'92 KACC 1992. 10. 19~21

# A Recognition of Hand Written Hangul by Parallel Procedure of Character Segments and Structure

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Abstract

In general, recognition of Hand written characters requires to apply an algorithm which takes into consideration of the individual differences.

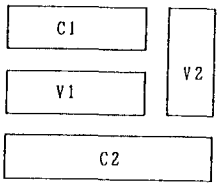
Considering the differences, the authors propose a new method for recognizing Hand written Hangul by parallel procedure analyzing both the segments and the structure of the character.

In the previous recognition method[1] proposed by the authors two severe restrictions were placed. The element representing consonant/○/ was closed, and the character elements were separated each other. In order to remove these two restrictions, the authors propose an improved algorithm.

It is shown that Hangul in its simplified form is well recognized by using this improved algorithm.

## 1. Introduction

Hangul characters are composed of 14 consonants and 10 vowels as basic character elements. Hangul characters are generated from the combination of 24 character elements. The elements are generated from basic segements /, \, |, —, ○/. Futhermore, consonants and vowels are arranged as shown in Fig.1. The recognition of Hangul is performed by finding the segments or the structure some researches about the recognition of Hangul have been carried out, but the almighty method is not find until now. The authors also have researching about the problem, and proposed the following two methods. The first method was to find the segments of the Hangul and to make fuzzy inference for the input pattern and the reference with the same number of segments[1]. The second method was to find the structure of the Hangul. The characters were classified into six structure patterns based on the peripheral distributions which were the projections of the characters to x and y axes. The characters




C1,C2; All kinds of consonant.
V1 ; ㅡ, ㅗ, ㅜ, ㅠ, ㅣ (Vowel)
V2 ; ㅏ, ㅑ, ㅓ, ㅕ, ㅐ, ㅒ, ㅔ, ㅖ, ㅣ (Vowel)

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

were recognized by taking pattern matching with the references in the classified pattern[2].

However, in these recognition methods, two severe restrictions were placed. The element representing consonant/○/ was closed and each element was saparated from the other elements. In order to remove these two restrictions, the authors propose an improved algorithm in this paper.

## 2. Recognition based on the Number of Segments and the Structure of Hangul

The procedure to recognize the Hangul based on the segments or the structure is as follows :

<2.1> Recognition Based on the Number of Segments

- Read the character by camera.
- Find the number of segments for the character.
- Look for the feature parameters to each segment.
- Transform the feature parameters to fuzzy data. The fuzzy data is send to the fuzzy inference part.

<2.2> Recognition Based on the Structure of Hangul

- Read the character by camera.
- Decide which structure pattern does the character belong to.
- Find the number of segments for the character.
- Take pattern matching with the references in the classified pattern, according to the classifying algorithm by the prerepheral distribution shown in Fig.3.

<2.3> Fuzzy Inference

The rule for recognition is made of fuzzy relation ($R_{ij}$) which is the relationship between the feature parameter ($S_j$) and the character($C_i$). The rule takes the form of IF [ condition of fuzzy relation ] THEN [ result of character ] as follows:

Group g; rule i;

IF [ ····· $S_j$ is $R_{ij}$ ····· ] THEN $C_i$.

where g is the group having the same number of segments, i is the number of the characters and j is the number of the feature parameters.

The feature parameters are the number of the segments, the starting and the ending coordinates of each segment, the length of the segment and the angle. We calculate the grade of fuzzy inference in terms of min-max operation as follows :

$$h R_{ij} \circ A_j(C_i) = \max_s [h R_{ij(sj,ci)} \wedge h A_{j(sj)}]$$

$$= W_{ij}$$

The character giving the maximum grade calculated as mentioned above becomes the recognized one.

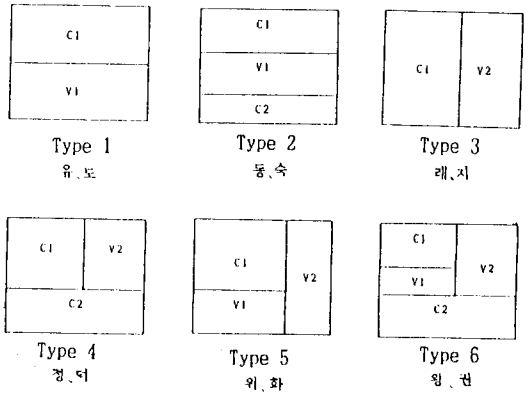



Fig.2. Structure patterns of Hangul.

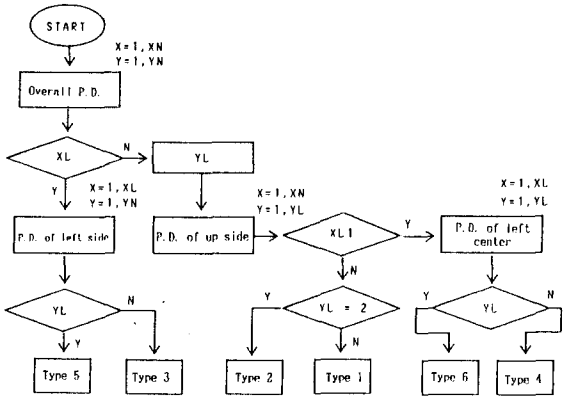



Fig. 3. Algorithm of the classification.

## <2.4> Parallel Procedure in Fuzzy Inference

The recognition of Hangul can be carried out based on either method of <2.1> or<2.2>. But, the authors propose the parallel procedure including both method. First, the peripheral distributions which are the projections of the characters to x and y axes are obtained. Second, thinning algorithm is performed, and the two recognition procedures are taken in parallel as shown in Fig.4.

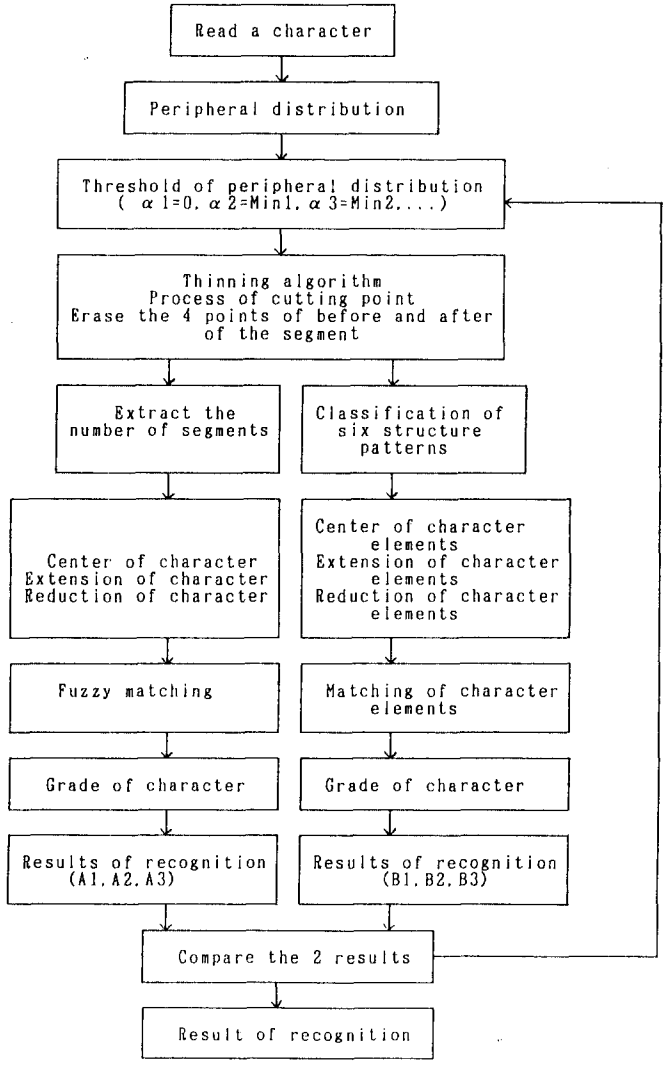


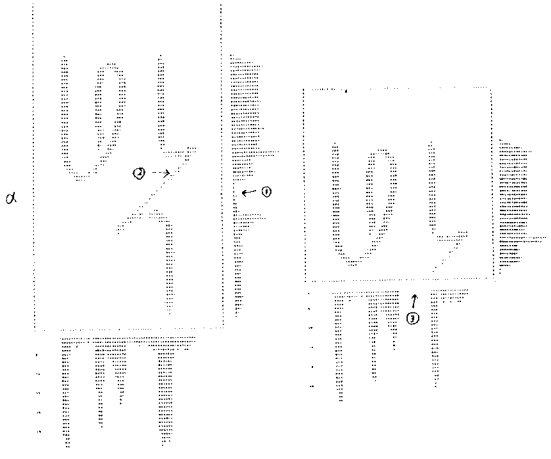

Fig. 4. Parallel procedure in fuzzy inference.

If the result of the process based on the segments is same as that of process of the character elements, it becomes the finally recognized result. If the results are different each other, the threshold in the separation of the segment by peripheral distribution is changed and repeated the same procedure until we get the same inferred result.

## 3. Some Improvements

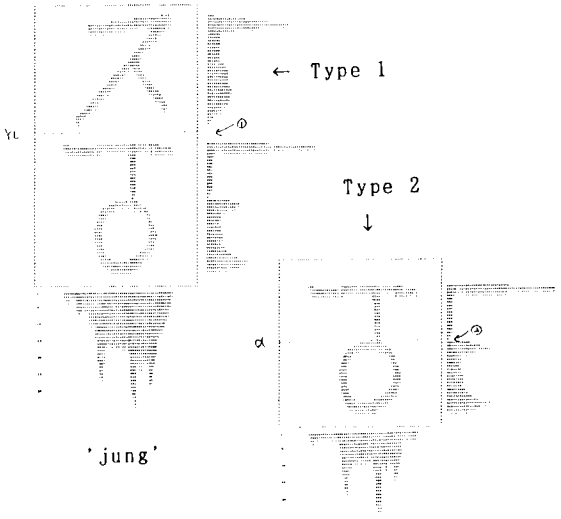
### <3.1> Recognition of the Character Element Connected with the Others

In order to apply the recognition method by structure or the number of segment it is necessary that the segment is not connected with the others. To recognize the character element in connected case, we calculated the peripheral distributions x and y axes. At the point where the value of peripheral distribution is less than a given threshold value, we erase the segment, as shown in Fig.5.a.



'park'

Fig.5.a Recognition of the number of segments by peripheral distribution.




'jung'

Fig.5.b Recognition of the structure by peripheral distribution.

Fig.5 Rcognition by peripheral distribution.

In Fig.5.b, the character is recognized as type 1. But, we can recognize it as type 2 by using peripheral distribution method as mentioned above.

### <3.2> Improved Recognition Method of Consonant/○/

In the previous recognition method, the consonant/○/ was recognized, if the starting coordinate equaled to the ending coordinate. In order to succeed to recgonition of /○/, it had to be written as closed form. To be overcome the weekpoint, the authors propose the improved method as follows: We prepare for 3 by 3 square mask shown in Fig.6. The number of around the object point gives a direction code. The recognition of consonant/○/ is performed by this direction code. We recognize the character as consonant/○/, if more than four direction codes are included in the route from the starting point to ending

point. These examples are well recognized by this method. The consonant/○/ of an opening in up-side is shown in Fig.7.a, and the consonant/○/ of an opening in down-side is shown in Fig.7.b.

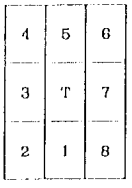



Fig.6 Direction code of 3 by 3 mask. T is object point.

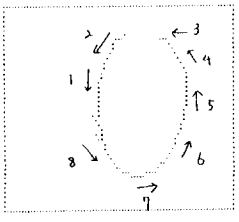


Fig.7.a Opening in up-side.

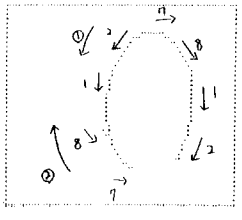


Fig.7.b Opening in down-side.

Fig.7. Improved recognition method of consonant/○/.

## 4. Experimental Result

The random names taken from Korean spiritual and cultural research institute published in 1983 are written by some people. We made fuzzy rules for 154 Hangul characters. We applied the recognition methods to the Hangul characters written by four men and three women. The recognition results were 80 percent correct answers by the method based on the number of segments and 83 percent by the method based on structure of Hangul[1][2]. One of the reasons unsucceeded in recognition was that the character elements were connected with the others. Then, we applied the improved algorithm by parallel procedure of the character segments and the structure to 368 Hand written Hangul characters. The correct answers improved to 87.4 percent. This improvement was accomplished by overcoming the difficulties in recognition such that the character elements were connected each other and the consonant/○/ was not closed. The effectiveness of the improved algorithm has been confirmed through simulation studies.

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