The Study on Dynamic Images Processing for Finger Languages

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***Abstract*--- In this paper, we realized a system that receives the dynamic images of finger languages, which is the method of intention transmission of the hearing disabled person, using the white and black CCD camera, and that recognizes the images and converts them to the editable text document. We use the afterimage to draw a sharp line between indistinct images and clear images from a series of inputted images, and get the character alphabet from the array of continuous images and output the accomplished character to the word editor by applying the automata theory. After the system removes the varied wrist part from the data of clean image, it gets the centroid point of hand by the maximum circular movement method and recognizes the hand that is necessary to analyze the finger languages by applying the circular pattern vector algorithm. The system abstracts the characteristic vectors of the hand using the distance spectrum from the center of the hand and it compares the characteristic vector of inputted pattern from the standard pattern by applying the fuzzy inference and recognizes the movement of finger languages.**

I. Introduction

In Korea, two kinds of the sign languages are used.[1]

One is the natural sign language that is made and developed by the hearing handicapped people, the other is the grammatical sign language which is systematized to the Korean grammar that uses the sign of the natural sign language, the finger character and the finger numeral. The finger character is most essential element of the grammatical sign language.

The researches for the hearing handicapped people are classified roughly into two groups. One is the study of changing the characters to the sign language or the finger language, and the other study is the opposite changing. In case of the former, there is a Korean-sign language translation system that organizes sign language dictionary using the morpheme analysis library and outputs the dynamic images through it.

In case of latter, there is a system that recognizes the finger language and the sign language among the dynamic gesture of the hands derived from the data of the shape and the direction of the hands and the velocity change of the hand movement using data glove. But it is hard for users to use this system because of the expensive equipment and the inconvenience by using the gloves. Also, another Korean sign language recognition system, which uses the glove equipment and the vision system that traces the position of the hand using the color camera simultaneously.

In this paper, we reduce the time required to recognize the finger language and get the satisfied recognition rate by realizing the system that receive the hand motion of the finger language from the black and white CCD camera as the input, and outputs the characters on the word processor.

II. The organization and the considerations of the system

2.1 The organization of the system.

The system algorithm, realized in this paper, is shown in Fig.1. The continuous image of the finger language, 20frames/sec, are inputted to the computer by suing a black and white CCD camera. After this, our system extracts the indistinct images through the afterimage and determines the used image or not as the combination of the character alphabet by checking for the existence of the indistinct image. The system removes the indistinct image frames and gets rid of the part of a wrist, which is very changeable, from the acquired distinct image by the maximum circular movement method. The system finds out the centroid point of the hand from the centroid point extracting algorithm.

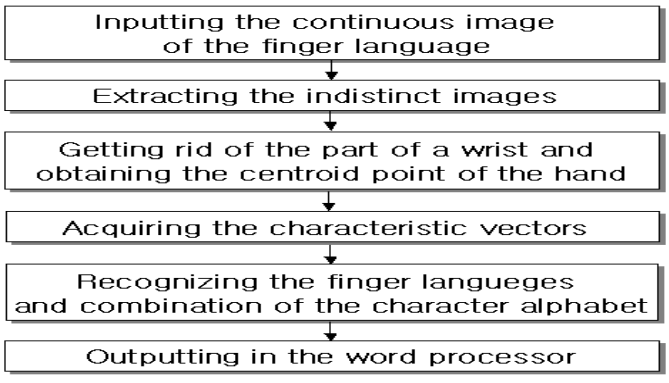


Fig. 1. Organization of the whole system.

By applying the circular pattern vector algorithm to the obtained centroid point of the hand, the system extracts the distance spectrum and educes the characteristic vectors of the each finger languages from this. The educed characteristic vectors are used for recognizing the movement of the finger languages, which express the character alphabet, by using the fuzzy inference. The recognized movement of the finger languages classifies the character alphabet by the number of the frame and the existence of indistinct image. The system outputs the compounded Korean characters on the word processor by using the automata theory.

2.2 The considerations of the system.

Because of using the black and white CCD camera, the background color of the movement of the finger language is black in order to recognize the hand. The camera is located at the 45° of the right side and 45° of the upper side of the subjects to take a picture of the various finger language. According to the subjects, the size of the bonds and the thickness of the finger, and so on are changed, so a specific person make an experiment as a subject to prevent the variation of the value of the characteristic parameters.

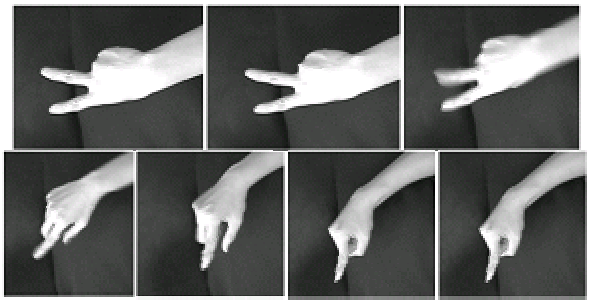
2.3 The environment of the system realization

(1) Hardware
- Pentium-IV PC
- CPU : Intel 2.0 GHz
- Video board : DT3155
- Peripheral equipment : CCD black and white camera (640 X 480)

(2) Software
- O.S : Windows XP (professional)
- Frame capture program : DT-acquire
- Language : visual C++

III. The image input of the finger language and the image classification

We find out that image input of 20 frames/sec is appropriate to recognize the continuous movement of the finger language of the subject and we use binary conversion [9] to analyze the image.



[ㄷ] → [ㄷ] → indistinct image → indistinct image → indistinct image → [ㅗ] → [ㄷ] → recognize as [도]

Fig 2. Recognition method of images

As shown in Fig2, at the binary converted image, the indistinct image has the afterimage around the hand on account of the shaking of the image by the continuous movement of the hand. In case of binary conversion, the afterimage is classified by the excessive change of the pixel value, so it is handled as the indistinct image without the recognition process. The existence of the indistinct image is a standard of judgment of the image data that is used for the classification of character alphabet. As shown in Fig.2, the system stores continuous images, which is photoed with the indistinct and the distinct images, to the array and recognizes the finger language with the exactly recognized continuous images by using the images of the array.

IV. Extraction of the centroid point and the characteristic vectors [10]

4.1 The maximum circular movement method [10]

As shown in Fig.3, the maximum circular movement method moves the maximum circle, which is touched internally on the inside of the object, in order. This method is used for the extraction of the just line element or the thickness of the line element from the image. In this paper, we use this method to extract the start point and the end point of the wrist.

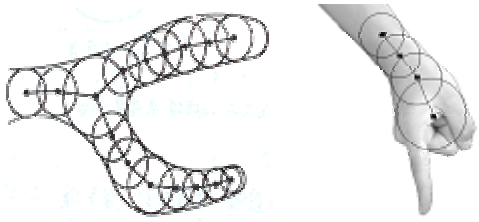


Fig. 3. Abstraction of the centroid point of object by the maximum circular movement method

4.2 The centroid point extraction algorithm [10]

As shown in Fig.4, we make a circle with a radius ‘A’ from the center of the hand outline, and get the value of the coordinates, which comply with the any constant degree θ, by the equation (1). We obtain the difference value ‘d’ between the value of the coordinate and the hand outline, and get the radius r by the equation (2) We can obtain the thickness of the object by finding out the minimum radius ‘r’ among the standardized values by θ.

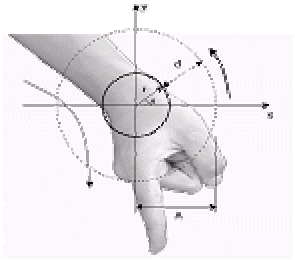


Fig. 4. Maximum circular movement method

Because of the centroid point, in the hand image, have to be extracted at the fixed position, the system extracts the thickness of the hand by using the maximum circular

movement method. From this information, the system finds out the center of the circle that has the maximum radius r and extracts the centroid point of the hand.

$$x_n = A\cos\theta_n$$
$$y_n = A\sin\theta_n \ (n=1,\ 2,\cdots,\ i)$$
$$r_n = \sqrt{x^2{}_n + y^2{}_n} - \sqrt{(x_n - x'_n)^2 + (y_n - y'_n)^2}$$

4.3 The extraction of the centroid point of the hand.

Fig. 5-a shows the hand image that removes the part of the wrist, which is excessively changeable, from the acquired distinct image by the maximum circular movement method. Fig.5-b shows the image of extracting the central point of the hand in the image that removes the part of the wrist by using the central point extraction algorithm [10].

a. Image of removing the wrist

b. Image of abstracting the centroid point of hand

Fig. 5. After removing the wrist, abstraction of the point of hand

As shown in Fig.6, an incidence angle of the wrist is an interval angle from the central point of the extracted hand to the end point of the wrist.

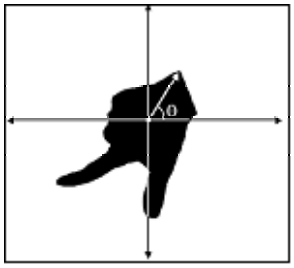


Fig. 6. The incident angle of the wrist

4.4 The distance spectrum and the extraction of the characteristic vector.

We obtain the distance spectrum for the 180 degrees of an angle, which is obtained at 2degree intervals from the center of the hand, by using the circular pattern vector algorithm [10]. As shown in Fig.7, we extract the 4 characteristic vectors for the recognition of the finger language as follows; The 1st characteristic vector is the distance between the wrist and the first characteristic point, the 2nd characteristic vector is the distances between the characteristic points, the 3rd characteristic vector is the number of the characteristic points, the 4th characteristic vector is the thickness of the first characteristic point.

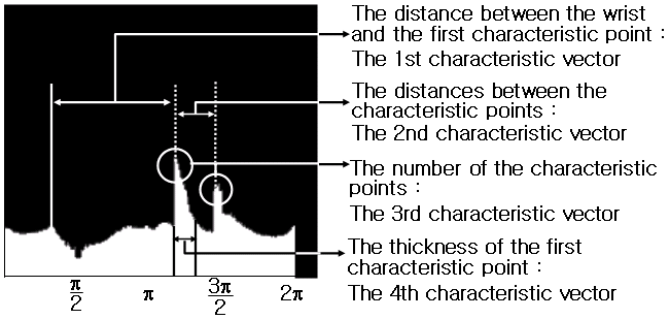


Fig. 7. Abstraction of the characteristic vector from the distance spectrum

V. The pattern recognition and the combination of the character alphabet

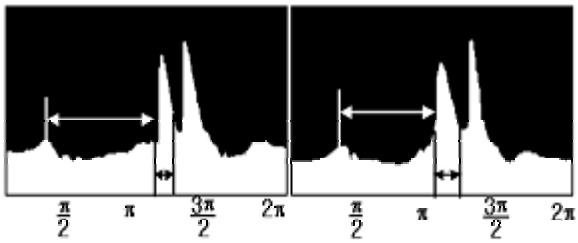
5.1 The recognition of the finger language.

We group the movement of the finger language into three steps for the recognition of the finger language. At first, we divide the character alphabet into 4 groups with the number of the characteristic points that is not change. Next, we subdivide the 4 groups by using the incidence angle of the wrist. Finally, we classify the subdivided group with the existence of black pixel, which makes a distinction between the motion of the back of the hand and the palm of the hand, in the fixed range from the centroid point to be able to recognize the finger language.

5.2 Fuzzy Inference [11]

After the classification of the three steps, we make distinct recognition of similar movement of the finger language possible for the similar movement in the classified group by using the fuzzy inference.

Because of the character to classify the finger language is different in each classified group, the rule of the fuzzy inference appears differently. For example, we explain the recognition of the input pattern ‘ㄷ’ ([digut] ; a kind of Korean consonant) to the standard pattern of the ‘ㄷ’ and the ‘ㅌ’ ([tigut] ; a kind of Korean consonant) those are similar shapes of the finger language. As shown in Fig.8, the distance spectrum between the ‘ㄷ’ and the ‘ㅌ’ has almost no difference.



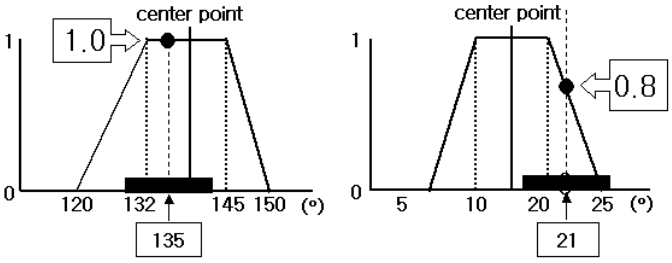
(a) The distance spectrum of ‘ㄷ’

(b) The distance spectrum of ‘ㅌ’

Fig. 8. An example of the distance spectrum

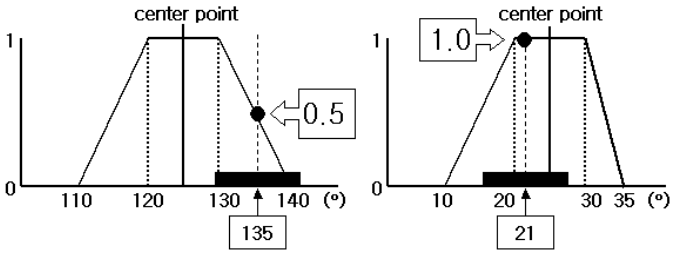
As shown in Fig.9 and 10, the system infers the recognition rate of the finger language ‘ㄷ’ and ‘ㅌ’ from the

belonging degree of the first characteristic vector and the 4th characteristic vector, then recognizes the input pattern that has higher recognition rate. In the example of the Fig.9 and the Fig.10, the recognition rate of 'ㄷ' is higher than 'ㅌ', so inputted pattern is recognized as 'ㄷ'. By the similar method, the other movements of the finger language, belonged to the other groups, are recognized through the fuzzy inference that uses some of 4 characteristic vectors as input parameters.



(a) The first characteristic vector (b) The fourth characteristic vector

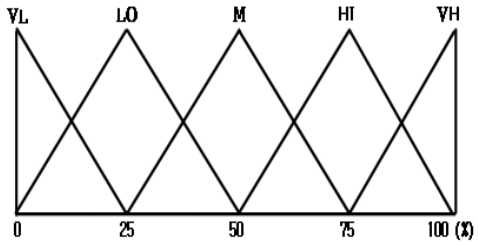
Fig. 9. The membership function for the characteristic vector of 'ㄷ'



(a) The first characteristic vector (b) The fourth characteristic vector

Fig. 10. The membership function for the characteristic vector of 'ㅌ'

Fig.11 shows the membership function of the standard pattern, and the table 1 shows the fuzzy inference rule. Fig.12 shows the membership function of the recognition rate that is obtained from the membership function of the standard pattern and the fuzzy inference rule.



VL(Very Low) : The degree which is belonged to a standard pattern is very low.

LO(Low) : The degree which is belonged to a standard pattern is low.

M(Middle) : The degree which is belonged to a standard pattern is middle.

HI(High) : The degree which is belonged to a standard pattern is high.

VH(Very High) : The degree which is belonged to a standard pattern is very high.

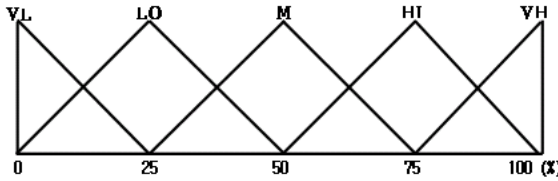
Fig. 11. The membership function of the standard pattern

Table 1. Fuzzy inference rule

I \ II	VL	LO	M	HI	VH
VL	VL	VL	LO	M	M
LO	VL	LO	LO	M	HI
M	LO	LO	M	HI	HI
HI	M	M	HI	VH	VH
VH	M	HI	VH	VH	VH

I : The assigned degree of the 4th characteristic vector in standard pattern

II : The assigned degree of the 1st characteristic vector in standard pattern



VL(Very Low) : The recognition rate of finger languages is very low.

LO(Low) : The recognition rate of finger languages is low.

M(Middle) : The recognition rate of finger languages is middle.

HI(High) : The recognition rate of finger languages is high.

VH(Very High) : The recognition rate of finger languages is very high.

Fig. 12. The membership function of the recognition rate

5.3 The experimental result and the combination of the characters.

Because of the value of the characteristic parameters might be change according to the subject, a specific subject experiments 30 words and sentences, which are constructed to contain all of the Korean consonants and vowels, 20 times each. The readjusted experimental result is shown in the table 2. The classified character alphabet is combined to the Korean character by using the automata theory and outputted to the word process like as shown in Fig.13.

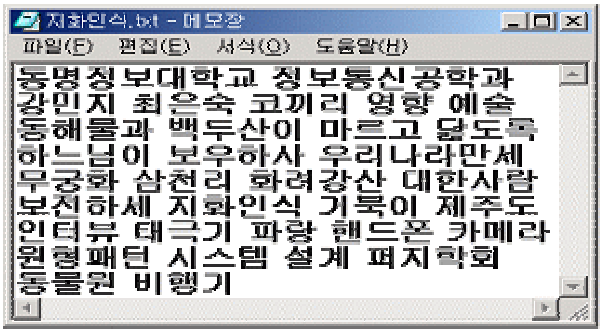


Fig. 13. The screen of the output result

VI. The conclusion and the problems in future

In this paper, we realize a system that receives the continuously changed movements of the finger language as the inputs and through the recognition process outputs it as the Korean character to the word processor.

Table 2. Result of the experiment

Word	Number of character	A number of the movement of the finger languages	The recognition rate of the word	The recognition rate of the movement of the finger languages
동명정보대학교	7	18	100.00%	98.20%
정보통신공학과	7	20	94.00%	95.20%
강민지 최은숙	6	16	87.90%	93.20%
코끼리	3	7	83.30%	74.90%
영향 예술	4	11	83.00%	90.00%
동해물과	4	11	73.7%	88.60%
백두산이	4	10	83.50%	87.20%
마르고 닳도록	6	15	83.00%	88.90%
하느님이 보우하사	8	17	78.90%	89.10%
우리나라만세	6	13	81.90%	93.20%
무궁화	3	8	89.00%	90.00%
삼천리	3	8	94.20%	95.20%
화려강산	4	11	79.80%	93.20%
대한사람	4	10	71.30%	88.80%
보전하세	4	9	94.70%	96.60%
지화인식	4	11	87.90%	93.20%
거북이	3	7	92.30%	94.30%
제주도	3	6	78.00%	93.20%
인터뷰	3	7	100.00%	100.00%
태극기	3	7	95.50%	96.40%
파랑	2	5	89.00%	93.20%
핸드폰	3	8	92.32%	97.20%
한라산	3	8	93.64%	98.20%
카메라	3	6	89.00%	93.20%
원형패턴	4	12	100.00%	100.00%
시스템	3	7	83.00%	98.20%
설계	2	5	75.90%	93.20%
퍼지학회	4	9	70.45%	93.20%
동물원	3	10	83.77%	97.70%
비행기	3	7	78.00%	93.20%
평균 인식율			86.23%	93.22%

We removed the part of the wrist by using the maximum circular movement method, and obtained the centroid point of the hand by using the centrol point extraction algorithm. We get the distance spectrum by the circular pattern vector algorithm, and obtain the 4 characteristic vectors; the distance between the wrist and the first characteristic point, the distance between the characteristic points, the number of the characteristic points and the thickness of the first characteristic point etc. by using the algorithm. We subdivide the movement of the finger language by using the obtained characteristic vectors and use the fuzzy inference for the similar movement. We can get the recognition rate for the movement of the finger language is, on an average, 93.5% and the average recognition rate for the word of the finger language is 86.2%. The recognition method for the color image processing has relatively long time, because it has to analyze the color information and the hand range per one frame. In this paper, we use the black and white image, so it has relatively short data processing time than the color image, and because of the image processing after eliminating the indistinct image, we can reduce the time.

The recognized finger language is combined and expressed to the Korean language by using the automata theory and output it to the word processor. So the normal people and the hearing handicapped people can understand each other more conveniently.

The study in future is as follows; firstly we hope to study not only the movement of the finger language that uses the hand but also carrying out the natural sign language, which includes the flow of the movement and the facial countenance of the man, and the finger language side by side. Secondly, we consider that the experiment is done not by the specific subject, but by the general subject. Finally, we think over the meaning inference system that converts the habitual expression of the hearing handicapped people into the general expression, for example, the system infers “a swimming beach” from the meaning of “salty+ waves + swimming + place”.

REFERENCES

[1] Jung-Bae Kim, “Extension of the real-time Korean sign language(KSL) recognition system using colored hand tracke”, Korea Advanced Institute of Science and Technology, a thesis of a master’s degree , 1998.

[2] Kyung-Hyuk Kwon, Yo-Seop Woo, Hong-Ki Min, “Design and Implementation of a Korean Text to sign Language Translation System”, Korea Information Processing Society Vol. 7, No. 3, pp.756-756, 2000.

[3] Young-joon Oh, Hoon Chang “Desian and Implementation of Text Recognition Algorithm for Sign Language Interpretation System” Korea Information Science Society Vol. 29, No. 2, pp.691-693, 2002.

[4] Tae-Soo Kim, Joong-Chang Chun, Kyoung-Ai Choi, “Development of Korea-sign Language Generating System based on Motion-Primitives” Korea Multimedia Society Vol. 4, No. 3, pp.238-245, 2001.

[5] Jong-Ho Han “A Study on Motion Image Processing for Dactylology Education Systems” Graduate School HanKuk University of Foreign Studies Department of Computer Science a thesis of a master’s degree, 1996.

[6] Jae-Hyun “A Study on Multiple Marker Detection Techniques for Korean Sign Language” The Graduate School of Seoul Woman’s University Department of Computer Science a thesis of a master’s degree, 1999.

[7] Chan-Su Lee, Jong-Sung Kim, Gyn-Tae Park, Won Jang, and Zeung-Nam Bien “Implementation of Real-Time Recognition System for Continuous Korean Sign Language(KSL) mixed with Korean Manual Alphabet(KMA)” The Institute of Electronic Engineers of Korea Vol.35, Chapter C, No.6, pp.76-87, 1998.

[8] Jong-Sung Kim, Chan-Su Lee, Won Jang and Zeungnam Bien “On-line Dynamic Hand Gesture Recognition System for the Korea Sign Language(KSL)” The Institute of Electronic Engineers of Korea Vol.35, Chapter C, No.2, pp.61-70, 1997.

[9] Dong-hyeok Jang, “Digital Image Processing by using the Visual C++”, infogate press, 2001.

[10] Jung Hyang-Young, Shin Il-Sik, Sohn Young-Sun “Cursor Control by Finger motion using Circular Pattern Vector Algorithm”, Korea Fuzzy Logic and Intelligent Systems Society Vol.11, No.6, pp.487-490, 2001.

[11] Yong-Yop Choi, An Introduction to Fuzzy Engineering, Woong-bo press, 2000.