A New Feature of Uniformity of Image Texture Directions Coinciding with the Human Eyes Perception*

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Abstract. In this paper we present a new feature of texture images which can scale the uniformity degree of image texture directions. The feature value is obtained by examining the statistic characteristic of the gradient information of the image pixels. Simulation results illustrate that this feature can exactly coincide with the uniformity degree of image texture directions according to the perception of human eyes.

1 Introduction

The research of image texture features has been a hot topic for long. Many methods to portray the image texture characteristics have been proposed in a large number of literatures [1]. In resent years, some intelligent methods such as neural network based techniques have been presented [2-6].

An important characteristic of texture image is the distributing trait of texture directions. For images with strong texture structures (e.g., bark, cloth, rock), the statistic properties of texture directions are generally very useful in most practical applications. But peculiar features to reflect the distributing property of texture directions have been seldom studied. The widely used Tamura feature of directionality, which is constructed in accordance with psychological studies on the human perception of texture, is one of these peculiar features. This feature is obtained by examining the sharpness degree of a histogram which is constructed from the gradient vectors of all the image pixels.

But the Tamura feature of directionality behaves not so well in reflecting an important property, i.e., texture direction uniformity, of images. Undoubtedly, a feature reflecting the uniformity degree of image texture directions according to the perception of human eyes is very useful in many fields.

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* This work was supported by the National Natural Science Foundation of China (Nos.60472111 and 60405002).

L. Wang and Y. Jin (Eds.): FSKD 2005, LNAI 3614, pp. 727 – 730, 2005.
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2 The Tamura Feature of Directionality

To compute the Tamura feature of directionality, firstly images need to be convoluted with Prewitt masks to obtain the horizontal and vertical differences, ΔH and ΔV, of the image. Then, gradient vector at each pixel can be computed as follows:

$$|\Delta G| = (|\Delta H| + |\Delta V|)/2 \ . \tag{1}$$

$$\theta = \tan^{-1}(\Delta V + \Delta H) + \pi/2 \ . \tag{2}$$

where $|\Delta G|$ is the magnitude and θ is the angle .

Then, by quantizing θ and counting the pixels with the corresponding magnitude $|\Delta G|$ greater than a threshold, a histogram of θ, denoted as H_D, can be constructed. And the Tamura feature of directionality is obtained as follows:

$$F_{dir} = \sum_{p}^{n_p} \sum_{\phi \in w_p} (\phi - \phi_p)^2 H_D(\phi) \ . \tag{3}$$

where p is ranged over n_p peaks; and for each peak p, w_p is the set of bins distributed over the peak; while ϕ_p is the bin that takes the peak value. We can see that this equation reflects the sharpness of the peaks, i.e., a smaller value of F_{dir} will corresponding to the image which gets a sharper peaks histogram.

However, we can also see from eqn. (3) that the angle distances between every two peaks can not be reflected out. So the uniformity of texture directions can not be reflected. In allusion to this shortage, we present a new feature in the next section.

3 The New Feature of Direction Uniformity

Just like the computing of the Tamura feature of directionality, with a selected threshold of $|\Delta G|$ denoted with letter b, we can also construct a histogram of θ. The area $[0, \pi]$ is equally divided into m parts called as m bins indexed with integer 1, 2, 3…, m. Suppose that the initial value of every bin is zero. Examining the gradient vector of each pixel, if the magnitude $|\Delta G|$ is larger than b, then the value of the bin in which the angle θ is contained in will be added by one.

Then the probability histogram is obtained by dividing each value by the sum of the m values of the m bins. Pick out k bins with the greatest k probability values. The integer k is determined by a threshold d with the follow conditions:

$$\sum_{i=1}^{k} p_i \geq d \quad \text{and} \quad \sum_{i=1}^{k-1} p_i < d \ . \tag{4}$$

Generally, the value of d is selected around 0.5. The k bin values are normalized by the following formula:

$$prb_i = p_i / \sum_{i=1}^{k} p_i \qquad \text{i =1, 2,..., k.} \tag{5}$$

Thus we get k bins with their indexes and normalized probability values prb_i. It should not be forgotten that the index of each bin indicates the direction this bin indicates. In other words, for an image, we then obtained its k texture directions with k largest probability values. For each bin, we consider the acute angle with the first bin, which gets the largest probability value, as the angle distance:

$$a_i = \begin{cases} m - |i_i - i_1| & if\ |i_i - i_1| \geq (m/2) \\ |i_i - i_1| & otherwise \end{cases} \qquad \text{i=1,2,…,k} \tag{6}$$

where m is the fore mentioned number of bins .The presented new feature is computed by the following formula:

$$F_{unf} = k \bullet \sum_{i=1}^{k} [(-prb_i \ln prb_i)] \bullet \sum_{i=1}^{k} a_i^2 prb_i \tag{7}$$

From the formula we can deduce that the smaller values of F_{unf} correspond to the images which have stronger texture directionality and better direction uniformity.

4 Simulation Results

The texture images in our experiments are all coming from the widely used Brodatz's. The algorithm mentioned above needs three parameters, i.e., the number of bins m, the thresholds b and d. In our experiments we adopted Prewitt masks, assume that the number of bins is 12, the threshold b is 9, and the threshold d is 0.5.

Figure 1 and 2 are the series of the same images sorted by the directionality values and by the new feature values respectively. It can be clearly seen that the new feature has some superiority than the Tamura feature of directionality in reflecting the image texture direction characteristic. Further more, it can also be found that the new feature of texture direction uniformity is to completely coincide with the human eye.

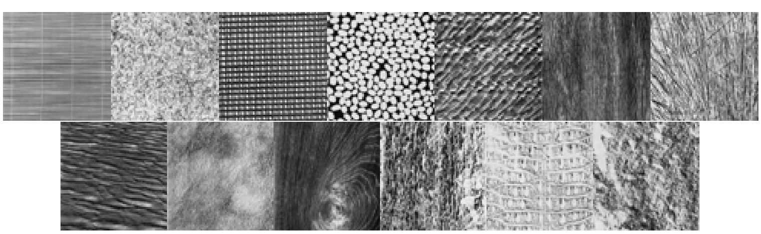

Fig. 1. Texture images sorted by the values of directionality of Tamura feature from smallest to greatest

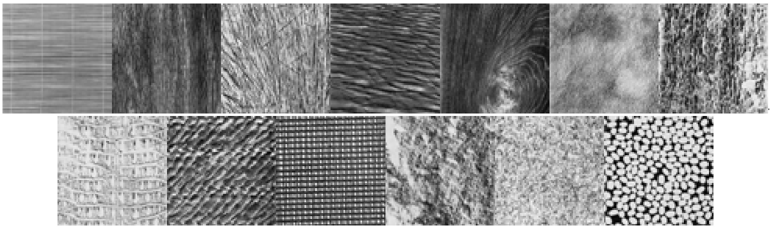

Fig. 2. The same texture images sorted by the values of the new feature from smallest to greatest

5 Conclusions

This paper has presented a new image texture feature and investigated its implementation ability. The simulation result showed that the new feature is effective in reflecting the degree of the image texture direction uniformity and the strength of image texture directionality. The image sequence sorted by value of this feature of each image also illustrates that the feature can exactly coincide with the uniformity degree of image texture directions in the light of perception of human eyes.

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