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Local tri-directional patterns: A new texture feature descriptor for image retrieval

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ABSTRACT

Texture is a prominent feature of image and very useful in feature extraction for image retrieval application. Statistical and structural patterns have been proposed for image retrieval and browsing. In the proposed work, a new texture feature descriptor is developed. The proposed method uses local intensity of pixels based on three directions in the neighborhood and named as the local tri-directional pattern (LTriDP). Also, one magnitude pattern is merged for better feature extraction. The proposed method is tested on three databases, in which first two, Brodatz texture image database and MIT VisTex database are texture image databases and third one is the AT&T face database. Further, the effectiveness of the proposed method is proven by comparing it with existing algorithms for image retrieval application.

1. Introduction

Many techniques for image retrieval have been developed in the past few years due to extreme increment in digital images. Large image database and retrieval of similar images became a direct and real world problem. Many kinds of features exist in the image, and texture is one of them. Texture is a powerful feature of an image that can be recognized in a form of small repeated patterns. There are many types of texture, e.g., artificial texture, original texture, rough texture, silky texture, etc. Texture is mostly contained in images of rocks, leaves, grass, woods, walls, etc. Even in natural images different types of texture exist. Many local features have been proposed by researchers in past few years. Local features extract the information regarding to local objects in the image or local intensity of pixels. Local patterns consider the neighboring pixels to extract the local information in the image. Most of the local patterns proposed by researchers, were uniform for all neighboring pixels. A very few patterns utilized the pixel information based on the direction. This work is mainly concentrated on a direction based local pattern which can provide better features with respect to uniform local patterns. Extensive surveys of content based image retrieval are presented in past few years [1,2].

1.1. Related work

Gray level co-occurrence matrix (GLCM) was proposed for image classification by Haralick [3]. This matrix extracts features, based on co-occurrence of pixel pairs. GLCM was used in rock texture retrieval in [4]. Zhang et al. proposed a method for texture features that computes edge images using the Prewitt edge detector and extracts co-occurrence matrix for those edge images instead of original images [5]. Feature extraction has been performed on the co-occurrence matrix using statistical features. Transformation domain was also utilized for feature extraction by researchers. Wavelet packets were used for the feature extraction and applied for image classification in [6]. Gabor filter was proposed for image retrieval and browsing [7], and texture classification [8]. Rotation invariant feature vector has been proposed using Gabor filters for content based image retrieval [9]. To overcome computational complexity of Gabor wavelet, Rivaz and Kinsbury proposed a new feature vector based on complex wavelet transform and applied it to texture image retrieval [10]. A modified curvelet transform has been proposed and used for image retrieval [11]. Two novel features 'composite sub-band gradient vector' and 'the energy distribution pattern string', have been proposed for efficient and accurate texture image retrieval system [12]. These features were extracted from wavelet sub-band images.

A robust texture feature called the local binary pattern (LBP) [13] was proposed by Ojala, and it uses the local intensity of each pixel for feature vector extraction. Further, uniform and non-

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uniform patterns were discriminated based on appearance. Also, patterns were converted into rotation invariant [14]. LBP uses the difference of center pixel and boundary pixel with a threshold for binary pattern. Instead of a single threshold value, an interval was used and local ternary pattern (LTP) was obtained, which further converted into two binary patterns [15]. The local binary pattern was considered as first order derivative, and second and more order derivative patterns were proposed and called local derivative pattern (LDP) [16]. The LDP was proposed for face image recognition. LBP variance (LBPV) is proposed for texture classification [17]. Pyramid transformation of local binary pattern has been proposed using Gaussian and wavelet based low pass filters and called pyramid local binary pattern (PLBP) [18]. Again a pyramid based algorithm was proposed using LBP and LBPV with Guassian low pass filter and used for smoke detection in videos [19]. Murala et al. proposed local ternary co-occurrence pattern based on local ternary pattern and local derivative pattern [20]. After binary and ternary, local tetra patterns (LTrP) were obtained using horizontal and vertical directional pixels [21]. Further, local tetra pattern was divided into binary patterns for feature vector histogram. In LBP, all neighboring pixels were considered as same for every center pixel, and the pattern map was created according to the difference of neighboring pixels with the center pixel. In center symmetric local binary patterns (CSLBPs), a pattern has been created using only interest region pixels instead of all neighborhood pixels [22]. Papakostas et al. have been proposed a moment based local binary pattern image classification [23]. Feature extraction in transformation domain using Gabor filters and Local binary pattern has been performed in [24], and proposed method is applied in synthetic and multi textured images for segmentation. Binary patterns based on directional features, have been proposed in the directional local extrema patterns [25]. Yuan proposed a rotation and scale invariant local pattern based on high order directional derivatives [26]. The local edge pattern based on the Sobel edge image, has been proposed in [27]. The Sobel edge image was created first, then LEPSEG was computed for image segmentation and LEPINV was obtained for image retrieval. Local extrema patterns were proposed for object tracking [28]. Extended local extrema patterns with multi-resolution property were proposed in [29] for image retrieval. Murala et al. proposed the local maximum edge binary pattern (LMEBP) [30]. The LMEBPs considered the maximum edge from the local difference and extracted the information based on eight neighborhood pixels. This method was combined with Gabor transform and experimented on image retrieval and object tracking. Block division and primitive block based methods have been proposed using local binary pattern and applied to image retrieval system [31]. In this method, images were divided into blocks, and then comparison was conducted on blocks. Local mesh patterns (LMeP) have been proposed for medical image retrieval that create the pattern according to surrounding pixels for a particular center pixel [32]. Also, Gabor wavelet has been used for multi-scale analysis. Further, the local mesh patterns were improved in [33], where the first order derivative also included in the local mesh pattern and called local mesh peak valley edge pattern (LMePVEP).

1.2. Main contribution

Local binary pattern creates local pattern based on center and surrounding pixels. It measures the relationship and forms a pattern. In the proposed method, center and neighboring pixel relationship is considered in an instructive way that directional information can be utilized of image. Mutual relationship of neighboring pixels in three most significant directions are examined in the proposed work. A magnitude pattern is also considered using same three direction pixels, and both patterns histogram are combined for feature vector. The proposed method is tested on two texture and one face image database for performance. Presented work is organized as follows: Section 1 presents introduction of the problem and it includes motivation and related work. Section 2 explains local patterns and the proposed method. The framework of the proposed method, algorithm and similarity measure are demonstrated in Section 3. Experimental results are obtained in Section 4. Finally, the whole work is concluded in Section 5.

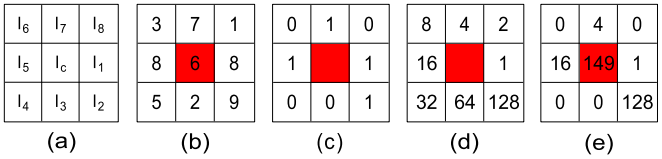

Fig. 1. Local binary pattern example. (a) Center and neighboring pixel notations. (b) Sample window. (c) Local binary pattern using threshold with center pixel. (d) Weights. (e) Pattern value.

2. Local patterns

2.1. Local binary patterns

Ojala et al. invented the local binary pattern for texture images. Based on performance and speed, LBP operator is used in image classification [14], facial expression recognition [34], medical imaging [35], object tracking [36], etc. The LBP operator for p neighborhood and r radius is defined as below:

$$LBP_{p,r} = \sum_{l=0}^{p-1} 2^l \times S_1(I_l - I_c)$$

$$S_1(x) = \begin{cases} 1 & x \geq 0 \\ 0 & else \end{cases} \tag{1}$$

where I_c and I_l are center and neighborhood pixel intensities respectively. Histogram of LBP map is calculated using eqn. (2), where *Pattern* is LBP, and the size of image is $m \times n$. A sample window example of LBP pattern is shown in Fig. 1.

$$His(L)\,|_{Pattern} = \sum_{a=1}^{m}\sum_{b=1}^{n} S_2(Pattern(a,b), L);$$

$$L \in [0, (2^p - 1)]$$

$$S_2(i,j) = \begin{cases} 1, & i = j \\ 0, & else \end{cases} \tag{2}$$

2.2. Local tri-directional patterns

Local tri-directional pattern is an extension of LBP. Instead of uniform relationship with all neighboring pixels, LTriDP consider the relationship based on different directions. Each center pixel have some neighboring pixels in a particular radius. Closest neighbor consists of 8 pixels all around the center pixel. Further, there are 16 pixels in next radius and so on. Closest neighboring pixels are less in number and gives more related information as they are nearest to center pixel. Hence, we consider 8-neighborhood pixels for pattern creation. Each neighborhood pixel at one time is considered and compared it with center pixel and also with two most adjacent neighborhood pixels. These two neighborhood pixels are either vertical or horizontal pixels as they are closest to the considered neighboring pixel. The pattern formation is demonstrated in Fig. 2 and explained mathematically as follows.