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Research on the Correlation among the Features of Character Recognition Based on BP Network

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Abstract: The feature combination is the study object of this study. The concept of feature combination and the problem in it are introduced. In order to study the relationship between features, some features are selected and a research platform of character recognition based on BP network is designed. The recognition rates of these features are obtained on the platform. The correlations of the feathers are researched based on the data of recognition rates and a parameter of describing the correlation among features is proposed. The experimental data shows that the parameters used to describe the correlation conform to the facts.

Key words: Feature combination, correlation, BP network;,,character recognition

INTRODUCTION

There are lots of methods of character recognition and they are divided into two classes based on the type of characteristics. One class is known as the recognition methods with structure characteristics and another is known as the recognition methods with statistical characteristics. In the recognition methods with statistical characteristics, the method with artificial neural network is applied widely in pattern recognition because of it's strong ablity of adaptive learning, massively parallel computing, nonlinear transformation and fault tolerance (Ou and Yuan, 2006; Jun and Weng, 2006).

The main advantage of BP neural network is that the characteristics applied in classification are combined arbitrarily without modifying the recognition algorithm.The arbitrarily combination of characteristics is known as the technology of feature fombination (Caimao *et al*., 2010; Wang *et al*., 2007). BP neural network is a best tool for studying the technology of feature combination. In BP neural network, the progress of feature combination is that two features of some dimensions are pieced together one feather of more dimensions.Then recognition is carried out based on the combination feather. For example, there are two feature vector A and B:

$$A = \{a_1, a_2, \dots, a_n\}, B = \{b_1, b_2, \dots, b_m\}$$

where, n is the dimension number of feature vector A and m is the dimension number of feature vector B. In order to promote the recognition rate, feature vector A and feature vector B are fitted into a new feature vectors C:

$$C = \{a_1, a_2, \dots, a_n, b_1, b_2, \dots, b_m\}$$

Dimension number of the feather vector C is n+m. But the combination of feature vectors doesn't always promote the recognition rate.The reason is that the correlation among feathers causes ambiguity of recognition.The correlation among feathers must be thought over while designing the classifier of pattern recognition and influence of the correlation among feathers on the recognition rate must be discussed.The lower the correlation among feathers is,the higher recognition rate of the combination of the feathers is.Now no study about the correlation among feathers with BP neural network has been reported in literature.This study researches the subject of the correlation among feathers by selecting some feathers and designing a recognition paltform with BP neural network.

SELECTION OF FEATHERS TO BE RESEARCHED AND THEIR ROLES IN CHARACTER RECOGNITION

Selection of feathers to be researched: Because the study pays attention to the correlations among feathers, 13 feathers of characters are selected to study. They are gridding feature,contour length,number of passing through, horizontal projection, vertical projection, invariant moments, skeleton, center of object, area of

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object, area of backgroud, mean square deviation, entropy, four vertex and center feather.

- Gridding feature (marked as T1) (Wu *et al*., 2005). The feather reflects the global distribution of pixels in characters and it varys while rotating and distorting characters.The grid is 3×3 and the feather has 9 dimensions.One of 9 dimension in the feather saves the number of pixels in the corresponding grid..
- Contour length (marked as T2). The feather records the number of 4-connectivity and 8-connectivity. Let N_4 be 4-connectivity of characters and let N_8 be 8-connectivity of characters, let C be contour length, $C = N4+N8*\sqrt{2}$
- Number of passing through (marked as T3). The feather has two dimensions. One dimension of the feather records the number of change of pixel's value along the horizontal direction and the other dimension records the number of change of pixel's value along the vertical direction
- Horizontal projection (marked as T4). The feather has 8 dimensions and they record respectively the numbers of objective pixels in the character along 8 horizontal scan lines
- Vertical projection (marked as T5). The feather is same as T4 besides the direction of scanning is vertical
- invariant moments (marked as T6) (Xue and Ding, 2010). Invariant moments of images remains the same while shifting,rotating,scaling. Here two feathers are selected and T6 is of 2 dimensions
- Skeleton feather (marked as T7). There are many types of points in the skeletons of characters. The points selected as feathers includes endpoint, isolated point, branch point and intersection. T7 is is of 4 dimensions. let:

$$t = \sum_{i=0}^{7} |x_{i+1} - x_i|$$

where, $X_i$is sum of 8-connectivity pixels around the pixel P,and $x_0 = x_8$. While t = 0?2?6?8, the pixel P is separatively isolated point, endpoint, 3_branch point,4_branch point?

- Center of object (marked as T8). The feather is calculated according to the following formula:

$$Gx = \Sigma\Sigma(iC(i, j))/ \Sigma\Sigma C(i, j), Gy = \Sigma\Sigma(jC(i, j))/\Sigma\Sigma C(i, j)$$

where, (Gx,Gy) is the coordinate of center of object, C(i, j) is value of the pixel at (i, j). T8 is of 2 dimensions?

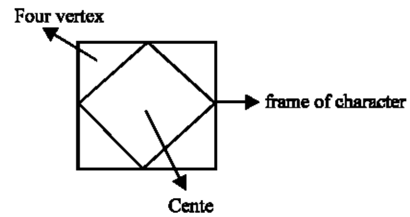

Fig. 1: Positions of four vertex and center in one character

- Area of object (marked as T9).The feather is sum of objective pixels in the character and is of 1 dimension
- Area of backgroud (marked as T10). The feather is sum of background pixels in the character and is of 1 dimension
- Mean square deviation (marked as T11). Let $\mu = \Sigma bP(b)$, $T11 = \Sigma(b-\mu)2P(b)$
- Entropy (marked as T12). Let $bN = \Sigma P(b)2$, $T12 =-\Sigma P(b)\log 2P(b)$
- Four vertexes and center feather (marked as T13). The feather is composed of four vertexes feather and center feather. four vertexes feather record number of objective pixels located four vertexes of character and center feather records number of objective pixels in center (Fig. 1)

In order to contrast,the experiment uses the same BP neural network.since dimension number of the combination feather is no more than 17, the input level of the BP neural network which the experiment used is of 17 nodes. Because character set to be recognized is digital character, the output leve of the BP neural network is of 4 nodes. The hidden level of the BP neural network is of 9 nodes. Every node in the input level of BP neural network corresponds to one dimension of the combination feather. If one node in the input level of BP neural network doesn't correspond to one dimension of the combination feather, inputing value of the node is set to zero.

INFLUENCES OF SINGLE FEATHER AND COMBINATION OF THEM ON CORRECT RATE OF RECOGNITION CHARACTERS

Recognition rate of single feather is shown in Table 1 and Fig. 2

Recognition rate of the combination feather is shown in Table 2. In Table2, every row and every column correspond to one feather and the feathers of recogniton is the combination of row feather and column feather.

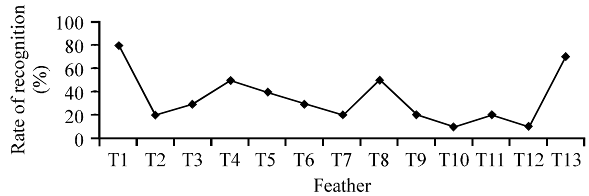

Fig. 2: The recognition rate of single characteristic

Table 1: Recognition data of Single characteristics

Feather mark	Rate of recognition	Trainng No.	Mean square error
T1	0.81	50000	0.145582
T2	0.22	50000	4.124622
T3	0.31	50000	3.059627
T4	0.54	50000	1.103642
T5	0.42	50000	2.014013
T6	0.33	50000	4.665376
T7	0.23	50000	3.321618
T8	0.51	50000	3.397142
T9	0.22	50000	4.602974
T10	0.1	50000	4.964557
T11	0.21	50000	4.577678
T12	0.13	50000	4.602173
T13	0.71	50000	0.663992

The Data of Table 1 and 2 show that combination of some feathers promotes recognition rate,combination of some other feathers reduces recognition rate and the recognition rate of combination of the other feathers is among the recognition rate of the single feathers. For example,combination of T1 and T3 increases recognition rate and combination of T8 and T13 does alse. combination of T2 and T7 reduces recognition rate and combination of T6 and T7 does alse.That shows that there are the correlation among feathers and the correlation among feathers influences the recognition rate of the combination of feathers.So study about the correlation among feathers is important for classifying and recognizing character with the combination of feathers.The following section will analyses it in detail.

ANALYSIS OF CORRELATION AMONG THE FEATHERS

Figure 3 is a research model of the correlation of feature fusion with BP neural network:

Set of feathers A and set of feathers B are the conditions of T,that is T = F(A, B), F is a logic function.Because BP neural network is non-linear transformation,the form of F isn't described in detail.For quantitative representation of the correlation among feathers,suppose that the change of recogniton rate after the combination of feathers depends on only the correlation among feathers. For one character set, if set of feathers A and set of feathers B are no correlation completely, the combination of them must be able to promote the recogniton rate.If not,the change of recogniton rate after the combination of feather is related to the degree of correlation among feathers. It is certain that the higher the degree of correlation among feathers, the greater the influence on recognition rate. This can be explained as the high correlation among feathers causes ambiguity while recognizing character. The following defines and describes the correlation among feathers with the change of recogniton rate before and after combining the feathers.

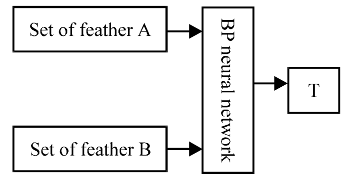

Fig. 3: The correlation model of feature fusion

In order to describe relation between two feathers,the study introduces a parameter λ to describe the correlation between two feathers:

$$\lambda = R_r/R_N \tag{1}$$

R_N is a sum of the recogniton rate of each single feather. Rr is the recogniton rate after combining feathers. For feather a and feather b, $R_N = R_a+R_b$.R_N is a standard to measure the correlation of feathers.The reason is that maximun recognition rate after combination of feather a and feather b is R_a+R_b and only when there are no relevance between feather a and feather b. If there is a little correlationa between feather a and feather b, the recognition rate after combination of them is less R_a+R_b:

$$\lambda = R_{ab}/(R_a+R_b) \tag{2}$$

where, R_{ab} is the recognition rate after combination of feather a and feather b,R_a is the recognition rate of feather a,R_b is the recognition rate of feather b.

In fact, $R_{ab}=R_a+R_b$ while feather a and feather b are completely independent. i.e $\max(\lambda) = 1$.Λ is biger and the degree of correlation between feather a and feather b is less. The correlation among the feathers listed in the study are shown in Table 3 which are calculated with the formula (2):

The data of Table 1, 2 and 3 show that λ can represent the correlation among feathers. It is true that Λ is bigger and the degree of correlation among feather is less. For example, λ of combination of T2 and T3 is 0.9811 and the correlation between T2 and T3 is low. The recognition rate after the combination of T2 and T3 is

Table 2: The recognition rate between two characteristics

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13
T1	-	0.81	0.92	0.9	0.93	0.81	0.33	0.81	0.74	0.81	0.93	0.81	0.81
T2		-	0.52	0.41	0.32	0.21	0.1	0.31	0.22	0.13	0.32	0.25	0.63
T3			-	0.5	0.51	0.42	0.21	0.43	0.49	0.41	0.42	0.4	0.7
T4				-	0.72	0.4	0.21	0.74	0.33	0.67	0.7	0.31	0.62
T5					-	0.45	0.23	0.51	0.4	0.58	0.53	0.44	0.71
T6						-	0.11	0.27	0.25	0.2	0.21	0.1	0.63
T7							-	0.22	0.21	0.11	0.1	0.24	0.15
T8								-	0.26	0.52	0.31	0.3	0.77
T9									-	0.27	0.2	0.24	0.6
T10										-	0.23	0.2	0.65
T11											-	0.34	0.67
T12												-	0.65

Table 3: Correlation between features

	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13
T1	0.7864	0.8214	0.6667	0.7561	0.7105	0.3173	0.6136	0.7184	0.8901	0.9118	0.8617	0.5329
T2	-	0.9811	0.5395	0.5000	0.3818	0.2222	0.4247	0.5000	0.4063	0.7442	0.7143	0.6774
T3		-	0.5882	0.6986	0.6563	0.3889	0.5244	0.9245	1.0000	0.8077	0.9091	0.6863
T4			-	0.7500	0.4598	0.2727	0.7048	0.4342	1.0469	0.9333	0.4627	0.4960
T5				-	0.6000	0.3538	0.5484	0.6250	1.1154	0.8413	0.8000	0.6283
T6					-	0.1964	0.3214	0.4545	0.4651	0.3889	0.2174	0.6058
T7						-	0.2973	0.4667	0.3333	0.2273	0.6667	0.1596
T8							-	0.3562	0.8525	0.4306	0.4688	0.6311
T9								-	0.8438	0.4651	0.6857	0.6452
T10									-	0.7419	0.8696	0.8025
T11										-	1.0000	0.7283
T12											-	0.7738

Table 4: The relationship between parameter and change of recognition rate

Change of recognition rate	Range of λ
Higher	$0.6<\lambda<1.2$
Lower	$0.1<\lambda<0.4$
No significant change	$0.4<\lambda = 0.5$

0.52,which is greater than 0.22 (which is the recognition rate of single T2)and 0.31(which is the recognition rate of single T3). The result is consistent with the fact. Feather T2 can divide character set {A, D, G} into {A} and {D, G} and T3 can divide character set {A, D ,G} into {A, D} and {G}. So the combination of T2 and T3 can recognize anyone in character set {A, D, G}. λ of the combination of T7 and T13 is 0.1596 and the recognition rate after combination of T7 and T13 is 0.15. But recognition rate of T7 is 0.23 and recognition rate of T13 is 0.71. That shows correlation between T7 and T13 is greater. By analyzing the data in Table 3,the relation between λ and the change of recognition rate is shown in Table 4.

CONCLUSION

The study selects 13 feathers and the combination of them to recognize digital characters of 10 font sizes. Letter characters are used to test and verify. A parameter describing the correlation among feathers is introduced and the relation between the parameter and the change of recognition rate after combination of feathers is presented. Analysis of the data shows that the correlation among feathers exists indeed and it influences recognition rate after the combination of feathers. The research result help to select feathers to recognize characters.

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