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Recognition of English Calling Cards by Using Projection Method and Enhanced RBF Network

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Abstract

In this paper, we proposed the novel method for the recognition of English calling cards by using the projection method and the enhanced RBF (Radial Basis Function) network. The recognition of calling cards consists of the extraction phase of character areas and the recognition phase of extracted characters. In the extraction phase, first of all, noises are removed from the images of calling cards, and the feature areas including character strings are separated from the calling card images by using the horizontal smearing method and the 8-directional contour tracking method. And using the image projection method, the feature areas are split into the areas of individual characters. We also proposed the enhanced RBF network that organizes the middle layer effectively by using the enhanced ART1 neural network adjusting the vigilance threshold dynamically according to the homogeneity between patterns. In the recognition phase, the proposed neural network is applied to recognize individual characters. Our experiment result showed that the proposed recognition algorithm has higher success rate of recognition and faster learning time than the existing neural network based recognition.

Key words: English Calling Cards, Projection, RBF Network, Horizontal Smearing, Contour Tracking, ART1, Vigilance Threshold

1. Introduction

Recently, for the increased need of the storage and management of analog sources of personal information such as calling cards and memos etc., new technologies are coming out that recognize the calling cards via the photo sensor equipped on mobile phones, PDAs and like mobile devices. For the efficient management of in-disorder calling cards, it is required that calling cards are automatically recognized to digital data and it is saved and managed on the database. This paper propose the novel method that recognizes and digitalizes the personal information from the scanned images of English calling cards by using the projection method and the enhanced RBF (Radial Basis Function) network.

Generally, The recognition process of calling cards consists of the extraction phase of character areas and the recognition phase of extracted characters[1]. In this paper, the feature areas including character strings are separated from the original images by using the horizontal smearing algorithm and the 8-directional contour tracking algorithm in the extraction phase. And using the image projection method, the feature areas are split into the areas of individual characters. The enhanced RBF network is proposed that organize the middle layer effectively by using the enhanced ART1 neural network adjusting the vigilance threshold dynamically according to the homogeneity between patterns. In the recognition phase, the proposed neural network is applied to recognize individual characters. Our experiment result showed that the proposed recognition method has higher success rate of recognition and faster learning time than the existing neural network based recognitions. This paper describes the proposed recognition algorithm in detail in Section 2 and 3, and presents the experiment results in Section 4. Finally it is concluded in Section 5.

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2. Feature Area Extraction Algorithm

Fig. 1 shows the overall structure of the proposed recognition algorithm of calling cards, which consists of the feature area extraction phase and the character recognition phase.

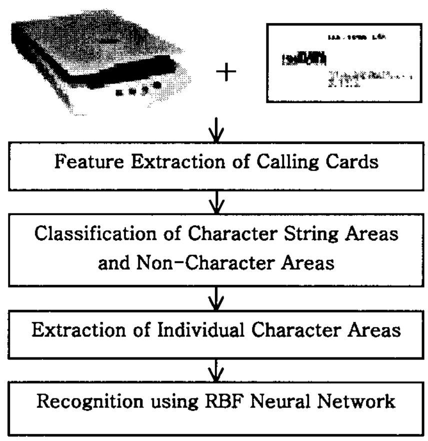

Fig. 1. Overall structure of calling-card recognition algorithm

In the feature area extraction phase, first of all, noises are removed from the scanned images of calling cards. Next, the feature areas including non-character components such as picture and logo etc. and the ones including character strings are extracted from the images, and from the latter areas individual character areas are split into and normalized for the character recognition. Fig. 2 shows the feature area extraction phase in detail.

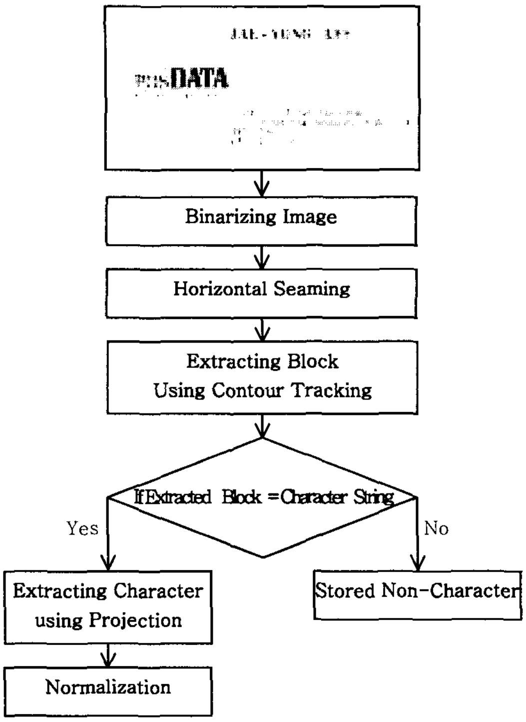

Fig. 2. Feature area extraction procedure

2.1 *Extraction of character string areas*

In the calling cards, characters have statistically constant width and space between them. And this paper connects component areas using the horizontal smearing method that removes spaces between two areas and combines into a larger area[2], and extracts the feature areas from the images by applying 8-directional contour tracking method[3] to the smeared images.

The feature areas are classified to two types, the character string area including only characters and the non-character areas including components such as pictures, logos etc. Because this paper has a concern to the character string areas, it selects only the character string areas among the feature areas considering the statistical characteristics of characters areas in the calling cards and the general design pattern of the cards. The method that determines whether the feature area is a character string area or not is in detail as follows: If we assume that C_H and C_W are the height and the width of the feature area in pixels respectively, $C(x, y)$ is the value, 0 or 1 of the pixel (*x*, *y*), and I_H is the height of the calling card image,

$$H_C = I_H \times \alpha, \quad R_C = \frac{\sum_{x=1}^{C_H} \sum_{y=1}^{C_W} \{C(x, y) \times 1\}}{C_H \times C_W}$$

if $\{(C_H \geq H_C) \cap (R_C \geq t_L) \cap (R_C < t_U)\}$ *then*

the feature area is a character string area

else

the feature area is a non - character area

Where H_C is the allowable minimum height of the feature areas, R_C is the rate of black pixels to the total pixels in the feature area, and the constants α, t_U, t_L are empirically set as 0.09, 0.95, and 0.30 respectively, based on the statistical analysis of calling card images.

The character string areas selected are used in the next processing phases, extraction of character areas and character recognition. Fig. 3 shows an example of the calling card image, and Fig. 4 shows the result generated by applying the horizontal smearing method to Fig. 3. Fig. 5 shows the character string areas extracted from Fig. 4 by applying the 8-directional contour tracking method and the above classification algorithm.

Fig. 3. A calling card image

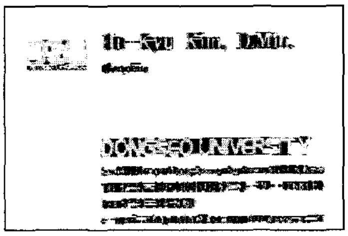

Fig. 4. Result of the horizontal smearing processing

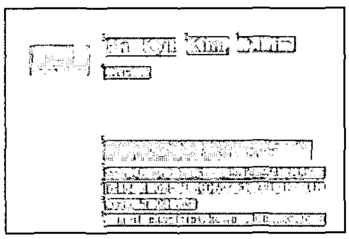

Fig. 5. Feature areas extracted from Fig. 3

2.2 Extraction of individual character areas

This paper uses the image projection method to extract individual character areas from the character string areas in the original image. Because characters are isolated from the neighborhood ones in the calling card image, the bi-directional, vertical and horizontal projection method is able to being efficiently applied. In this paper, the procedure to extract individual character areas from the character string areas consists of two steps. Step 1: Given a character string area, the vertical projection method is applied to the area, and as tracing the projection values in the horizontal direction, the position that has the projection value above the given threshold value p_V is determined as the left boundary of a individual character area. And after the left boundary is determined, the first position that becomes lower than p_V is determined as the right boundary of the individual character. The same process is repeatedly done until the left and right boundaries of all individual characters are extracted in the given feature area. Step 2: For individual areas having the left and right boundaries, the horizontal projection is applied. The same process as Step 1 is done in terms of the given threshold value p_H, and the top and bottom boundaries of the individual areas are determined. The threshold value p_V and p_H is empirically given.

Fig. 6 shows an example of the extraction of individual character areas. As shown in Fig. 6, the sizes of individual areas are various, and the individual areas are normalized to the constant size.

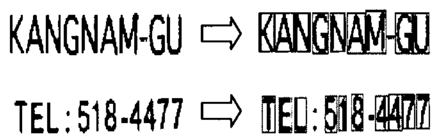

Fig. 6. Example of individual area extraction

3. Character Recognition using the Enhanced RBF Network

The RBF (Radial Basis Function) network have the characteristics such as fast learning time, generality and simplicity etc. and is mainly applied to the classification of learning data and the modeling of non-linear systems [4][5][6]. The middle layer of RBF network carries out the role of clustering the learning vectors by classifying homogenous learning vectors to the same cluster. In the clustering procedure, the homogeneity between learning vectors is represented as the distance between learning vectors, and if the distances between a learning vector and all vectors in a cluster are smaller than the given constant radius, the learning vector is classified to the cluster. But the usage of the constant radius in the clustering involves primarily the errors in clustering and therefore the decrease of the success rate of recognition[7]. And for the improvement of the success rate of recognition, this paper proposed the enhanced RBF network that adapts the ART1 network to the learning structure between the input layer and the middle layer and applies the output layer of the ART1 network to the middle layer.

In the ART1 network, the vigilance threshold determines inversely the allowable degree of mismatch between any input pattern and saved patterns[8][9]. The large value of vigilance threshold classifies an input pattern to new category in spite of a little mismatch between the pattern and the expected patterns, and oppositely the small value may allow the classification of the input pattern to an existing cluster in spite of a much mismatch. Moreover, because many application of image recognition based on the ART1 network give the empirical value to the

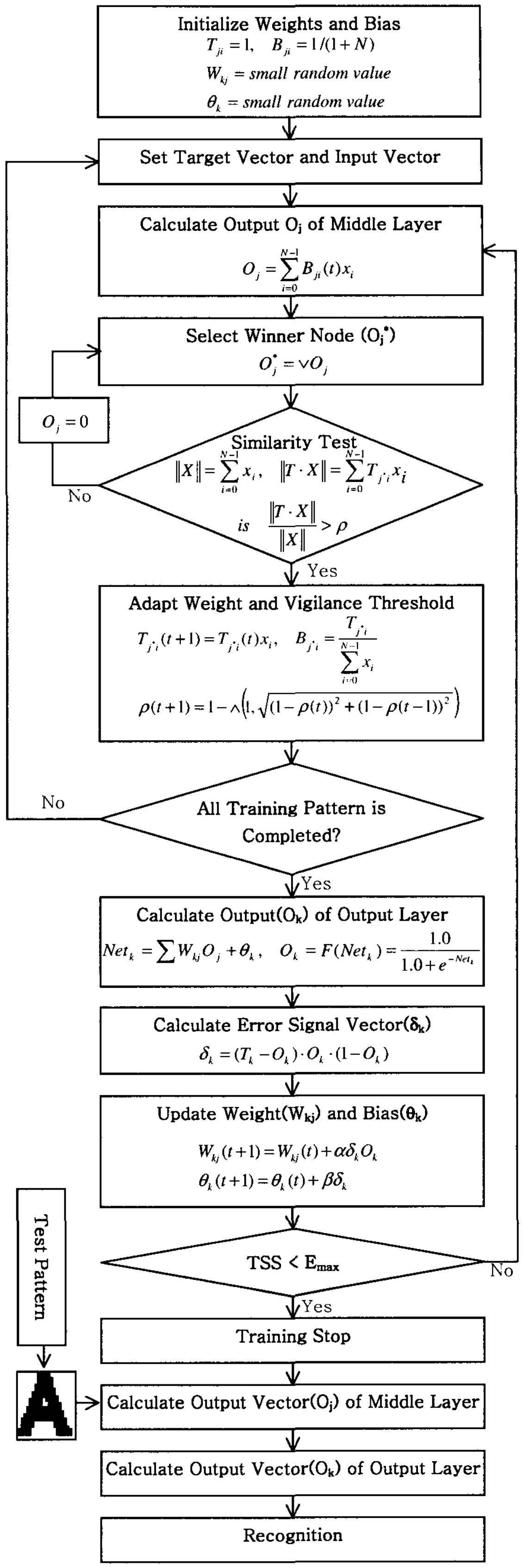

Fig. 7. Learning and recognition algorithm of the enhanced RBF network

vigilance threshold so that the decrease of the success rate of recognition may be incurred. To correct this defect, this paper enhances the ART1 network adjusting the vigilance threshold dynamically according to the homogeneity between patterns by using Yager's intersection operator, one of fuzzy connection operators. The fuzzy intersection operator has the property that the output value is not greater than the minimum value in all input values, and the Yager's intersection operator is described in Eq. (1).

$$\mu_{X_1 X_2} = 1 - \min\left\{1, \left((1-\mu_{X_1})^p + (1-\mu_{X_2})^p\right)^{\frac{1}{p}}\right\} \qquad (1)$$

Eq. (2) shows the equation applied to the ART1 network for refinement in this paper, which dynamically adjusts the vigilance threshold ρ by using Yager's intersection operator Eq. (1).

$$\rho(n+1) = 1 - \min(1, \sqrt{(1-\rho(n))^2 + (1-\rho(n-1))^2}) \qquad (2)$$

This paper enhances the RBF network by applying the modified ART1 network as the middle layer, as shown in Fig. 7. And we call the modified RBF network as the enhanced RBF network.

4. Experiment Results

We implemented the recognition system of calling cards based on the proposed algorithm by using C++ Builder tool on the Intel Pentium-IV 2GHz PC, and performed the recognition experiment by using 40's calling card images with 1500x800 pixel size. Fig. 8 shows a success case of individual character extraction, and oppositely Fig. 9 shows a failure case. As shown in Fig. 9, the proposed method for individual character extraction doesn't extract the connected characters in the calling card images. Fig. 10 shows the output screen of recognition experiment in the implemented recognition system.

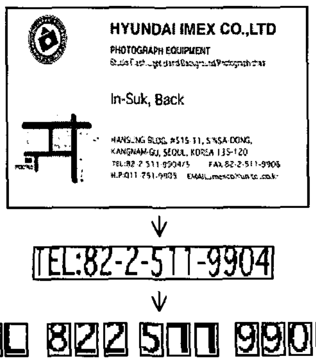

Fig. 8. Success case of individual character extraction

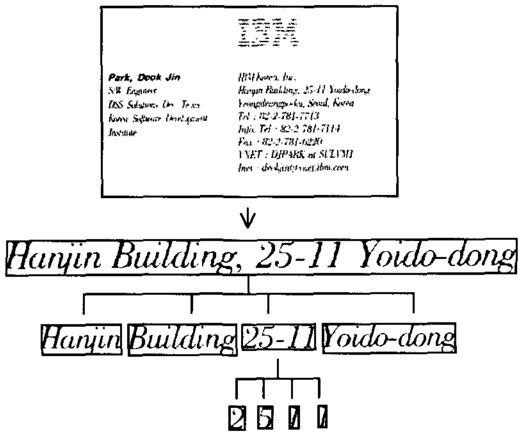

Fig. 9. Failure case of individual character extraction

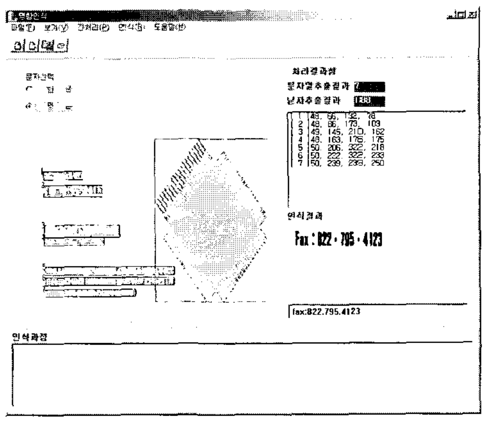

Fig. 10. Output screen of character extraction and recognition of calling cards

Table 1 shows the results of the feature area extraction in our experiment. The results show the total number of extracted areas from 40's images, the number of success of extraction and the number of failure of extraction. As shown in the Table 1, the number of extraction failure for the character string areas is ignorable compared with the number of success.

Table 1. Results of feature area extraction in the experiment

	Character string area	Non-character area
Total number of extracted areas	485	50
Number of success	483	47
Number of failure	2	3

The results of the individual character extraction on the extracted feature areas are shown in the Table 2. As shown in the Table 2, the failure rate of individual character extraction is near to 9%, which is incurred from the failure of extraction of continually connected characters. The results show the defect of the individual character extraction method based on the image projection.

Table 2. Results of individual character extraction in the experiment

	Results
Total number of individual character in the images	6352
Number of success	5821
Number of failure	531

Table 3 shows the results of the character recognition in our experiment using the enhanced RBF network.

Table 3. Result of character recognition in the experiment

	Results
Total number of extracted individual characters	5821
Number of success in the recognition	5576

For the performance evaluation of character recognition, as showed in Table 4, the results for learning and recognition were measured and compared when the enhanced ART1 proposed in this paper and the conventional ART1 were applied to the middle layer of the RBF network.

Table 4. The comparison of the performance for learning and recognition

RBF network based on the enhanced ART1		
	Middle layer nodes / Input patterns	The rate of success in recognition
English character	279 / 470	2767 / 2876
Number	82 / 160	2154 / 2240
Special character	13 / 25	655 / 705
RBF network base on the conventional ART1		
	Middle layer nodes / Input patterns	The rate of success in recognition
English character	408 / 470	2759 / 2876
Number	135 / 160	2150 / 2240
Special character	19 / 25	641 / 705

In the recognition experiment, the individual characters were classified to the three classes, the English characters, the numbers and the special characters, and for each class, the number of nodes of the middle layer and the success rate of recognition were measured. For the RBF network based on the conventional ART1, the initial vigilance threshold was set and fixed as 0.85, while in the RBF network based on the enhanced ART1, the vigilance threshold was set initially as 0.85 and adjusted dynamically in the learning process. We measured the number of nodes of the middle layer for the efficiency evaluation of the learning process. For the 470 English characters, the proposed RBF network and the RBF network based on the conventional ART1 generated 279 and 408 nodes respectively.

That is, the proposed RBF network is more effective in learning individual characters on the business card images. The success rate of character recognition was measured in each character class for the performance comparison of recognition. While in the English and number character classes, there was little the performance difference between the proposed RBF network and the RBF network based on the conventional ART1, the proposed RBF network showed the higher success rate of more 2% in the special character class.

Therefore, the results of the experiment on the forty business cards confirmed that the performance of learning and recognition for the proposed RBF network was better than the RBF network based on the conventional ART1.

5. Conclusions

This paper proposed the novel recognition algorithm of English calling cards. The proposed algorithm, first, removes noises from the scanned image and transforms to the binary image. Based on the statistical analysis of the design pattern of calling cards, the algorithm extracts the feature areas including characters, picture and logo etc. from the preprocessed image by using the horizontal smearing method and the 8-directional contour tracking method, and extracts the individual character areas from the feature areas including only characters by using the image projection method. Also, this paper proposed the enhanced RBF network adapting the modified ART1 network to the middle layer, and applied it to the character recognition phase.

The recognition experiments on the 40's images of English calling cards showed that the feature area extraction method based on the smearing and the contour tracking methods is so very finely suitable for the calling card images as the rate of failure can be ignored, and the individual character extraction method based on the image projection has the defect of the extraction failure of continually connected characters. Moreover, the enhanced RBF network recognized effectively the individual character so that it showed the high success rate of recognition.

In the future work, we will investigate and develop the preprocessing and recognition methods for the calling cards with the hand-written characters.

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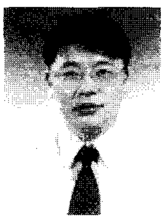

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