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PATTERNS RECOGNITION VIA ARTIFICIAL NEURAL NETWORK SYSTEMS

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ABSTRACT

This paper considers the problem of patterns recognition using the artificial neural network systems. The artificial neural network systems provide en effective tool for classifying patterns and/or characters by learning them in a certain repeated hashion. The mechanism of the learning process and the structure of neural network systems used are main concerns in the accurate and fast classification of the patterns which are slightly different each other.

The neural network system employed in this study has three layers structure which is composed of input, intermidiate, and output layers. Our main concern is to develope an effective learning mechanism how to learn the patterns fastly and accurately. The experimental study performed shows that there exists an effective learning method to get higher recognition ratio in classifying the several different patterns by artificial neural network system constructed.

1. INTRODUCTION

The problem of patterns recognition based on an artificial neural network system has attracted one's attention in various industrial applications[1,2]. The artificial neural network system provides an effective tool for classifying patterns and/or characters by learning them in appropriate repeated fashions. Main concern in the appiications is how to construct the mechanism and the structure of the neural network system in order to obtain accurate and fast clasiffication of the patterns which are slightly different each other.

In this study we forcus our attention to develope an effective learning mechanism how to learn the patterns using three layers neural network system which is composed of input, hidden or intermidiate, and output layers.

The patterns to be recognized are five digts(1~5) which have slightly different shapes. We used 16×16(=256) neural units in the input layer in the experimental study in order to reduce unnecessary machine time of computation. The output layer has five neural units in order to recognize five digits. We use four neural units in the intermediate layer since the experimental results indicated that the best number of neural units is four in order to get the accurate classification of the patterns.

The teaching signals which correspond to five digits are stored. The learning method used for the artificial neural network system above is well known back propergation method[3]. The experimental results obtained shows that there exist an effective learning method to obtain higher recognition ratio in classifying the slighthy different five digits by using the artificial neural network system constructed.

One of the effective learning is that the artificial neural network system learns each digits iteratively N times at first and secondly the learning process is repeated R times. We will explain precisely the learning process in the succeedings. The experimental results revealed that for the case where N×R=100 (constant) there exists appropriate combinations of N and R to yield higher recognition ratios.

In section 2 the system of patterns recognition and artificial neural network system are explained. Section 3 presents the learning method including the back propergation method. Section 4 illustrates the results recognized for various shapes of five digits using the best learning method obtained from the computer calculations. Conclusions follow in Section 5.

2. Patterns Recognition Based on Artificial Neural Network System

The configlation of patterns recognition system used in this study is shown in Fig.1. The patterns recognition system consists of three layers artificial neural network system where the input layer has 256 neural units(256 pixels), the intermidiate layer has 4 neural units , and the output layer has 5 neural units mentioned in the introduction.

The input patterns are five digits, viz., 1 ~ 5. The three layers neural network system is learned by the back propergation method(denoted BPM). The system equations for the artificial neural network system are specified as follows. The input of the j-th unit in the intermidiate layer U_j(j=1~ 4) is given by

$$U_j=\sum_i W_{ji}+\theta_j \ , \ j=1\sim 4 \qquad (2.1)$$

where I_i is the output of the i-th neural unit in the input layer (i=1~ 256),W_{ji} is synapsis weight from the i-th neural unit in the input layer to the j-th neural unit in the intermidiate layer, and θ_j is the offset or threshold of the j-th neural unit in the intermidiate layer. The output of the j-th neural unit in the intermidiate layer H_j is specified by the nonlinear relation such that

$$H_j=f(U_j), \ j=1\sim 4 \qquad (2.2)$$

where f is the sigmoid function given by

$$f(x)=1/(1+\exp(-2x/\mu_0)). \qquad (2.3)$$

In the above equation μ_0 is coefficient of slope of the function.

Similary, the input of the k-th neural unit in the output layer S_k(k=1~ 5) is specified by

$$S_k=\sum_j V_{kj}H_j+\gamma_k \ , \ k=1\sim 5 \qquad (2.4)$$

where V_{kj} is the synapsis weight from the j-th neural unit in the intermidiate layer to the k-th neural unit in the output layer, and r_k is the offset in the output layer. Hence the output of the k-th neural unit in the output layer O_k is given by

$$O_k=f(S_k), \ k=1\sim 5 \qquad (2.5)$$

The above equations present the system equation of artificial neural network system with three layers structure. The learning process is performed by adjusting the weights and the offsets (W_{ji},V_{kj},O_j,R_k) to minimize the errors between the outputs and the teaching signals correponding to the input patterns.

3. Learning Method Via BPM

The learning is performed by the BPM. The patterns recognition based on the artificial neural network system is illustrared in Fig.1. This figure shows that the input signals consists of 256 binary(0,1) pixels and these pixels correspond to 256 neural unit in the input layer.

The relation of the input layer, intermidiate layer, output layer, and teaching signals are described by the system equations shown above. We will show the BPM in order to learn the patterns to be recognized. The BPM method presents the adjustment of the synapsis weights and the offsets to minimize the errors by the following equations.

$$V_{kj}(new)=V_{kj}(old)+\alpha\,\delta_k H_j \qquad (3.1a)$$
(synapsis weight)

$$W_{ji}(new)=W_{ji}(old)+\alpha\,\sigma_j I_i \qquad (3.1b)$$
(synapsis weight)

$$\gamma_k(new)=\gamma_k(old)+\beta\,\delta_k \qquad (3.2a)$$
(offset)

$$\theta_j(new)=\theta_j(old)+\beta\,\sigma_j \qquad (3.2b)$$
(offset)

where δ_k and σ_j are defined by

$$\delta_k=(T_k-O_k)O_k(1-O_k) \qquad (3.3)$$

$$\sigma_j=\sum_k \delta_k V_{kj} H_j(1-H_j) \qquad (3.4)$$

and α and β are the coefficients of convergence in the steepist decent method, and T_k is the teaching signal. The BPM provide us with the minimum synapis weights and offsets in order to recognize the patterns quickly.

4. Learning Patterns and Results

The experimental studies of learning the patterns (five digits) were performed by a NEC personal computer 9801. The shapes of the five digits are illustrated in Fig.2. We used the following values for the BPM.

$$\mu_0=0.75 \qquad (4.1a)$$

$$\alpha=0.4 \qquad (4.1b)$$

$$\beta=0.3 \qquad (4.1c)$$

The initial values for the iteration of the BPM concerning the synapsis weights are random values which exist the following regions.

$$-0.5 \leqq W_{ji}, V_{kj} \leqq 0.5 \qquad (4.2a)$$

$$0 \leqq \theta_j, \gamma_k \leqq 0.5 \qquad (4.2b)$$

Using the above values the five digits shown in Fig.2 are learned by the BPM based on three layers artificial neural network system. The problem considered in this study is to find how to learn the patterns effectively and correctly. One of the learning process of the patterns is illustrated in Fig.3. In the figure N denotes the number of iterations in the BPM learning one pattern and R denotes the number of the reputations learning five patterns. Hence, the total number of interations in the leaning process is equal to N× R. We changed the combination of the values N and R in order to find the best learning approach by fixing N× R=100.

The teaching signals are also illustrated in Table 1. One of the experimental results is shown in Table 2. In this table the comination of N=5 and R=20 is used. The corresponding outputs to the input digits 1～5 are nearly erual to these in Table 1.

Based on the experimental result, the each eight patterns of the five digits 1～5 which is totally equal to 40 patterns were learned by the artificial neural network system. The number of iteration in learning one pattern is setted to be N=5 and the number of reputations is setted to be R=20. Therefore N× R=100 is the number of learning process in order to learn one pattern and the total number of learning process is equal to be 4000. We used the combination of N=5 and R=20 because this combination yielded best recognition ratio among other combinations. The eight patterns for the digit 2 are illustrated in Fig.4 and Table 3 shows the output values.

We obtained the result such that in this experimental study the recognition ratio is 90 % if the error between the output and teaching signal is less than 0.1 and the recognition ratio is 100 % if the error is less than 0.2.

5. Conclusions

In this study, the problem how to learn the patterns was considered. We found what kind of learning process is better in order to recognize the handwritten patterns by the BPM based on the three layer artificial neural network system proposed. The next step is to recognize the various patterns and characters in on-line fashsion. This is considered in a feature study.

References

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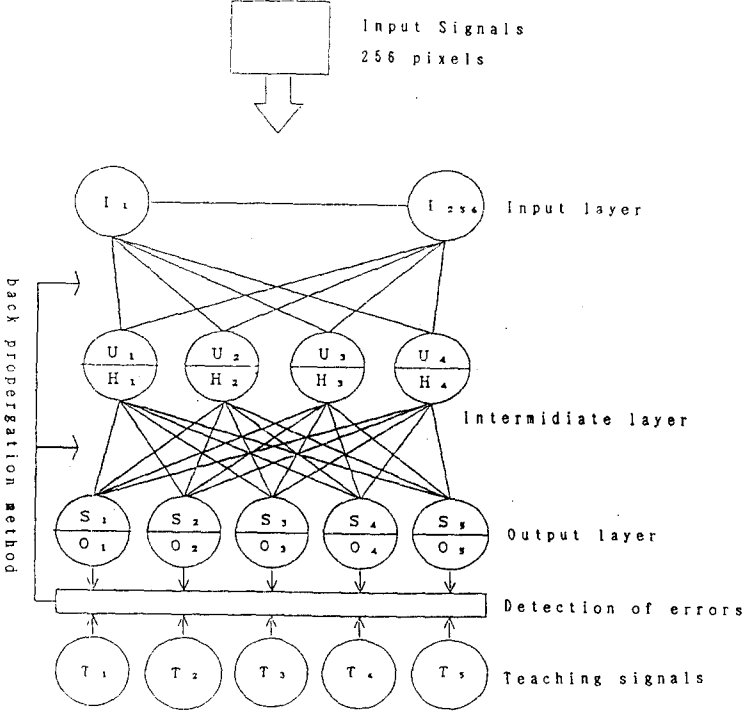

Fig.1 Patterns Recognition Based on Artficial Neural Network System

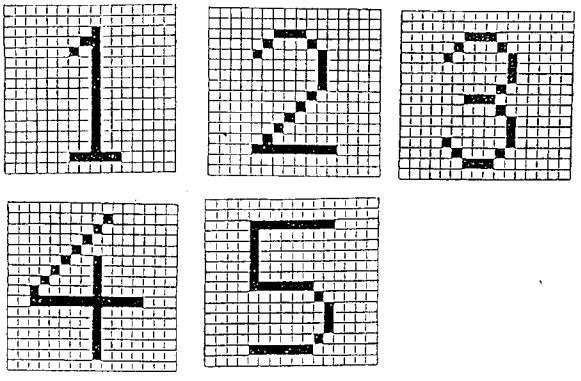

Fig.2 Five Digits Pattern for Recognition

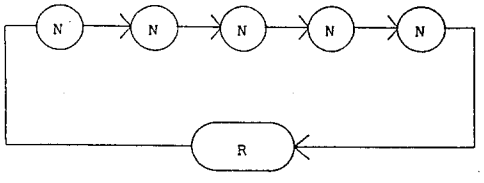

Fig.3 Conceptual Configulation of Learning Process

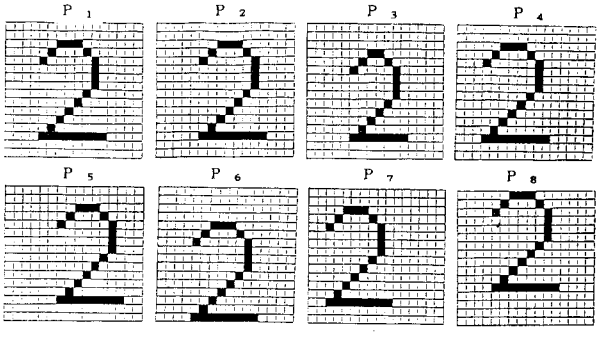

Fig.4 Eight Different Shapes of Digit 2

		Teaching signals				
		T_1	T_2	T_3	T_4	T_5
Input Characters	1	1	0	0	0	0
	2	0	1	0	0	0
	3	0	0	1	0	0
	4	0	0	0	1	0
	5	0	0	0	0	1

Table 1 Teaching Signals

	O_1	O_2	O_3	O_4	O_5
1	.913	.080	.017	.048	.098
2	.020	.852	.093	.062	.011
3	.035	.119	.848	.058	.179
4	.057	.097	.052	.889	.077
5	.050	.024	.068	.051	.863

Table 2 Output of Artficial Neural Network Systm(N=5,R=20)

	O_1	O_2	O_3	O_4	O_5
P_1	0.0266	0.9529	0.0052	0.0026	0.0051
P_2	0.0194	0.9594	0.0068	0.0036	0.0040
P_3	0.0247	0.9711	0.0025	0.0018	0.0074
P_4	0.0175	0.9618	0.0085	0.0046	0.0029
P_5	0.0189	0.9700	0.0040	0.0023	0.0061
P_6	0.0140	0.9744	0.0030	0.0016	0.0111
P_7	0.0083	0.9855	0.0036	0.0014	0.0097
P_8	0.0020	0.8653	0.1294	0.0003	0.0790

Table 3 Outputs of Artficial Neural Network System(N=5,R=20)for Eight Patterns of digit Two