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Recognition of Hand Written Hangul by Neural Network

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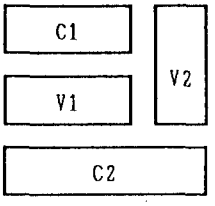
< Abstract >

In this paper we discuss optimization of neural network parameters, such as inclination of the sigmoid function, the numbers of the input layer's units and the hidden layer's units, considering application to recognition of hand written Hangul. Hangul characters are composed of vowels and consonants, and basically classified to six patterns by their positions. Using these characteristics of Hangul, the pattern of a given character is determined by its peripheral distribution and the other features. After then, the vowels and the consonants are recognized by the optimized neural network.

The constructed recognition system including a neural network is applied to non-learning Hangul written by some Korean people, which are the names randomly taken from Korean spiritual and cultural research institute.

1 Introduction

Hangul characters are composed of 14 consonants and 10 vowels as basic character elements. The elements are generated from basic segments(—, | , ／, ＼, ○).



C1, C2; All kinds of consonant

V1 ; ㅡ, ㅗ, ㅜ, ㅠ, ㅛ

V2 ; ㅏ, ㅑ, ㅓ, ㅕ, ㅣ, ㅐ, ㅒ, ㅔ, ㅖ

Fig. 1. Configuration of consonants and vowels of Hangul.

Furthermore, consonants and vowels are configured as shown in Fig. 1. Although more than 14,000 combinations of vowels and consonants are possible, Hangul characters are classified into six structure patterns[1]. Considering the above special features of Hangul, the authors propose a recognition system.

At first the structure of the Hangul character is found based on its peripheral distribution, then the vowels and consonants are recognized individually by neural networks.

2 Optimization of Neural Network Parameters

As the learning process for the neural network, the authors applied moment method including feed back. The moment

algorithm is a learning algorithm which updates the parameters based on the previous values. The algorithm is stopped when the error becomes less than 0.01.

The neural network is constructed as in Fig. 2.

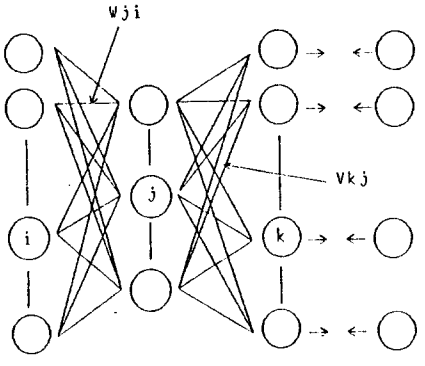


Fig. 2. Neural network structure

The calculation process of the network is as follows;

$$U_j = \sum_i W_{ji} \cdot I_i + \theta_j \quad (1)$$

$$H_j = f(U_j) \equiv 1/(1 + \exp(-U_j)) \quad (2)$$

$$S_k = \sum_j V_{kj} \cdot H_j + \gamma_k \quad (3)$$

$$O_k = f(S_k) \quad (4)$$

Here W_{ji} is the weight from the input layer's unit i to the hidden layer's unit j and V_{kj} is the weight from the hidden layer's unit j to the output layer's unit k, and θ_j is the threshold in the hidden layer's unit and γ_k is the threshold in the output layer's unit.

These weight parameters are optimized by the following moment method with feed back.

Step 1. Set initial values of the parameters $W_{ji}^{(0)}$, $V_{kj}^{(0)}$, $\theta_j^{(0)}$, $\gamma_k^{(0)}$ to small random values.

Step 2. Set the character elements for learning.

Step 3. From (1), (2), (3), (4) calculate the output of the network using the initial values of parameters.

Step 4. Calculate the error $\delta_k^{(0)}$ by the difference between the output $O_k^{(0)}$ and teaching signal $T_k^{(0)}$.

$$\delta_k^{(0)} = (O_k^{(0)} - T_k^{(0)}) \cdot O_k^{(0)} \cdot (1 - O_k^{(0)}) \quad (5)$$

Step 5. Calculate the error $\sigma_j^{(0)}$ by the $\delta_k^{(0)}$, $V_{kj}^{(0)}$ and $H_j^{(0)}$.

$$\sigma_j^{(0)} = \sum_k \delta_k^{(0)} \cdot V_{kj}^{(0)} \cdot H_j^{(0)} \cdot (1 - H_j^{(0)}) \quad (6)$$

Step 6. Update $V_{kj}^{(0)}$ and $\gamma_k^{(0)}$ to $V_{kj}^{(1)}$ and $\gamma_k^{(1)}$ as follows;

$$V_{kj}^{(1)} = V_{kj}^{(0)} + \alpha \cdot \delta_k^{(0)} \cdot H_j^{(0)} \quad (7)$$

$$\gamma_k^{(1)} = \gamma_k^{(0)} + \beta \cdot \delta_k^{(0)} \quad (8)$$

$$\Delta W_k^{(1)} = m \cdot \Delta W_k^{(0)} + \delta_k^{(0)} \quad (9)$$

Here α and β are fixed as 0.4 and 0.3, and m is a moment coefficient fixed as 0.6.
ΔW is the previous modification values of the V_{kj}, γ_k.

Step 7. Update $W_{ji}^{(0)}$ and $\theta_j^{(0)}$ and to $W_{ji}^{(1)}$ and $\theta_j^{(1)}$ as follows;

$$W_{ji}^{(1)} = W_{ji}^{(0)} + \alpha \cdot \sigma_j^{(0)} \cdot f_i^{(0)} \quad (10)$$

$$\theta_j^{(1)} = \theta_j^{(0)} + \beta \cdot \sigma_j^{(0)} \quad (11)$$

$$\Delta W_j^{(1)} = m \cdot \Delta W_j^{(0)} + \sigma_j^{(0)} \quad (12)$$

Step 8. Set the next learning pattern

Step 9. Carry out the learning process using the parameters settled as $W_{ji}^{(1)}$, $V_{kj}^{(1)}$, $\theta_j^{(1)}$, $\gamma_k^{(1)}$.

Step10. Repeat the process until the error becomes 0.01.

In this research 24 Hangul character elements are recognized by using the neural network. Twenty hand written Hangul character elements are given to carry out the learning algorithm.

The authors want to find the optimal values of the numbers of the hidden layre's units, the input layer's units, and the inclination of the sigmoid function.

The learning time changes with the number of the hidden layer's units as shown in Table 1. The relation between the recognition rate and the number of the hidden layer's units is shown in Fig. 3. From the Table 1 and Fig. 3, the appropriate number of the hidden layer's units is chosen as 40.

Table 1. Relation between the number of the hidden layer's units and the learning time

H.L.	20	30	40	50	60
L.T.	30	36	37	40	51

(I.L.= 135, O.L.= 10, Sigmoid= 0.5)

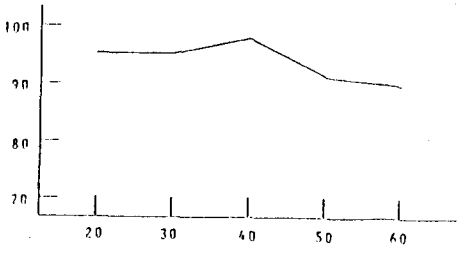


Fig. 3. Relation between the recognition rate and the numbers of hidden layer's units

The learning time changes with the inclination of the sigmoid function as shown in Table 2. The relation between the recognition rate and the inclination of the sigmoid function is shown in Fig. 4. From Table 2 and Fig. 4 the appropriate inclination of the sigmoid function is chosen as 0.5.

Table 2. Relation between the inclination of the sigmoid function and the learning time

S.F.	0.4	0.5	0.6
L.T.	37 times	33 times	37 times

(I.L.= 135, H.L.= 40, O.L.= 10)

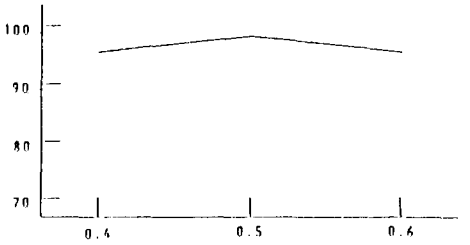


Fig. 4. Relation between the recognition rate and the inclination of the sigmoid function

The learning time changes with the number of the input layer's units as shown in Table 3. The relation between the recognition rate and the number of the input layer's units is shown in Fig. 5. From Table 3 and Fig. 5 the appropriate number of the input layer's units is chosen as 135.

Table 3. Relation between the number of the input layer's units and the learning time

I.L.	60	135	375
L.T.	83 times	33 times	27 times

(H.L.= 40, O.L.= 10, Sigmoid= 0.5)

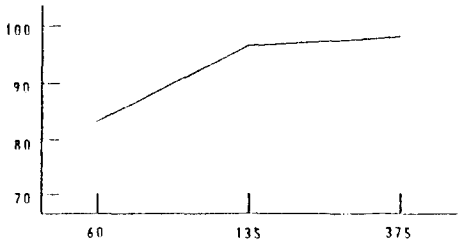


Fig. 5. Relation between the recognition rate and the number of input layer's units

3 Recognition Procedure

The authors propose a hand written Hangul recognition system which includes the neural networks to recognize vowels and consonants. The neural networks are optimized by the back propagation algorithm using the moment method as mentioned above. The recognition procedure is shown in Fig. 6.

A hand written Hangul character is read in a computer through a camera as density values of 400×400 points. They are transformed to binary values by a given threshold. Next, the value at region of 4×4 is determined as 1 if more than half of the region's points is 1. In the other case, the value at the region is determined as 0.

Then the character is given as binary values of 82×82.

The structure pattern of the character is found by the peripheral distribution and some knowledge rules[1]. After the character is separated into vowels and consonants, they are recognized by the neural networks respectively.

As an example, the network structure for recognizing the consonant is shown in Fig. 7. The numbers of input layer's units, hidden layer's units, and output layer's units are 135, 40, and 14 respectively. These units are optimized by preprocessing as mentioned in Sec. 2.

4 Experimental Result

Examples of the hand written Hangul patterns for recognition are shown in Fig. 8.

The recognition process of hand written Hangul 'hoang' is shown in Fig. 9.

The authors applied the recognition method to Hangul characters written by seven men and five women. These are the names randomly taken from Korean

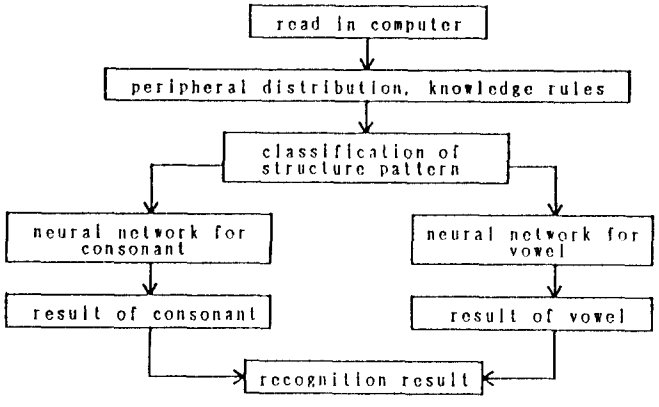


Fig. 6. Recognition procedure of Hand written Hangul

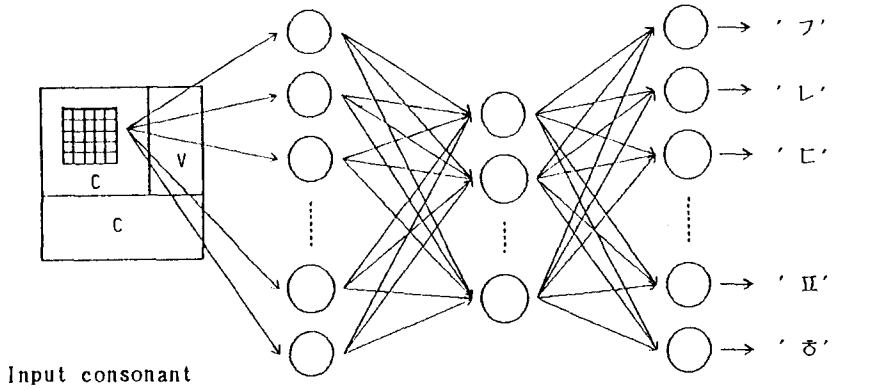


Fig. 7. Neural network structure of consonant

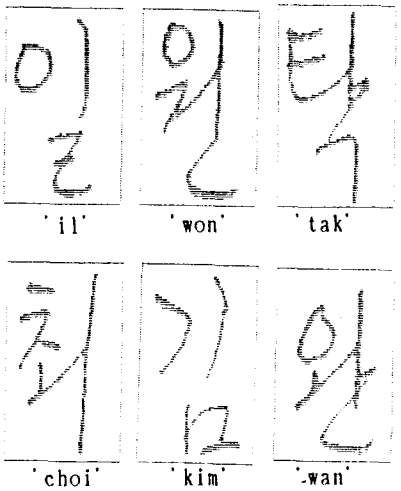


Fig. 8. Examples of hand written Hangul for recognition

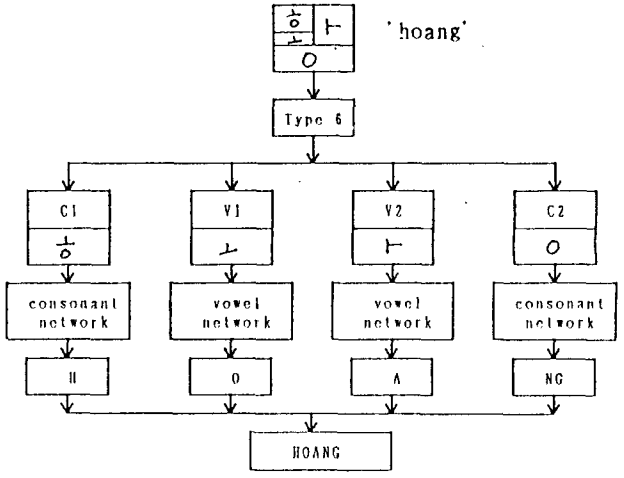


Fig. 9. Recognition process of hand written Hangul 'hoang'

spiritual and cultural institute. In this experiment, 91.87 percent of 613 charcters are recognized correctly by this method. Some of the errors are caused in the process of classification, because of the connection of the character elements.

References

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