color space, $I1QC_b$, is constructed by combining the I1 part of the I1I2I3 color space and the chromatic component images, C_b and Q, of the YC_bC_r and YIQ color spaces correspondingly so as to exploit the effect of joint color texture feature. The $I1QC_b$ color space, whose component of images having matching characteristics, increases the distinctive power for retrieval system. Then opponent color spaces I1Q, QC_b and $I1C_b$ are utilized for the capturing of LMCTP features. The feasibility of the proposed framework is experiments on benchmark databases such as MIT VisTex database (DB1), Corel 1000 database (DB2). Experimental study shows that the proposed pattern gives average retrieval precision of 99.8 for DB1 and 76.5 for DB2, respectively.

1. Introduction

Different sort of digital image archives and multimedia libraries is the core motive of retrieving system. As the utilization of content based image retrieval (CBIR) has been booming in haste, there is an increasing need to employ proper technique that satisfies user's preference in retrieving related images from the large database. Generally, two classes of approaches are adopted in image retrieval system i.e., text based and content based approaches. There exist two limitations of using text based approach in retrieval system: the enormous task is required for physical image annotation and understanding of textual descriptor varies with the user's observation. To deal with this problem, image retrieval system is carried out based on the image content. A lot of theoretical and empirical study carried out by various authors using various techniques is presented in Refs. [1–4].

Feature extraction plays the vital role in describing content of the image for retrieving interrelated images from massive image repositories. Conventionally, low level visual content of the image such as color descriptor, texture feature, shape of the image, and spatial position are key features that can represent images efficiently. Colors are effective features in CBIR system, they are described on a variety of color spaces such as RGB, HSV, YC_rC_b, LAB and LUV [5]. Various color features are available for image indexing and retrieval including color histogram (CH), color moments (CM), color coherence vector (CCV), fuzzy color histogram (FCH) [6–11]. HSV, YIQ, LAB, YC_rC_b and I1I2I3 color spaces have rich human perception and more discriminating power rather than RGB, so they can be much utilized to represent colors instead of RGB [12,13]. Opponent features captured by using discrete cosine transform in the YIQ color image for face detection is implemented in Ref. [14]. Texture features are the core part of the CBIR owing to the fact that it can discriminate objects with similar color and shape and it is a challenging task to model these features effectively. Typically, there have been two types of texture feature extraction methods such as statistical approach, structural approach. Former includes co-occurrence matrix, Tamura features, markov random field, multi resolution geometric features (gabor transform, wavelet transform, ridgelet transform and curvelet transform) while the latter approach comprises fourier transform, fractals for characterizing the texture by discovering structural primitives and their rules. Broad literature surveys on texture descriptors in the application of CBIR system, pattern identification and texture retrieval system are presented in Refs. [15–28]. A huge number of retrieval systems are developed by various groups, authors such as Faloutsos et al. [29], Pentland et al. [30], Ma et al. [31], Gupta and Gain [32], and Smith and Chang [33].

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Local image feature extraction creates a center of attention in recent years as they are tolerant to distortions, illumination changes, image transformations and occlusion. Dozens of feature descriptors were proposed by focusing various image properties like SIFT descriptor [34], SURF descriptor [35], LBP [36], LDP [37], and LTrP [38]. In order to boost the retrieval performance and to have strong human perception in CBIR system, the use of color and texture features jointly pays more attention in the present state of image retrieval world. As the extraction of color and texture features separately has proven to be inefficient for natural images, this paper proposes a local mesh color texture patterns which takes advantage of both local binary pattern and local color texture features used for discriminating the information derived from opponent spatial color textural patterns within the local region. This pattern increases the corresponding effect using merged color and textural information which forced the creation of LMCTP. This paper is planned as follows: Introduction about the low level features was given in Section 1. Related works of texture image retrieval system are specified in Section 2. The core roles of the manuscript are highlighted in Section 3. Description of color space conversion and previous patterns are mentioned in Sections 4 and 5, respectively. The Proposed patterns are explained in Section 6. Empirical evaluations of the proposed method are described in Section 7. Section 8 reveals the conclusions.

2. Related work

Research in texture based image retrieval (IR) system had come up with local binary pattern (LBP) descriptors to capture distinctive local features form the input image due to its speed and performance than its counterpart features like k-d tree, co-occurrence matrix. LBP reached better performance when comparing with other methods like Eigen face and Fisher face [37,39]. The inspiration behind LBP comes from the reality that the entire image region is splitted into sub-regions where each pixel is encoded in terms of relationship amid the center pixel and their nearby pixels. These patterns will be formed as histogram to represent the texture information. Different manifestation of LBP were proposed by various researchers for multiple domain specific application like facial expression, image retrieval, medical applications in terms of rotation invariant texture measures are presented in Refs. [39–42]. Then the LBP is incorporated into multi-scale heat kernel based LBP descriptor for extracting intrinsic structural information for best representation of texture features in face recognition [43]. Extended LBP called local derivative pattern (LDP) was recommended to encode additional detailed information rather than first order derivatives and expanded the same thing for *n*th order LDP's [43]. As LBP and LDP do not support for natural pictures owing to varying use of light sources, occlusion, pose, another variation was contributed by Tan et al. [44] called local ternary pattern (LTP) for face recognition under various lighting conditions. Edge information are extracted according to distribution of edges using LBP, LDP and LTP where encoding was done on either horizontal direction or vertical direction. Murula et al. [38] developed local tetra pattern (LTrP) to improve the performance by extending the directions which considers all the four directions for central gray pixel for describing the structural formation of the local textures. Tetra pattern can be computed along 0° and 90° directions in first order derivatives. Three binary patterns are calculated for each direction, hence collectively 12 binary patterns are generated along with one magnitude pattern as the 13th pattern. This feature sets are used as texture features for representing textures in an image. Existing pattern such as LOCTP proposed by Jeena Jacob et al. [45] is extracted by opponent color channels from RGB space itself which is less efficient for human perception. The proposed approach is based on new hybrid color space that is more powerful and rich in human perception being suitable for the effective usage of color information.

3. Major contribution

The aforementioned empirical survey helped us to formulate a new framework which combines color and texture as joint color texture information rather than by using either color or texture features. The major intention of this paper is to contribute a valuable new framework which makes use of both color and texture information together as dual features to progress the retrieval performance. The major role of this paper is triple,

(1) This paper proposes a hybrid color space I1QC$_b$ where I1, Q, and C$_b$ channel is extracted from the I1I2I3, YIQ and YC$_b$C$_r$ color space correspondingly to increase the effectiveness of color components to discriminate color image and to reduce rate of correlation between components.
(2) Novel local mesh color texture feature (LMCTP) is proposed where LMCTP features are derived from spatial color textural patterns of different components of the local image region.
(3) This paper makes use of opponent color texture features from the hybrid color space I1QC$_b$ that captures the texture patterns of spatial connections between spectral bands to extract color texture features jointly.

Since I1I2I3, YIQ and YC$_b$C$_r$ color space are more powerful and rich in human perception [11], I1QC$_b$ space is proposed to utilize intensity information, chrominance information from I1, Q and C$_b$ channels, respectively. In order to effectively utilize this information, this paper hybrids three color channels from three different color spaces to create new color space I1QC$_b$ for improving the retrieval performance. LMCTP operator is obtained by computing the texture patterns over opponent channels of I1QC$_b$ color space which is used as combined color–texture descriptor to extract uniform and non-uniform color–texture features [47].

4. Color space conversion

4.1. RGB to I1I2I3 color space transformation

Color of pixels is normally characterized as three values by Red, Green and Blue (rgb). Multiple color features are required such as intensity, hue, chrominance and saturation in order to differentiate the colors by using either linear or non-linear transformation. Here, I1I2I3 introduced by Ohta et al. [48] is a linear mapping of RGB color image and it is used for uncorrelated features. Among I1I2I3, I1 is taken to combine with Q and C$_b$ component of the YIQ and YC$_b$C$_r$ images. The following are standard conversion formula of I1I2I3 from rgb color space.

$$I1 = \frac{(r+g+b)}{3}$$
$$I2 = \frac{(g+b)}{2} \quad . \tag{1}$$
$$I3 = \frac{(2g+r+b)}{4b}$$

4.2. RGB to YIO color space transformation

The YIQ color space has copious applications in image processing and it has been originally derived from the YUV space in which *I* defines In-phase and *Q* refers to Quadrature. This is the modulation method required to transmit color information and it utilizes