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Dynamic texture recognition using multiresolution edge-weighted local structure pattern☆

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ABSTRACT

Dynamic texture has been found as a powerful cue for modeling natural scenes such as fire, waves and smoke, etc. It combines appearance with motion to characterize the moving scene that exhibits certain spatially repetitive and time-varying visual patterns. This paper proposes a new method of recognizing dynamic texture using the well-known texture descriptor, local binary pattern. The new variant differentiates different structural patterns more efficiently using the additional information from the local patch. This pattern information is further combined with shape information to improve the discriminative power of texture descriptor. The proposed method is extended to multiscale using classifier fusion scheme to capture the spatio-temporal content of a moving scene at multiple scales, thus improves representation capability of the new descriptor. Proposed descriptor is tested on three dynamic texture databases: UCLA, Dyntex and Dyntex++. Results demonstrate that the proposed feature descriptor outperforms various state-of-the-art approaches on all representative databases in terms of classification accuracy.

1. Introduction

Texture is an important and rich source of information for the analysis of an image. Texture mainly depicts the spatial arrangement of color or intensities in an image or a selected image region. In literature, a wide range of descriptors has been proposed to measure the texture information of a visual phenomenon. Usually, the majority texture descriptors work well for uniform textures. However, the natural texture in the real world is not uniform in nature. They show certain stochastic nature due to the changes in orientation, scale or any other appearance feature. Thus, it is required to gather the texture complexity in a specified image region to discriminate different textures.

Edge information in a specified region helps to determine the characteristic of texture complexity. Earlier studies used edge features to get the boundary information of micro and macro textures. Edge feature shows high contrast changes between the boundaries and tends to cluster at the contours of the texture primitives. Thus, the edge information can be transformed to texture feature that reflects the properties of texture elements (e.g., shape, area, orientation) [1]. Various traditional motion models have been used in the past for the recognition and representation of dynamic texture but they fail to capture the stochastic nature of dynamic texture [2].

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1.1. Related work

In the spatiotemporal domain, various dense and sparse static texture descriptors are extended to spatiotemporal domain for dynamic texture recognition such as local binary pattern (LBP), shift invariant feature transform (SIFT), Gabor. However, LBP gained much popularity due to its simplicity and high descriptive power. It has been used extensively in spatial and spatiotemporal domain for the analysis of texture. Some prominent researches that use LBP as a tool to describe the dynamic textures are [2–6]. Recently, Tiwari and Tyagi [7–9] also proposed a series of techniques to recognize dynamic texture using LBP. In [7], authors proposed a completed modeling for describe dynamic texture (DT) using both sign and magnitude information of local differences. The completed volume local binary pattern (CVLBP) approach shows good result but it worsens the problem high dimensionality of volume local binary pattern (VLBP) descriptor [3]. Later on, in modified approach [9] authors resolve this problem by encoding a low dimensional descriptor using different formulation for the feature vector computation.

Edge feature is also used by some studies for dynamic texture modeling due to its simplicity and ability to capture micro and macro texture patterns. Some notable researches that have exercised edge feature for dynamic texture description and recognition are [10,11]. Some of these approaches use normal flow to measure edge motion; edge gradient vectors represent the spatial information, whereas the moving edges give the temporal information of a dynamic texture. Remaining approaches apply other tools to compute the edge features.

Other than LBP, various other tools are also used for the description and recognition of dynamic texture, such as linear dynamic system (LDS) methods [2,12,13,14], chaotic vector based methods [15,16], fractal based approaches [11,17,18] etc. Recently, subspace analysis based methods [19] have shown good performance in the dynamic texture recognition field.

Various authors have offered multiresolution or multiscale descriptor to capture spatiotemporal dynamic texture information at multiple scales. Zhao and Pietikäinen [3] have offered both single resolution and multiresolution extension of the LBP descriptor to the dynamic texture domain. However, their multiresolution approach is limited in its capacity to incorporate the information from different resolutions due to the exponential growth of the feature vector size. Recently, Arashloo and Kittler [20] have suggested a spatiotemporal descriptor for the representation and recognition of temporal textures, based on the binarized statistical image features (BSIF) descriptor. In addition, transform based approaches [17,21,22] also perform multiscale analysis to portray dynamic texture information at multiple scales. A review of various dynamic texture recognition techniques is provided in [23].

1.2. Contribution of proposed approach

Local Binary Pattern (LBP) [24] is the most popular dense feature descriptor for static texture classification. The major advantage of LBP is its computational simplicity and invariance to contrast variation. LBP only considers the sign of pixel differences for feature computation. However, the basic LBP operator suffers with some disadvantages and limitations in spite of its great success in computer vision and pattern recognition applications:

1. LBP is unable to differentiate the texture patterns properly; LBP uses the center pixel as a threshold and slightest variation in center pixel value will change the pattern value in the uniform or near uniform region of an image.
2. LBP directly uses the pixel intensity of the image local patch to define the texture pattern. It does not utilize other statistics of the image thus loses certain useful image information.
3. LBP only computes the texture pattern of the local image patch and ignores other texture information available in a local image patch such as the texture shape information.
4. The basic LBP operator has small spatial support; the operator is unable to detect large-scale textural structures properly.

To deal with these issues, we propose a new variant of LBP in the dynamic texture domain that contain the advantageous characteristics of basic LBP. Main contributions of this work are:

1. A new variant of LBP is proposed; instead of using center pixel to threshold neighborhood, a new local threshold is utilized for feature computation.
2. Image statistics is added to the feature vector to improve its discriminating power.
3. Gradient magnitude is used as a supplementary shape information and clubbed with the local structure pattern, computed using the new LBP variant.
4. A multiresolution scheme with classifier fusion technique is used to explore the texture information at different scales.

The rest of the paper is organized as follows. Section 2 describes proposed approach. Section 3 contains details of experiments conducted on various databases and their results and last section concludes the paper.

2. Proposed approach

An image texture patch in local DT volume has two different cues for discrimination from other texture patch: texture spatial pattern and texture shape form by its boundaries. The spatial pattern describes the surface structure of the texture, whereas the shape pattern is used to differentiate between a weak and strong contrast pattern. LBP only computes the

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