Proceedings of the 5th WSEAS International Conference on Signal Processing, Istanbul, Turkey, May 27-29, 2006 (pp56-58)

Handwritten Numeral Recognition Using Multi-wavelets and Neural Networks

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Abstract: In this paper, we develop a handwritten numeral recognition using multi-wavelets and neural networks. We first transform the character image into polar coordinate (r,θ) using the center of mass of the character as origin, then by performing the Fourier transform, characters spectrum achieved; afterward the multi-wavelet transformation is applied to get the proper features; to classify them into predefined classes they are fed to a feed-forward neural network. We apply this method on the MNIST dataset. The results show that there are some significant improvements on recognition performance. We could achieve 93.2% recognition rate.

Keywords: - OCR, Multi-wavelets, Neural networks, Pattern recognition, Invariant descriptor

1 Introduction

Nowadays character recognition is among the subjects which receive special attention during recent decades. Among all existing approaches, one approach is to extract the features that are invariant to translation, scaling and rotation. For this purpose Fourier translation could be used along or with the others descriptors as a good descriptor. Alshebeili et al [1] used Fourier spectrum of the character's projection on the X- and Y- axes as the features which compared with the features of 10 sets of characters were used as a model features. Although their method computational load is less, using the character's projection could decrease the recognition rate. Chen et al [2] used the shell coefficients of multi-wavelet orthogonal shell expansion which was performed on the outer contour of the character. They also believe that using multi-wavelet instead of Fourier could improve the recognition's rate. But just using the outer contour of a character may not contain all information enough to describe the character best.

Here, in this paper, we are going to present a novel shape descriptor for the recognition of the handwritten numerals. Here, at first just like what Chan and Bui [3] did, we translate the character into polar coordination (r,θ) using the center of mass of the character as origin to get translation and scale invariant. In order

to achieve character spectrum Fourier translation is applied. Afterward multi-wavelet translation is performed to get proper features. Therefore, without worrying of any existed shift on the pattern which may cause totally different multi-wavelet coefficient, we could use multi-wavelet properties. Finally we trained the feed-forward neural network to classify the characters with MNIST dataset. [4] The experimental result shows that there are some significant improvements in our proposed method.

This paper is organized as follows: section 2 explains the methodology. Section 3 shows the experimental results and section 4 gives the conclusions.

2 Methodology

Figure 1 shows the general diagram of character recognition. Recognition features are multi-wavelet coefficients which are normalized and scaled. For recognition, first of all, input characters that have been represented as the binary images transfer to polar coordinate using the center of mass of the character as origin. To this end we calculate the center mass of the character, denoted by (x_0, y_0) as Chen et al [3] did. By translating the origin of the coordinate system we achieved the translations invariance features. To scale invariance the character image is transform into coordinate system. Let $d = \max_{f(x,y)\neq 0} \sqrt{(x-x_0)^2 + (y-y_0)^2}$ be the longest distance from (x_0, y_0) to a point (x, y) on the character. We draw N concentric circles at (x_0, y_0) with radius $(d \times i)/N$, $i = 1,2,...,N$. Also, we form N angularity equal space radian vectors θ_i departing from (x_0, y_0) with angular step $2\pi / N$. For any small region $S_{ij} = \{(r,\theta) \mid r_i < r \le r_{i-1}, \theta_j < \theta \le \theta_{j-1}\}$ we calculate the average of $f(x, y)$ over this region and assign the average value to $g(r,\theta)$ in the polar coordinate system.

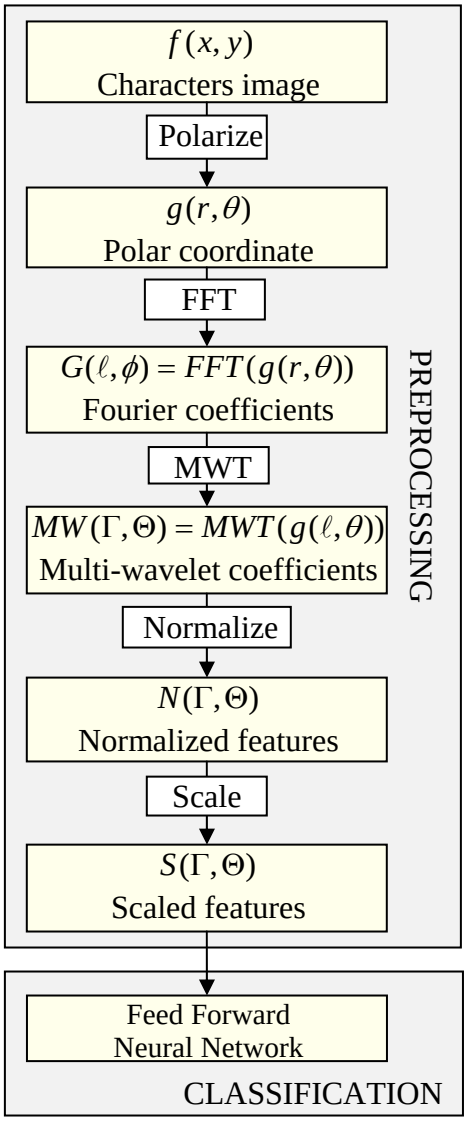

Fig.1. Recognition process block diagram

Figure 2 illustrates a character transformed into polar coordination. Here we apply Fourier transform to characters represented in polar coordination to obtain their spectrum. Finally to achieve the proper features the

multi-wavelet transform with cardbal2[1] [5] mother wavelet is performed on the character spectrum. Therefore, without worrying of any existed shift on the pattern which may cause totally different multi-wavelet coefficient, we could use multi-wavelet properties. At this stage the features are ready, they are normalized and scaled for better learning and used to train a feed-forward neural network for classification.

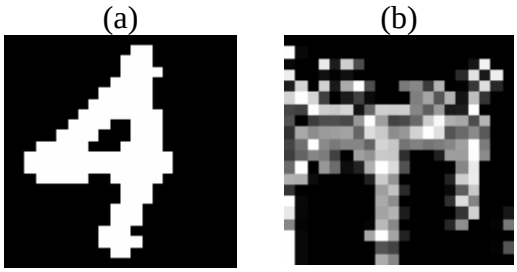

Fig.2. Illustrates a character transformed into polar coordination. (a) The original binary character. (b) The polarize character in polar coordinate

3 Experimental results

In this section we analyze the performance of proposed method described in section 2. Our experiments are performed on the MNIST dataset. Here the features extracted from 22×22 binary images from dataset by using multi-wavelet level 2 after performing Fourier transform. Then the features are normalized and scaled between [0, 1]. We use a three layer feed-forward neural network in our experiments. The number of nodes in each layer is given by $1152 \times 400 \times 1$. The network trained after 15000 epochs on the 2000 learning data and the testing results achieved from testing 1000 testing data form test dataset. Results show that the method recognition rate is 93.2%, but the weak point of this method may be the lengthening learning time because of large features size.

4 Conclusion

In this paper we introduced a new method for handwritten numeral character recognition, using multi-wavelets and neural networks. The features derived from Cardinal balanced multi-wavelet coefficient extracted from Fourier spectrum of polar coordination of characters. It should be mentioned that the descriptor is invariant with respect to rotation, scale and shift. The results show high recognition rate using shape descriptor described in section 2, however the method seems to have a week point i.e. the lengthening learning time because of large features size.

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