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Texture classification via extended local graph structure

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ABSTRACT

In this paper, we propose a simple and robust local descriptor operator, called the extended local graph structure (ELGS). The original local graph structure (LGS) performs very well in many domains, for instance face recognition, face spoofing detection and others. However, LGS has a few demerits such as LGS is not robust to the noise present in the image and LGS takes into considerations the horizontal graph and ignores the vertical graph which causes a loss in the spatial information. Therefore, we extend the idea of LGS by encoding the pattern into two directions. This is means that we take into consideration the vertical graph along with the horizontal graph and then concatenate the two computed histograms features to form a global descriptor. Experimental results on the UIUC and XU High Resolution texture databases show a promising performance.

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1. Introduction

The area of texture classification plays a very important role in many areas such as computer vision and image processing applications. Researchers, proposed several methods for extracting the features from the texture images, most of them were proposing algorithms to extract features that are robust to noise, rotation and illumination variations [1]. In [2] author proposed to extract robust texture feature based on polarograms and generalized co-occurrences metrics. Another researcher, proposed to extract the features in the spectrum domain [3]. Porter and Canagarajah [4] utilized the use of wavelet transform for texture classification problem. Authors in [5–7] utilize the use of texton dictionary from the training images to compute the histogram feature based on the textons.

Local binary pattern (LBP) is found to be the best performing dense descriptor and therefore has been used for various applications and extended by researchers. Recently Abusham et al. [8] proposed a new texture operator called LGS to encode the pattern of a given image. In the LGS operator, they have changed the structure of the original LBP where a dominant graph is utilized to address the problem of encoding the pattern. Moreover, they claimed that LGS is better than LBP because it takes into consideration the relation between the pixels that form the local graph [8] instead of the target pixel with its neighbours as in LBP. This feature in LGS makes it to be highly discriminative and its key advantages are: robust to illumination, monotonic gray level changes and computationally efficient especially for real time image analysis. Therefore, LGS has been widely used in various applications for instance face recognition, face detection and liveness detection.

Yet, there's a problem in LGS operator which is that the horizontal structure is not sufficient to capture the spatial information especially with a presented noise in the input image.

To this end, we propose a new descriptor based on the original LGS, i.e., extended local graph structure (ELGS). The idea behind this operator, is to compute the LGS feature into two directions (horizontal and vertical) in order to capture wider spatial information from edges/neighbours of the local graph and also to get the appearance and the spatial relation of a given pixel intensity. Finally, the method is very simple, but it performs very well.

This paper is organized as follows: in Section 2 we study the local binary pattern and local graph structure. The proposed method is introduced in Section 3 and experimental results are reported in Section 4. Finally, Section 5 concludes the proposed research.

2. Related work

2.1. Local binary pattern (LBP)

The most popular texture operator is the Local Binary Pattern (LBP) which is proposed by Ojala, Pietikainen, and Harwood [15]. This operator is simple, powerful and yet effective, The Local Binary Pattern operator threshold the neighbours of each pixel with the centre value and then obtain a binary number as illustrated in Fig. 1.

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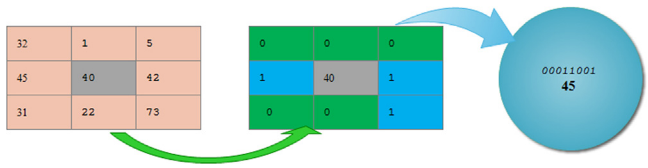

Fig. 1. The local binary pattern (LBP) operator.

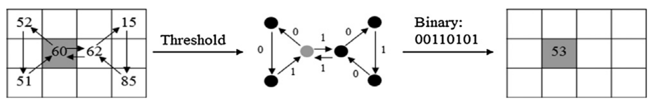

Fig. 2. The local graph structure (LGS) operator.

In addition, the Local Binary Pattern operator has become a popular method in many applications, such as face recognition and many others. The reason behind this is because of its discriminative power and simplicity. Finally, LBP is robust against illumination variation and monotonic grey-scale changes.

2.2. Local graph structure (LGS)

The basic structure of LGS is illustrated in Fig. 2. The idea is to have the dominant graph structure to encode the spatial information for any pixel $I(x,y)$ in the given image. This structure achieves considerable performance because it will not take the relation between the target pixel $I(x,y)$ and its neighbours but in fact it takes into consideration the relationship of the pixels that form the local graph structure. Also, local graph structure (LGS) is found to be computationally unexpansive with compare to local binary pattern (LBP).

The operator first starts by choosing the target pixel $I(x,y)$. As in the example of Fig. 2 the target pixel is 60 (in gray color) then LGS moves from this vertex to the next vertex which is 40 and found to be smaller than 60 hence we assign a binary value equal to zero on the edge connecting the two vertices. If we are moving from a large vertex to small/equal vertex then we assign a binary value equal to one. This process continues on both directions of the graph and then we compute the decimal value from the generated string.

This operator showed an encouraging performance in face recognition applications with compare to LBP. In addition, authors adopted the operator in tracking, recognition, plant identification and others extensions of LGS [8–14].

3. Texture classification using extended local graph structure (ELGS)

In this research work, the LGS presented in the previous section is utilized for texture description. The procedure for ELGS is based on using the LGS texture descriptor to build two descriptions (horizontally and vertically) and then combine them into a global description. These two descriptions are robust against variation in pose or illumination. Furthermore, the two descriptors are also invariant to translation and rotation since it considers both directions. Therefore, the texture descriptors are extracted using LGS in each direction (x-axis, y-axis) independently as shown in Fig. 3. Two descriptors (m, n) will be generated; then a histogram is computed (h,k) for each descriptor independently. The resulting histograms are combined yielding the spatially enhanced histogram K where the size is $m \times n$ and n is the length of a single LGS histogram. The generated histogram features encodes the appearance of the spatial relation of the texture image and also the global descriptors contains the information about the pattern in the (x-axis and y-axis).

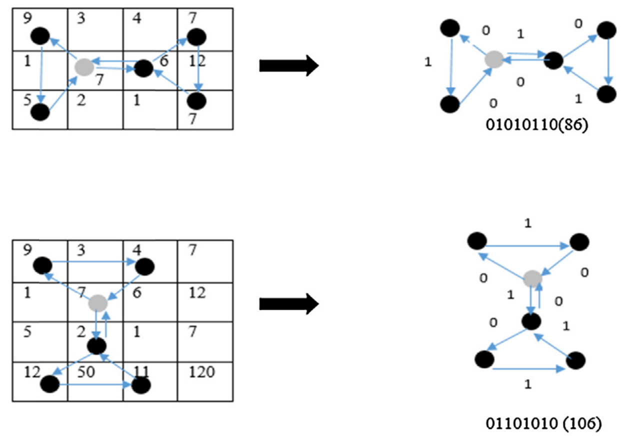

Fig. 3. Proposed extended local graph structure (ELGS) operator.

3.1. Motivation behind using the local graph structure

The local graph structure algorithm utilizes a unique property in which LGS takes into the consideration the relation of the pixels that form the local graph. Therefore, The relationship between the pixels that from the local graph gives strong pattern and thus can easily discriminate between texture patterns. In addition, it gives more information regarding the pattern rather than depending on one pixel as in Local Binary Pattern (LBP). For example LBP encodes different structural with the same LBP code as shown in Fig. 4.

While it's different in the ELGS, the proposed method encodes different structural into different patterns. The reason here is that the ELGS consider the relation of the pixels which form the local graph and the ELGS encodes the pattern into two different directions (horizontal and vertical) as shown in Figs. 5–6 and thus helps reducing the probability of getting the same ELGS code for different structural. This indicates that the local graph structure enhanced the discriminative feature by simply utilizing the concept of graph. Thus, this graph design is critical to the success of this operator and also the success of this operator is associated with the property of considering the relationship of the pixels that form the local graph. Moreover, in this paper we apply different radius R for the ELGS operator in order to achieve a better classification rate.

3.2. Classification

The idea of ELGS can be exploited further when defining the distance measure. For our empirical analysis, the following distance measures will be used to classify the texture images. In addition, we also study the different measures to find the suitable one for ELGS and the equations are defined below:

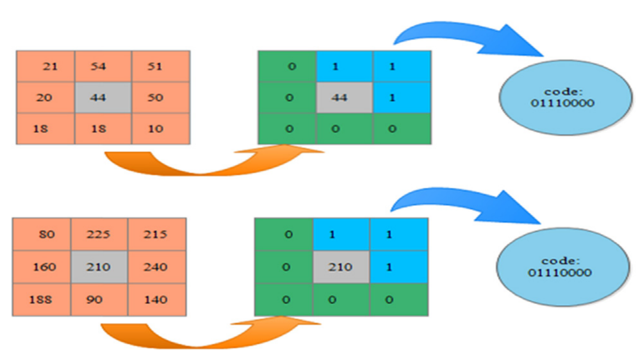

Fig. 4. Local binary pattern codes for different structure.

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