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Content based image indexing and retrieval using directional local extrema and magnitude patterns

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ABSTRACT

In this paper, we integrate the concept of directional local extremas and their magnitude based patterns for content based image indexing and retrieval. The standard ditectional local extrama pattern (DLEP) extracts the directional edge information based on local extrema in 0°, 45°, 90°, and 135° directions in an image. However, they are not considering the magnitudes of local extremas. The proposed method integrates these two concepts for better retrieval performance. The sign DLEP (SDLEP) operator is a generalized DLEP operator and magnitude DLEP (MDLEP) operator is calculated using magnitudes of local extremas. The performance of the proposed method is compared with DLEP, local binary patterns (LBPs), block-based LBP (BLK_LBP), center-symmetric local binary pattern (CS-LBP), local edge patterns for segmentation (LEPSEG) and local edge patterns for image retrieval (LEPINV) methods by conducting two experiments on benchmark databases, viz. Corel-5K and Corel-10K databases. The results after being investigated show a significant improvement in terms of their evaluation measures as compared to other existing methods on respective databases.

1. Introduction

Retrieval of images from large image databases has been an active area of research for long due to its applications in various fields like satellite imaging, medicine, etc. Content based image retrieval (CBIR) systems extract features from the raw images and calculate an associative measure (similarity or dissimilarity) between a query image and database images based on these features. Hence the feature extraction is a very important step and the effectiveness of a CBIR system depends typically on the method of extraction of features from raw images. Several methods achieving effective feature extraction have been proposed in the literature [1–4].

Texture is the most important feature for CBIR. Smith and Chang used the mean and variance of the wavelet coefficients as texture features for CBIR [5]. Moghaddam et al. proposed the Gabor wavelet correlogram (GWC) for CBIR [6,7]. Ahmadian and Mostafa used the wavelet transform for texture classification [8]. Moghaddam et al. Introduced new algorithm called wavelet correlogram (WC) [9]. Saadatmand and Moghaddam [7,10] improved the performance of the WC algorithm by optimizing the quantization thresholds using genetic algorithm (GA). Birgale et al. [11] and Subrahmanyam et al. [12] combined the color (color histogram) and texture (wavelet transform) features for CBIR. Subrahmanyam et al. proposed correlogram algorithm for image retrieval using wavelets and rotated wavelets (WC + RWC) [13].

Ojala et al. proposed the local binary pattern (LBP) features for texture description [14] and these LBPs are converted to rotational invariant for texture classification [15]. Pietikainen et al. proposed the rotational invariant texture classification using feature distributions [16]. Ahonen et al. [17] and Zhao and Pietikainen [18] used the LBP operator facial expression analysis and recognition. Heikkila and Pietikainen proposed the background modeling and detection by using LBP [19]. Huang et al. proposed the extended LBP for shape localization [20]. Heikkila et al. used the LBP for interest region description [21]. Li and Staunton used the combination of Gabor filter and LBP for texture segmentation [22]. Zhang et al. proposed the local derivative pattern for face recognition [23]. They have considered LBP as a nondirectional first order local pattern, which are the binary results of the first-order derivative in images.

The block-based texture feature which use the LBP texture feature as the source of image description is proposed in [24] for CBIR. The center-symmetric local binary pattern (CS-LBP) which is a modified version of the well-known LBP feature is combined with scale invariant feature transform (SIFT) in [25] for description of interest regions. Yao and Chen [26] have proposed two types of local edge patterns (LEP) histograms, one is

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LEPSEG for image segmentation, and the other is LEPINV for image retrieval. The LEPSEG is sensitive to variations in rotation and scale, on the contrary, the LEPINV is resistant to variations in rotation and scale. Subrahmanyam et al. [27] have proposed the DLEP which collects the directional edge information for image retrieval.

The above discussed various extensions of LBP features consider only the sign of differences but not magnitudes. The main contributions of this work are summarized as follows: (a) the existing DLEPs are considering only sign of difference between the pixels whereas our method considers the both sign as well as magnitudes and (b) the performance of the proposed method is tested on benchmark image databases.

The paper is summarized as follows: in Section 1, a brief review of content based image retrieval and related work is given. Section 2, presents a concise review of local pattern operators. The proposed system framework and query matching are illustrated in Section 3. Experimental results and discussions are given in Section 4. Based on above work, conclusions and future scope are derived in Section 5.

2. Local patterns

2.1. Local binary patterns (LBPs)

The LBP operator was introduced by Ojala et al. [14] for texture classification. Success in terms of speed (no need to tune any parameters) and performance is reported in many research areas such as texture classification [14–16], face recognition [17,18], object tracking, bio-medical image retrieval and finger print recognition. Given a center pixel in the 3×3 pattern, LBP value is computed by comparing its gray scale value with its neighborhoods based on Eq. (1) and (2):

$$LBP_{P,R} = \sum_{p=1}^{P} 2^{(p-1)} \times f_1(I(g_p) - I(g_c)) \tag{1}$$

$$f_1(x) = \begin{cases} 1 & x \geq 0 \\ 0 & \text{else} \end{cases} \tag{2}$$

where $I(g_c)$ denotes the gray value of the center pixel, $I(g_p)$ represents the gray value of its neighbors, P stands for the number of neighbors and R, the radius of the neighborhood.

After computing the LBP pattern for each pixel (j, k), the whole image is represented by building a histogram as shown in Eq. (3).

$$H_{LBP}(l) = \sum_{j=1}^{N_1} \sum_{k=1}^{N_2} f_2(LBP(j, k), l); \quad l \in [0, (2^P - 1)] \tag{3}$$

$$f_2(x, y) = \begin{cases} 1 & x = y \\ 0 & \text{else} \end{cases} \tag{4}$$

where the size of input image is $N_1 \times N_2$.

Fig. 1 shows an example of obtaining an LBP from a given 3×3 pattern. The histograms of these patterns contain the information on the distribution of edges in an image.

2.2. Block based local binary patterns (BLK_LBP)

Takala et al. [24] have proposed the block based LBP for CBIR. The block division method is a simple approach that relies on subimages to address the spatial properties of images. It can be used together with any histogram descriptors similar to LBP. The method works

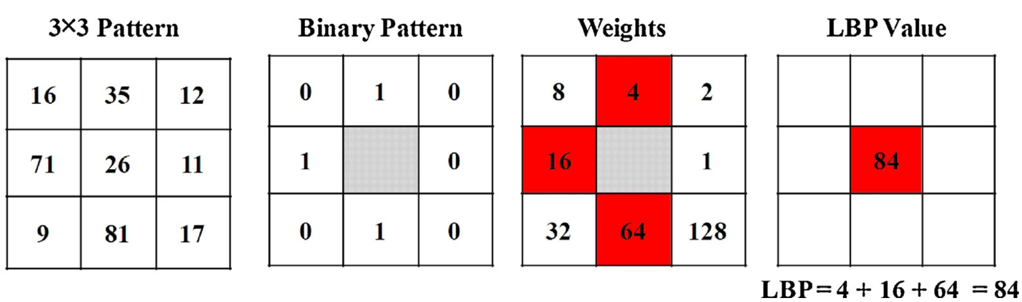

Fig. 1. Calculation of LBP.

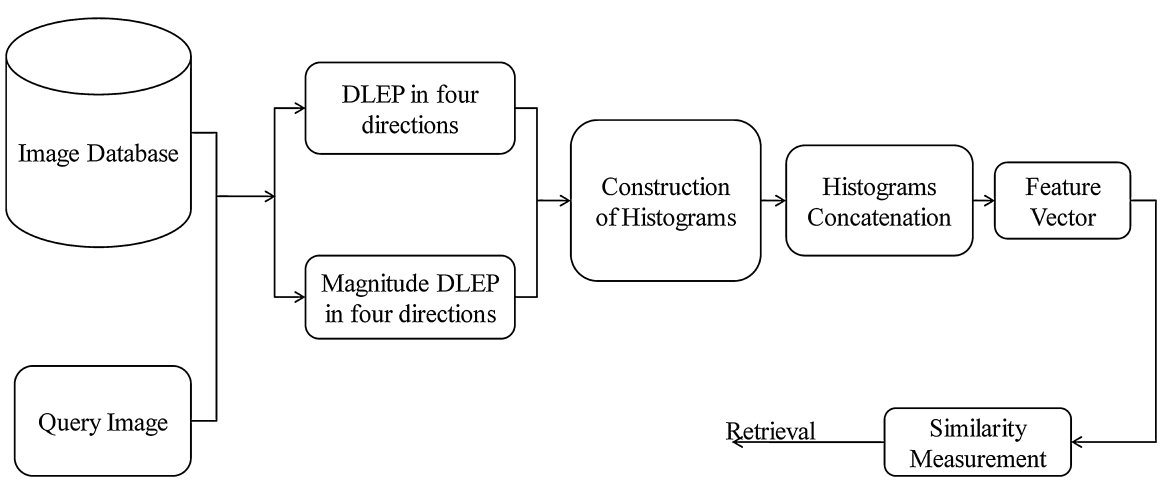

Fig. 2. Proposed image retrieval system framework.