Ekstraksi Ciri Tekstur dengan Menggunakan Local Binary Pattern

Texture Feature Extraction by Using Local Binary Pattern

Esa Prakasa

Pusat Penelitian Informatika, Lembaga Ilmu Pengetahuan Indonesia, Bandung, Indonesia
Email: esa.prakasa@lipi.go.id

Abstract

Local Binary Pattern (LBP) is a method used to describe texture characteristics of a surface. By applying LBP, texture pattern probability can be summarised into a histogram. LBP values need to be determined for all of the image pixels. Texture regularity might be determined based on the distribution shape of the LBP histogram. The implementation results of LBP on two texture types - synthetic and natural textures - shows that extracted texture feature can be used as input for pattern classification. Euclidean distance method is applied to classify the texture pattern obtained from LBP computation.

Keywords: *texture feature, local binary pattern, natural textures*

Abstrak

Local Binary Pattern (LBP) adalah salah satu metode yang digunakan untuk mendeskripsikan karakteristik tekstur permukaan. Dengan menggunakan LBP, probabilitas pola tekstur tertentu dapat dirangkum dengan menggunakan histogram. Nilai LBP dihitung secara merata pada setiap piksel yang ada dalam citra. Keteraturan pola tekstur suatu permukaan dapat diamati berdasarkan sebaran histogram nilai LBP. Hasil uji coba LBP terhadap dua kelompok tekstur - tekstur buatan dan alami - menunjukkan bahwa hasil ekstraksi ciri tekstur bisa digunakan sebagai input pada bagian klasifikai pola. Metode *Euclidean distance* digunakan untuk menklasifikasi pola yang diperoleh dari perhitungan LBP.

Kata kunci: ciri tekstur, *local binary pattern*, tekstur alami

1. Introduction

Local Binary Pattern (LBP) method has been used in various applications. The LBP algorithm was applied to recognise human face [1] and facial expression [2]. The LBP histograms are extracted from Gabor map of human face. These histograms are then concatenated into a single vector. The vector is considered as a pattern vector [1]. In the other implementations, the combination between LBP texture features and a Self-Organizing Map were applied to identify the quality of paper [3].

LBP is an operator for texture description that based on the signs of differences between neighbour pixels and central pixels [4, 5]. Figure 1 shows an example of the calculation of LBP values. For each pixel value in the image, a binary code is obtained by thresholding its neighbourhood with the value of the centre pixel. This binary code can be considered as a binary pattern. The neighbour pixel becomes 1 if the pixel value is greater than or equal to threshold value, and it becomes 0 if the pixel value is less than threshold. Next, the histogram will be constructed to determine the frequency values of binary patterns. Each pattern represents possibility of binary pattern found in the image. The number of histogram bins depends on the number of involved pixels in LBP calculation. If LBP uses 8 pixels, the number of histogram bin will be 2^8 or equal to 256.

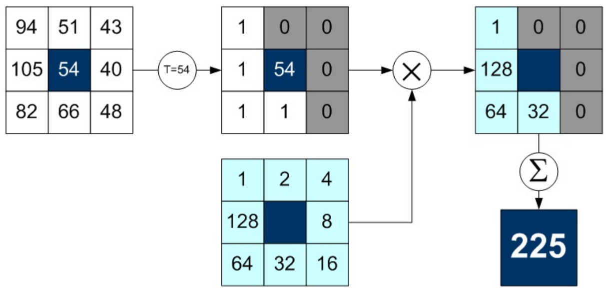

Figure 1. The stages of LBP calculation.

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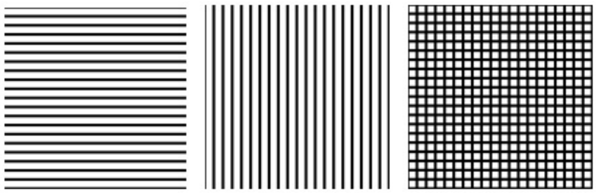

Figure 2. Synthetic images: horizontal, vertical, and cross lines.

The basic version of LBP operator uses the centre pixel value as threshold to the 3×3 neighbour pixels. Threshold operation will create a binary pattern representing texture characteristic. The equation basic of LBP can be given as follows.

$$LBP(x_c, y_c) = \sum_{n=0}^{7} 2^n g(I_n - I(x_c, y_c)) \qquad (1)$$

$LBP(x_c, y_c)$ is a LBP value at the centre pixel (x_c, y_c). I_n and $I(x_c, y_c)$ are the values of neighbour pixel and centre pixel respectively. Index n is the index of neighbour pixels. The function $g(x)$ will be zero if $x < 0$ and $g(x) = 1$ if $x \geq 0$. For example (see Figure 1), the centre pixel, 54, will be selected as threshold value. The neighbour pixels are assigned to 0 if its values are less than threshold. Conversely, it becomes 1, if the neighbour pixels are greater or equal to the threshold. The LBP value is computed by applying scalar multiplication between the binary and weight matrices. Finally, the sum of all multiplication results is used to represent LBP value. Therefore, LBP value of the matrix 3×3 shown in Figure 1 is $2^0 + 2^5 + 2^6 + 2^7 = 1 + 32 + 64 + 128$ or equal to 225. Some researchers have extended the types of LBP. The extended types are created by varying the number of involved pixels and neighbor location. Some examples of LBP variation are VLBP [6], circular LBP [7], Advanced-LBP [2], and center-symmetric LBP [8].

2. Methodology

This paper defines research work into three stages i.e. data collection, feature extraction, and pattern classification. The stages are detailed in the following sub sections.

2.1. Data Collection

Two image groups are used in the experiment. The images are categorised as synthetic and natural texture images. The synthetic image is generated from sine function. The images consist of horizontal, vertical, and mixture horizontal-vertical lines. The synthetic images is required in order to investigate LBP performance at the simplest image. The synthetic images are shown in Figure 2.

The natural texture images are collected from website of Texture Warehouse. 25 images are selected as data source. The images are divided into regular and irregular texture, but most of the textures are irregular. Each image is divided into some sub image samples which its size is 50×50 pixels. We use 75% of the samples for creating the reference pattern and 25% for the testing pattern. Figure 3 shows an example of natural texture and procedure to obtain image samples.

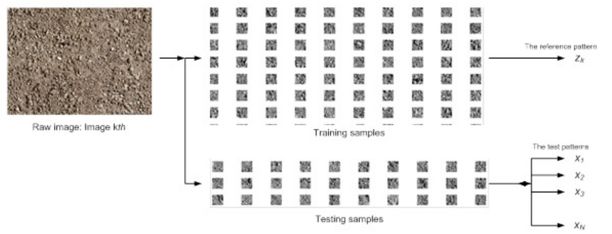

Figure 3. The sampling procedure of natural texture.

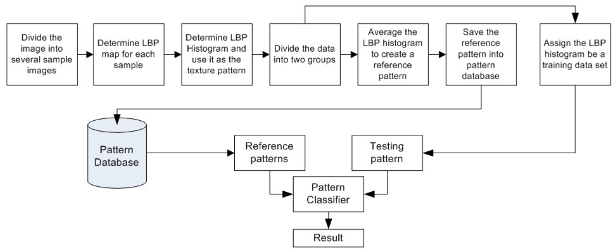

Figure 4. Flow diagram of feature extraction and pattern classification.

2.2. Feature Extraction

By using natural texture as the object, we will calculate their LBP bitmaps. The histogram will be extracted for each LBP bitmap. We will consider this histogram as the sample pattern. We divide the data into two groups. The first group will be used as reference patterns and the second group for the testing patterns. The reference pattern can be created by averaging a number of sample patterns. After the reference patterns have been created, we save them on pattern database. The pattern classifier will find the minimum difference between the input pattern as testing pattern and the reference patterns on database. The input pattern can be decided belong to a particular group, if the minimum difference has been achieved on that group. We enhance the contrast of psoriasis images by using histogram equalization. The enhancement results are shown in the next section. The complete stages of feature extraction and pattern recognition are illustrated in Figure 4.

2.3. Pattern Classification

The classification is built based on the extracted patterns from the image. Euclidean distance method is applied to classify the texture. This method is also known as minimum distance classifier. The equation

Table 1. The recognition rates of natural textures

Group	Accuracy (%)	Group	Accuracy (%)
1	43.8	14	65.6
2	84.4	15	96.9
3	68.8	16	43.8
4	40.6	17	56.3
5	84.4	18	65.6
6	71.9	19	93.8
7	68.8	20	93.8
8	65.6	21	31.3
9	46.9	22	15.6
10	100.0	23	84.4
11	84.4	24	68.8
12	100.0	25	25.0
13	71.9		

for calculating the distance between two patterns is given below:

$$D_k = \frac{1}{N}\sqrt{\sum_{k=-s}^{s}(\overline{x_i} - \overline{z_{k,i}})^2} \qquad (2)$$

Variable D_k is the Euclidean distance at the k-th group, $\overline{x_i}$ is the input pattern, $\overline{z_{k,i}}$ is the reference pattern at the k-th group, and N is the number of pattern element for each group. In this paper, 25 texture groups are used for experiment on the natural textures. The reference patterns are created by averaging patterns from 94 texture samples of the natural texture. 32 texture samples are used to test the system.

3. Results and Discussion

LBP filter was applied to the synthetic textures. The LBP bitmap is then converted into LBP histogram as depicted in Figure 5. The synthetic images contain only vertical, horizontal, and cross lines. In the image with vertical lines, three peaks can be found. The highest peak, scale 255, indicates the similarity values between the center and neighbor pixels. This value can be found on the area without boundaries of black line and white background. The next two peaks are representing two patterns of LBP (Figure 6). The patterns express two vertical boundaries. Those are the transition from black to white and white to black area.

Natural textures will be classified by applying the procedure of feature extraction and pattern classification. Figure 7 shows some texture examples with their LBP histograms. The average of LBP histogram from the same group is used as the reference pattern. Some patterns of natural textures are displayed in Figure 8.

The performance of pattern classification for the natural textures can be evaluated by using the percentage value of recognition rate. This value represents the ratio between the number of texture that recognized correctly and the number of tested textures. The recognition rate values for all texture groups are described in Table 1. The textures from group 10 and 12 have the highest rate. Their rates

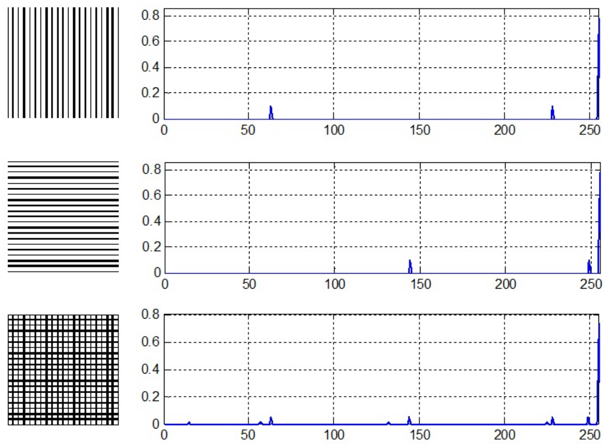

Figure 5. LBP histograms of synthetic textures.

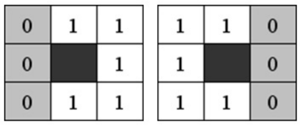

Figure 6. Two LBP patterns for the image of vertical lines.

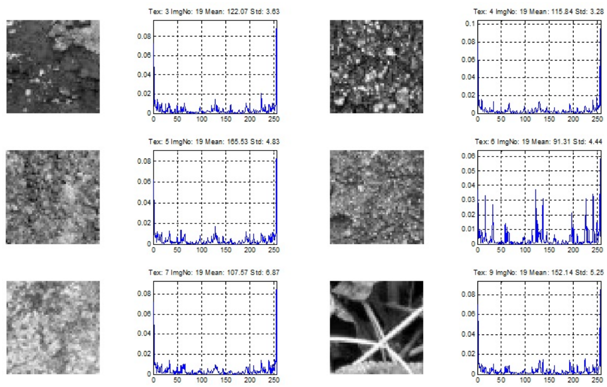

Figure 7. Natural textures with its LBP histograms.

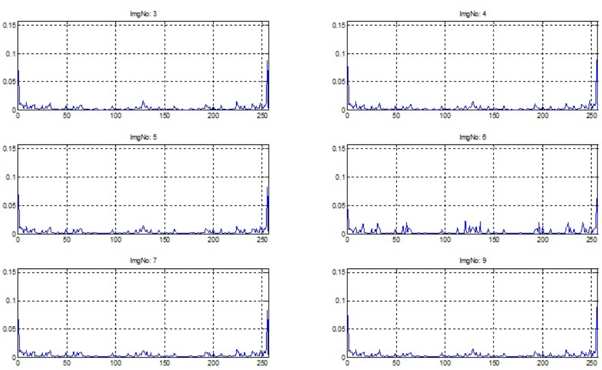

Figure 8. The reference patterns of natural textures.

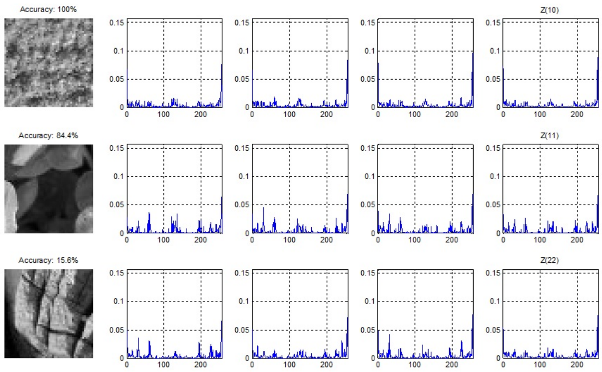

Figure 9. Examples of natural texture with high (top), medium (middle), and low accuracy (bottom).

are 100%. It can be realized, because the variation of texture surface is quite low. Even tough texture 10 and 12 are natural textures. The 3rd texture has the lowest recognition rate (see Figure 9), because the textures are extracted from wood cross section image. Its texture is varied along the radial direction.

4. Conclusion

LBP algorithm has been tested on synthetic and natural textures. The result shows that the algorithm is able to characterise and distinguish the surface textures. High accuracy can be achieved if the algorithm is implemented on the texture with low variance. The LBP and pattern recognition algorithm might be applied for further implementations, such as texture segmentation and grading on regularity of texture patterns.

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