ARTICLE IN PRESS
JID: CAEE [m3Gsc;September 7, 2017;21:55]

Computers and Electrical Engineering 000 (2017) 1–13

Contents lists available at ScienceDirect

Computers and Electrical Engineering

journal homepage: www.elsevier.com/locate/compeleceng

Texture features based on an efficient local binary pattern descriptor☆

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ARTICLE INFO

Article history:
Received 10 August 2016
Revised 10 August 2017
Accepted 15 August 2017
Available online xxx

Keywords:
Texture discrimination
Multi-scale representation
Bilateral filter
Keypoints extraction
Scale invariant feature transform
Mixed pixels

ABSTRACT

Texture characterization aims at describing the spatial arrangement of local structures within an image. However, mixed pixels that are generally located near boundaries of the regions represent challenge to perform accurate image texture discrimination. To address this problem, this paper proposes a robust discriminating texture features relying on an efficient Local Binary Pattern (LBP) descriptor, where the spatial information within image is taken into account. To determine for each pixel both a proper scale parameter and a threshold value to compute the LBP code, an efficient way relying on bilateral filter-based multi-scale image analysis is used. First, the difference of Gaussian operator is used to determine the corresponding scale. Second, key points based-approach is used to identify the threshold value of each pixel. This provides the ability to deal with mixed pixels. Then, LBP code is computed to characterize the texture information for each pixel. Experimental results, using both synthetic and real images, show that the proposed appropriate-scale-threshold selection strategy demonstrates a significant improvement in texture discrimination ability.

1. Introduction

Texture is one of the most important characteristics used in image analysis. It represents the different local structural features and their spatial arrangement within the image [1]. Mainly, because of their robustness against noise and illumination variations, texture features remain almost unchanged and this allows an accurate description of the image, conversely to the spectral intensity. Accordingly, texture feature extraction is an important task for many computer vision applications, such as image change detection and segmentation [2]. However, the challenge is the ability to discriminate of textures representing different spatial local structures. To cope with this problem, different approaches have been developed [3]. Among them, the grey-level co-occurrence matrix, which has been the focus of interest of an increased number of image processing works [4]. However, this approach is limited by the high computational cost. Local Binary Pattern (LBP) operator is considered as a powerful texture primitive descriptor characterized by its computation simplicity, and few parameters are required to be set [5]. This operator labels the pixels of an image by thresholding the vicinity of each pixel and considers the result as a binary number. One limitation of this operator lies in the fact that the associated parameters are fixed independently

☆ Reviews processed and recommended for publication to the Editor-in-Chief by Guest Editor Dr. A. H. Mazinan.

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http://dx.doi.org/10.1016/j.compeleceng.2017.08.009
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of the local spatial content of the image, which result into a limited discriminating textures ability of texture patterns. To address the aforementioned drawbacks, this paper proposes a novel texture extraction method based on an improvement of the original LBP descriptor, called Efficient LBP (ELBP). This operator takes into account both the local structure pattern and the spatial location related to the image pixels in order to characterize their texture information. To achieve this, an appropriate LBP code is computed with both a proper spatial scale parameter and a threshold value. The scale is determined according the local spatial pattern around the considered pixel, thus reducing the texture descriptors size. To determine the value of this scale accurately, Difference of Gaussian (DoG) operator is used. Furthermore, to improve the description of pixel characterized by mixture texture, the threshold value is determined by taking into account the spatial location of the considered pixel, thus, yielding a significant improvement in the texture discrimination ability. The defined texture features can be exploited subsequently for image classification or segmentation.

This paper is organized as follows: Section 2 describes related works, covering the original LBP operator and its extensions. Section 3 is devoted to detailed description of different steps of the proposed technique. Experiments results using a set of images are provided in section 4, evaluating the improvement of the proposed technique in terms of texture discrimination ability. Finally, some remarks and conclusions are given in the last section in addition to future works.

2. Related work

We first give a brief review of the original LBP method and its extensions that form the basis for our work. The original LBP, introduced in [5], describes the texture information of a pixel of an image by considering its surrounding elements. For that purpose, LBP method proceeds in three steps. First the eight neighbors in 3×3 window size are compared by the value of the considered central pixel [5].

$$LBP_{P,R}(x,y) = \sum_{p=0}^{P-1} s(i_p - i_c) \times 2^p \text{ where } s(x) = \begin{cases} 1 & x \geq 0 \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

where i_c and i_p are, respectively, gray-level values of the central pixel, and P surrounding pixels in the circle neighborhood of radius R. $s(.)$ is the sign function. Second, the decimal value corresponding to the resulted binary neighborhood is computed. Thereafter, a summation of the obtained values is performed to produce the LBP code that represents the local structure around the considered pixel.

Due to its robustness against illumination changes and its computation simplicity, and few parameters required to be set, LBP shows promising results for texture discrimination. However, this operator shows some drawbacks. One limitation lies in the fact that limiting the spatial window size on only 3×3 neighborhoods can lead to inability to capture dominant features with large scale structures. Furthermore, the LBP discrimination performance shows some limitations especially when irregular textures patterns are present in the image. To deal with the aforementioned drawbacks, different extensions of the original LBP operator have been proposed. The main focuses of interest of these methods are based on improvement of two parameters: 1) the selection of the appropriate threshold value and 2) the determination of the best neighborhood size.

2.1. Threshold value determination

Different strategies for threshold estimation have been developed. For instance, Jin et al. proposed an Improved LBP (ILBP) where the mean intensity of the pixels belonging to the considered 3×3 spatial window is computed [6]. Then, instead of using the central pixel as the threshold value, the corresponding pixels (including the central pixel) are put within threshold with their corresponding mean value in order to derive the LBP code. Even this solution yields some improvements of the original LBP in terms of local pattern discrimination, it cannot guarantee an accurate result, as when some pixels of the patch are noisy, it will strongly influence the mean value. In addition, when sharp variation exists between the different pixels in the patch, the mean value produces a false estimation of the distribution of the considered pixel set. Similar to the ILBP, Hafina et al. proposed the median LBP [7] where the median value of the 3×3 neighboring pixels is used as threshold. More recently, Liu et al. proposed Neighboring intensities LBP (NILBP) descriptor based on experimental studies [8]. In the NILBP, the threshold is obtained by dividing per 2 the sum of the pixels belonging to the spatial windows.

All these extensions of the original LBP seek the LBP code in the same way by taking the central pixel into account conversely to the original LBP method where the central pixel is discarded. However, these LBP versions differ only on the way the threshold value is computed. In addition to the threshold value, the selection of an appropriate neighborhood size is a key element of the LBP operator based texture. Since this choice has a great impact on the final performance. In this context, many approaches have been proposed.

2.2. Neighborhood size determination

The original LBP algorithm adopts local spatial kernel, e.g., a 3×3 window, to produce the LBP code to characterize the texture feature. However, texture patterns of different sizes may be present in an image. Thus, the LBP descriptor can fail to distinguish different texture features over a range of scales. To address this issue, Timo et al. proposed to use different