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A New Method for Feature Extraction and Image Classification Based on PCNN and Image Quality

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Abstract. Considering that PCNN is in accordance with human vision, so it has a good performance in image binaryzation and segmentation, the PCNN-based methods have advantage in feature extraction and image classification. In this paper, we propose a new method for feature extraction and image classification based PCNN which is more robust than others. This method mainly analyzes the quality and centroid of the image and extracts features from the relationship between different centroid. Then, the Euclidean distance distribution parameters used to describe these features. In image classification, the feature parameter also play an important role and distinguishes the difference between various object images efficiently.

Introduction

Feature extraction, as the basic part of image recognition, classification, and many other topics, is an important issue in image processing and computer version. In image processing, feature extraction used to detect and isolate various desired portions or shape of a digital image. Many algorithm proposed for getting more robust and efficient features. In low-level feature extraction, the research mostly concentrates on several direction such as edge detection[1,2,3], corner detection[4,5], blob detection[6,7,8,9], ridge detection[10,11], and scale-invariant feature transform (SIFT)[12,13,14,15,16]. In addition, there are also many shaped-based method like, template matching[18,19,20], thresholding[17], and hough transform[21,22,23,24].

PCNN is a self-organizing network that does not require training and the network was constructed by simulating the activities of the mammal's visual cortex neurons[38].Considering that PCNN is in accordance with human vision and has a good performance in image binaryzation and segmentation, the PCNN-based methods have advantage in feature extraction and image classification. Johnson proposed that using firing time as the features[25,26,27]. While, this kind of method would be badly effect by illumination change. In some researches, using the characteristics of PCNN entropy series, people extract the features and recognize some object in image [28,29]. What's more, the conception of quality is introduced into the image processing field and normalized moment of inertia (NMI) is used for feature extraction[30].

In this paper, we proposed a new method for feature extraction based on PCNN. Similar to the NMI feature extraction, we also use the image quality in processing and the quality parameters would play an important role in describing distribution of different pixels in an image. But the NMI feature would tend to be the same when there is a long strips or a round object in the image without background. That means NMI feature is unable to distinguish between some particular shapes for example a coin and a pen. In the method we proposed, the feature depends on the distribution of many partial or global centroid, rather than only a number of rotational inertia of the whole image in NMI method. Besides, a series of Euclidean distance would be adapt to describe the

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distribution of centroids. By this way, our proposed method has a better performance in feature extraction.

Method

Get Appropriate Binary Image by PCNN

In order to preprocessing and reducing the size of data, a PCNN model was applied in this paper. PCNN, rather than general traditional neural networks, has a single formed by a 2-D array of laterally linked pulse coupled neurons and not requires any training[25,26,27].

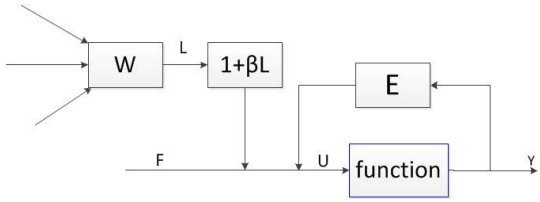

Figure 1: Neuron model of PCNN

Figure 2 is a simplified neuron model of PCNN. The PCNN model can be separated into three part which are the input module, the nonlinear modeulation module and the pulse generating module. Follow equations describe the model directly.

$$F_{i,j}[n]=I_{i,j} \tag{1}$$

$$L_{i,j}[n]=e^{-\alpha L}L_{i,j}[n-1]+V_L\Sigma_{k,l}W_{i,j,k,l}Y_{k,l}[n-1] \tag{2}$$

$$U_{i,j}[n]=F_{i,j}(1+\beta L_{i,j}[n]) \tag{3}$$

$$E_{i,j}[n]=e^{-\alpha E}E_{i,j}[n-1]+V_E Y_{i,j}[n-1] \tag{4}$$

$$f(x)=\begin{cases} 1 & U_{i,j}[n]>E_{i,j}[n-1] \\ 0 & else \end{cases} \tag{5}$$

For a better preprocessing result, the histogram equalization could be adapt to the i mage. Taking the image into the PCNN model to get a series of binary images (output pulsing images processed by the PCNN model).

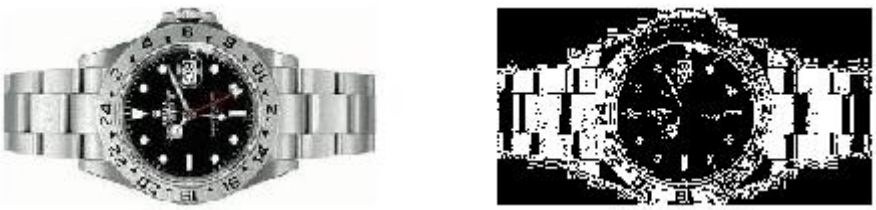

Figure 2: Original image(left side) and the binary image after processing(right side)

Feature Extraction

In this paper, a feature extraction method proposed based on image quality.

$$m=\Sigma_{i=1}^{M}\Sigma_{j=1}^{N} S_{ij} \tag{6}$$

Then, the centroid of an image can be define as following equation:

$$i_c=(\Sigma_{i=1}^{M}\Sigma_{j=1}^{N} iS_{ij})/(\Sigma_{i=1}^{M}\Sigma_{j=1}^{N} S_{ij}) \tag{7}$$

$$j_c=(\Sigma_{i=1}^{M}\Sigma_{j=1}^{N} jS_{ij})/(\Sigma_{i=1}^{M}\Sigma_{j=1}^{N} S_{ij}) \quad (8)$$

Different from using NMI feature extraction like papers [34,35], a new feature extraction method proposed based on the partial quality of image.

Considering that the whole pixel quality distribution could be described by the position of centroids and if reducing the size of current matrix, similarly, a partial centroid which represent the local pixel quality distribution can be achieved. Supposing that the mini-size matrix has an odd number of pixel in border and the same number of row and column. Naturally, the centroid of this local area not always located in the center of matrix. In a single matrix, when centroid located in the center, this center point is able to represent other point in this matrix and then this point should be saved for further processing. In another case, centroid and center mismatched, the center point may not stand for local quality distribution sufficiently and then this point should be abandoned. Duplicating afore-mentioned operations until the number of centroid remains the same or meet the specific criteria and a binary image can be got in current size of matrix. Then, increase the size of matrix and do the same things to the binary image computed from the last action. Along with the increasing of the matrix size, the centroid image would better describe a global distribution feature of quality in larger area. In order to avoid getting a centroid of an excessive large area which erases too much information of partial regions, the processing would be stopped when the descend rate of total point number becomes steady enough. Figure 4 shows the flow chart of this algorithm. In this algorithm the condition to stop iterative computation depends on the size of current process. Considering that smaller the matrix size is, the more centroid point gained, setting descend rate of point number related to size. A small descend rate adapted when counts in small size and a large one in bigger size.

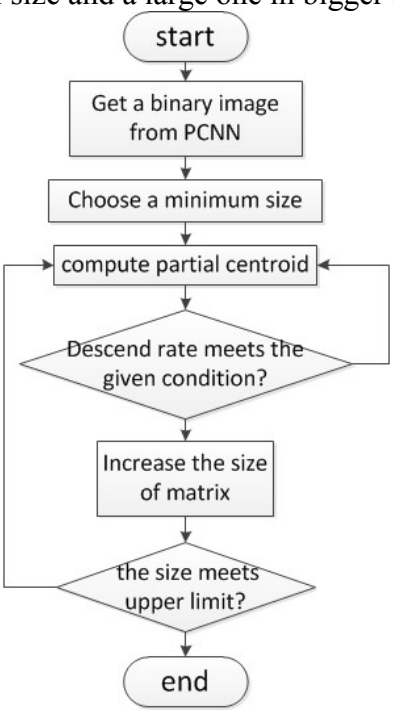

Figure 3: Algorithm flow chart

The partial centroid got from the binary image describe a kind of distribution situation of the pixels whose value is 1, which also means that the local characteristics of image could be reflect by these partial centroid. In our experiment, the maximum number of all the local centroid is 8[36].

Figure 4: Partial centroid distribution in the watch image

Considering the geometric deformation invariance (rotation invariance, translation invariance, stretch invariance .etc) of the feature constructed, the Euclidean distance can be calculated from each partial centroid to the global centroid and a distribution series can be made out represents local centroid distribution condition in current binary image. In order to get a more all-sided and accurate feature, many images in the same category should be processed for a stable and exact statistical feature of the object. The distribution of watch image shows in following Figure 5. (Normalize the distance first, then allocate the distance into different quantitative level. We choose 10000 level in our experiment. Number in different level should be normalized as well.)

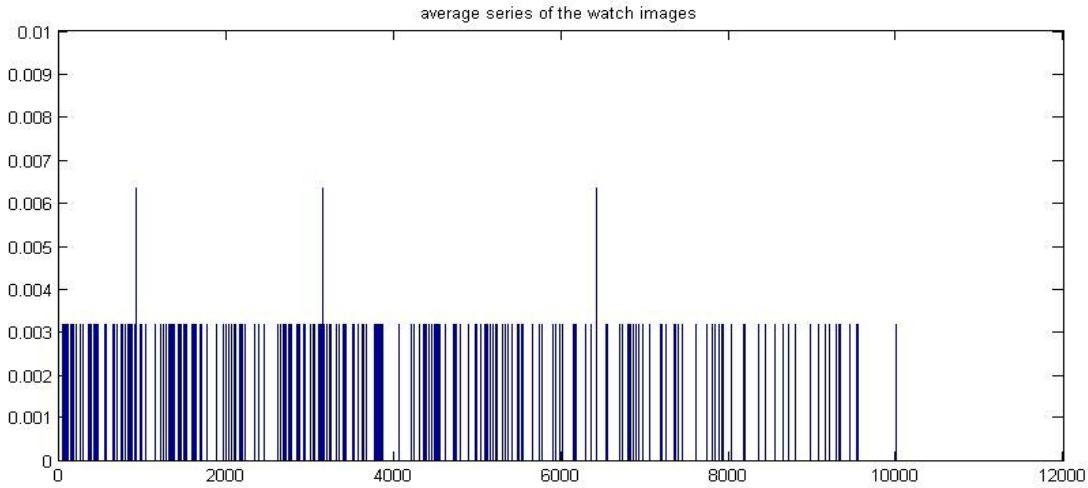

Figure 5: Distribution series of the watch image. The abscissa means the quantitative level and ordinate is normalized number which represents how many centroid distances are in this level

Experiment

To test our feature extraction method, many image classification experiments are performed. Test images are from Category101 [37].

Withdraw the partial centroid distribution series in each image from the same category. We can achieve an average distribution series as the feature of this sort of objects. By experiments, we find that partial centroid distribution series have an apparent differences among various kind of objects images. After cross-correlation operation between target series and other series, the object images belongs to the target category have a larger value of cross-correlation than the others. It is easy to classify different object by the result of cross-correlation. Matching result of the same category

of target (image of a motorbike) showed an excessive higher value than the incorrect images (image of a watch). The experiment result are showed in the following figures.

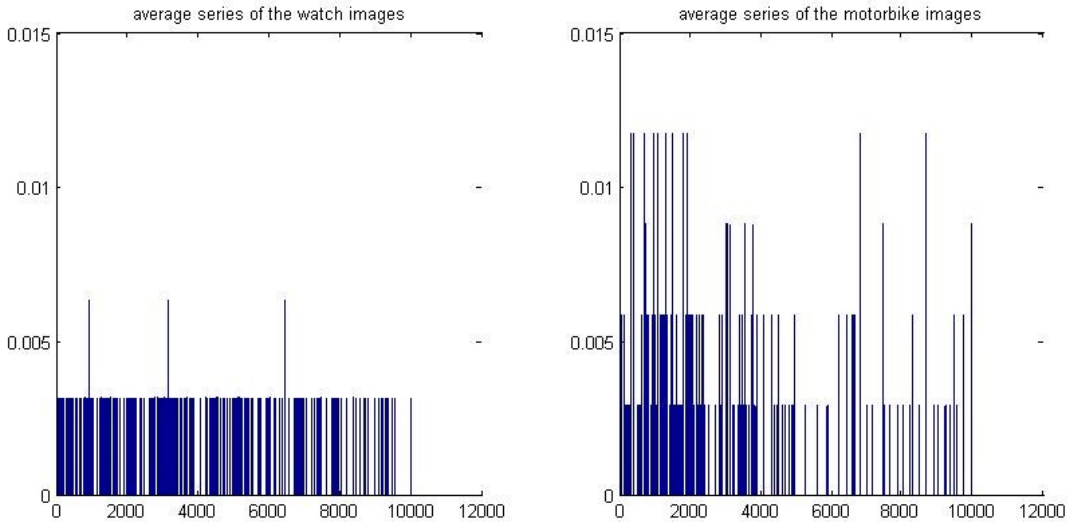

Figure 6: Comparison between watch images (left) and motor bike images (right)

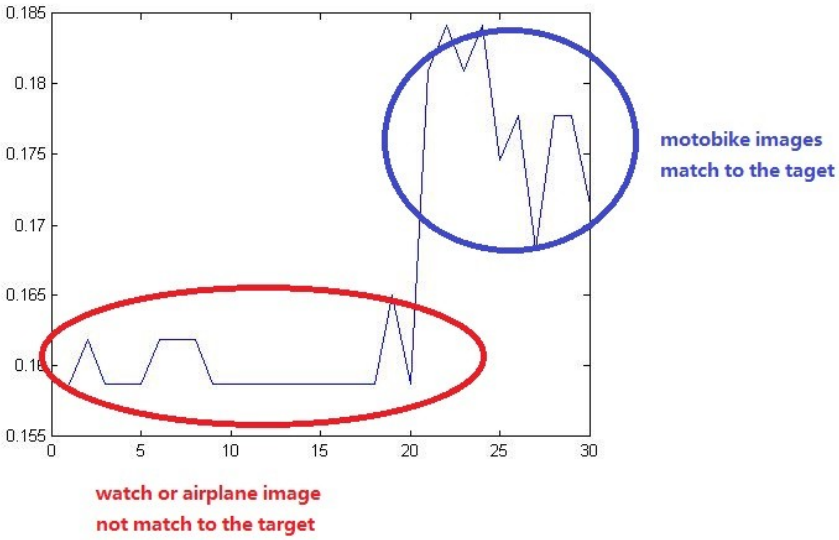

Figure 7: Match result of different images. The abscissa means the serial number of test image and ordinate is the normalized value of cross-correlation.

Several groups of contrast experiment result shows in the following Figure 8. In the experiment, our method shows a better performance to the others. The firing time feature is not robust in image classification and the accuracy rate fluctuate strongly. While NMI feature is better than firing time feature, but, in some particular object such as pizza and lotus, airplane and watch, NMI feature do not perform well.

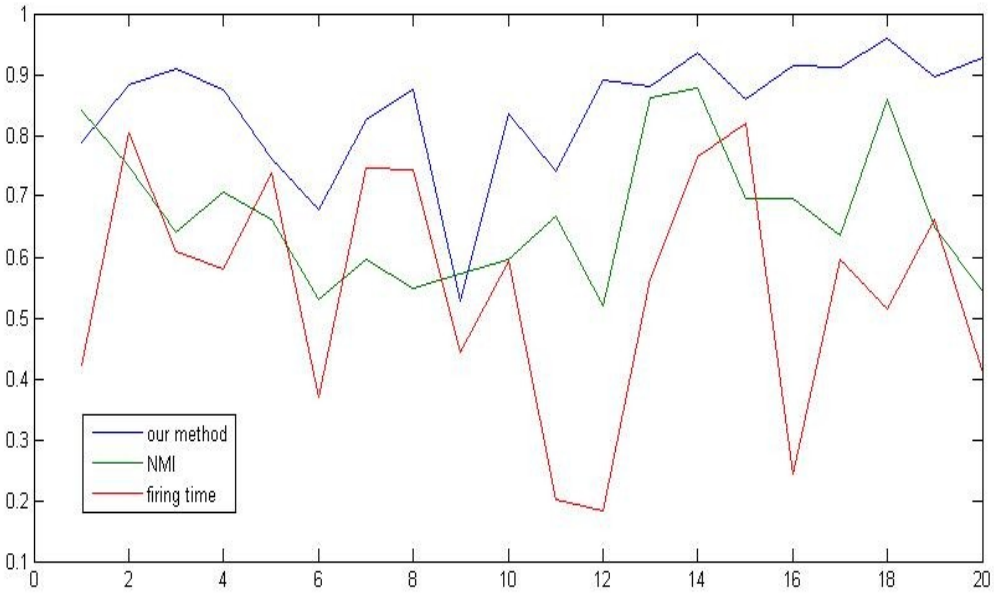

Figure 8: Contrast experiment result. The abscissa means the number of experiments and the ordinate is the accuracy rate of each method during the test.

Conclusion

In this paper, we proposed a new method for feature extraction based on PCNN and partial quality of images. It has a better performance than the others PCNN-based method. We will improve this method continuously and find a better algorithm to extract features.

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