Real Time Recognition of Finger-Language Using Color Information and Fuzzy Clustering Algorithm

Kwang-Baek Kim, Doo Heon Song and Young Woon Woo, *Member, KIMICS*

Abstract— **A finger language helping hearing impaired people in communication A sign language helping hearing impaired people in communication is not popular to ordinary healthy people. In this paper, we propose a method for real-time sign language recognition from a vision system using color information and fuzzy clustering system. We use YCbCr color model and canny mask to decide the position of hands and the boundary lines. After extracting regions of two hands by applying 8-directional contour tracking algorithm and morphological information, the system uses FCM in classifying sign language signals. In experiment, the proposed method is proven to be sufficiently efficient.**

Index Terms— **Finger-Language, Color Information, Fuzzy Clustering Algorithm**

I. INTRODUCTION

A finger language is designed to help communication between hearing impaired people and healthy people. [1] It s linguistic structure consists of motions and locations of two hands and ten fingers. However, most healthy people are not used to understand the language. Thus, there have been several researches to recognize the language from computer vision analysis. When extracting candidates of hand regions, it is not sufficient to use only HIS and YCbCr color information so that the result tends not to be clear enough to distinguish [2]. Another method using distance between images may have false negatives – recognizing hand region as background – when hands regions are little too far apart [3]. Thus, we propose a new method using color information and FCM algorithm in real time recognition. Candidates of hand regions are extracted by using skin color, hand position, and size information and FCM algorithm is used to classify and recognize features of finger language.

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Kwang-Baek Kim(first author) is with the Division of Computer and Information Eng., Silla University, Busan, 617-736, Korea (e-mail: gbkim@silla.ac.kr).

Doo Heon Song is with the Dept. of Computer Game & Information, Yong-in SongDam College, Gyeonggi-do, Korea (email: dsong@ysc.ac.kr).

Young Woon Woo(corresponding author) is with the Dept. of Multimedia Eng., Dong-Eui University, Busan, Korea (e-mail: ywwoo@deu.ac.kr).

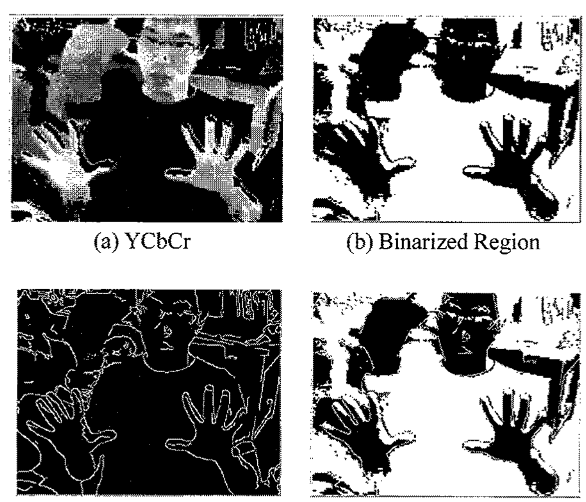
II. EXTRACTING CANDIDATE HAND REGION BY USING COLOR INFORMATION AND CANNY MASK

In this section, we apply a series of image processing algorithms to extract hand regions from real time vision images.

A. Skin Color Division Step

Here we explain the procedure to divide the image into skin color region and the rest. Since distinguishing skin color is sensitive to the light intensity, we use YCbCr color model which is most insensitive in distinguishing the light and skin color among available color spaces such as HSV and RGB. The YCbCr color model is the model to separate Y(intensity), Cb(Blue), Cr(red) from RGB space by using formula (1).

$$
\begin{aligned}
Y &= 0.3R + 0.59G + 0.11B \\
C_b &= 0.6R - 0.28G - 0.32B + 128 \\
C_r &= 0.21R - 0.52G + 0.31B + 128
\end{aligned}
\tag{1}
$$



(a) YCbCr (b) Binarized Region

(c) Canny Edge (d) After Logical Operation

Fig. 1. Extracting skin color region by Canny mask and color model transformation.

Fig. 1 shows the processes of extracting skin color region. As shown in Fig. 1 (a), YCbCr space directly transformed from RGB contains false positives that have similar color to skin. They are merged into one area after binarization as shown in (b). Thus in this paper, we apply logical AND operation between an image that extracts boundary lines of objects with canny mask and binarized image with YCbCr space transformation in order to distinguish skin color region from the background as shown in Fig. 1 (d).

B. Tracking and Extracting Hand Region

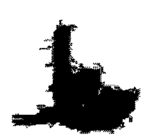
We apply 8-directional contour labeling tracking algorithm to the result image of section II.1. Among them, we choose two largest regions which are supposed to be face region and hand region. Then, the hand region is decided by its location information. Fig. 2 shows such process to extract hands region from original image with morphological information.

III. RECOGNIZING FINGER LANGUAGE BY FCM

In this section, we explain the process to recognize Korean consonants and numbers in finger language. Fig. 3 shows hand motions for Korean consonants (from 'ㄱ' to 'ㅎ') and numbers (from 1 to 10) in the language.

(a) Original Image

(b) Skin Region extracted by YCbCr color model and Canny mask



(c) Extracting Hand Region with morphological information

Fig. 2. Extracting hand region.

The Fuzzy c-means (FCM) is a method of clustering which allows one piece of data to belong to two or more clusters depending on the degree of membership to each cluster[4,5]. Thus, for n data vectors, we may have c fuzzy clusters ($c < n$) and each vector is classified into the cluster whose membership degree is the highest. The objective function of FCM is as formula (2)

$$J(u_{ik},v_i)=\sum_{i=1}^{c}\sum_{k=1}^{n}u_{ik}^{m}(d_{ik})^2$$
$$d_{ik}=d(x_k-v_i)=[\sum_{j=1}^{1}(x_{kj}-v_{ij})^2]^{\frac{1}{2}} \qquad (2)$$
$$v_i=v_{i1},v_{i2},\cdots,v_{ij},\cdots,v_{iL}$$

where x_k is the input data and u_{ik} denotes the degree of membership to cluster x_k, and v_i is the center of *i-th* cluster.

Step 1:
Initialize the number of cluster $c(2 \le c \le n)$, initial membership function $U^{(0)}$, and weighting exponent m and repetition r.

Step 2:
Compute the centroid of a cluster is the mean of all points, weighted by their degree of belonging to the cluster as shown in equation (3).

$$v_{ij}=\frac{\sum_{k=1}^{n}(u_{ik})^m x_{kj}}{\sum_{k=1}^{n}(u_{ik})^m} \qquad (3)$$

Step 3:
Update $U^{(r+1)}$ as formula (4).

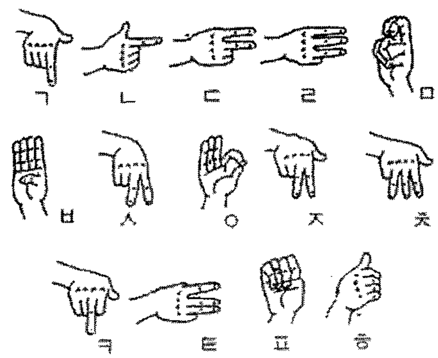
$$u_{ik}^{(r+1)}=\frac{1}{\sum_{j=1}^{c}\left(\frac{d_{ik}^{r}}{d_{jk}^{r}}\right)^{\frac{2}{m-1}}} \quad for \quad I_k=0 \qquad (4)$$
$$or \quad u_{ik}^{(r+1)}=0 \quad for\ all\ classes\ i$$

where $i\in\overline{I_k}$, $I_k=\{i\,|\,2\le c<n; d_{ik}^{(r)}=0\}$, $\overline{I_k}=1,2,...,c$, $d_{jk}=d(x_j,c_k)=\left[\sum_{i=1}^{p}(x_{ji}-v_{ki})^2\right]^{-1}$, $\sum_{i\in I_k}u_{ik}^{(r+1)}=1$.

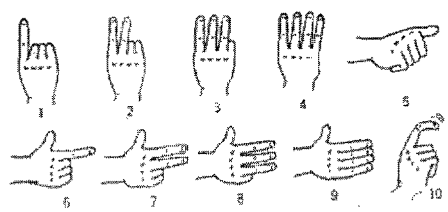
Step 4:

$$\Delta = \left\| U^{(r+1)} - U^{(r)} \right\| = \max_{i,k} \left| u_{ik}^{(r+1)} - u_{ik}^{(r)} \right|$$

If $\Delta > \varepsilon$ then stop (ε is an experimental threshold), otherwise $r = r + 1$ and go to Step 2.



(a) Hand Motions for consonants



(b) Hand Motions for numbers

Fig. 3. Hand motions in finger language.

IV. EXPERIMENT AND ANALYSIS

The experiment is done with IBM compatible Pentium-IV PC with 3GHz CPU and 1GB memory, implemented by Visual C++. We use NX-6000 camera from Microsoft and the image size is 320 x 240, 15 frames/sec and 5 repetitions for 14 consonants and 10 numbers. The result of the experiment is divided into two parts. The first part is the success rate of extracting hand regions with the proposed method. As one can see from Table I, the success rate of this experiment is 100%. The method is successful to extract hand regions for all 60 finger consonants and 50 finger numbers. Table II summarizes weighting exponent and threshold values in this experiment.

TABLE I
EXTRACTING HAND REGIONS

	Proposed Method (# of extracted /# of images)
Finger Consonants	60 / 60
Finger Numbers	50 / 50

TABLE II
PARAMETERS OF EXPERIMENT

m	ε
100	0.01

The, we classifies finger language patterns into language elements (consonants and numbers) by applying FCM in the latter part of the experiment. In performance evaluation of FCM algorithm used in this experiment for recognizing finger language signals, we used 60 consonants patterns and 50 number pattern videos as input and the result can be summarized as shown in Table III and Table IV.

TABLE III
RESULTS OF RECOGNIZING PATTERNS OF FINGER CONSONANTS (# OF SUCCESS/ # OF PATTERNS)

Consonants	ㄱ	ㄴ	ㄷ	ㄹ	ㅁ	ㅂ	ㅅ
Recognized	5/5	3/5	5/5	4/5	4/5	5/5	5/5

Consonants	ㅇ	ㅈ	ㅊ	ㅋ	ㅌ	ㅍ	ㅎ
Recognized	4/5	5/5	5/5	5/5	3/5	3/5	4/5

TABLE IV
RESULTS OF RECOGNIZING PATTERNS OF FINGER NUMBERS (# OF SUCCESS/ # OF PATTERNS)

Numbers	1	2	3	4	5
Recognized	5/5	5/5	4/5	4/5	4/5

Numbers	6	7	8	9	10
Recognized	3/5	5/5	5/5	5/5	4/5

The success rate of recognizing finger consonants is 83% (50/60) and that of recognizing finger numbers is 88% (44/50). In analyzing failed patterns, we found several common cases as followings;

1) Hand motions for consonant 'ㄴ' and number 6 are exactly same that they tend to be classified into wrong group.
2) Consonant patterns 'ㄹ' and 'ㅌ', pattern 'ㅁ' and 'ㅍ', number patterns 3 and 4 are too similar to distinguish in FCM.
3) Image loss by reflections interferences of learning patterns.

V. CONCLUSIONS

In this paper, we propose a new method for recognizing finger language in real time. The first step of our method is to transform the image into YCbCr color space and to apply canny mask to Cb and Cr part in extracting skin region. Then the 8-directional labeling contour tracking algorithm is applied to extract candidates of hand region and the morphological characteristics are used to decide the final hand region. This process is perfectly successful (100% extraction) in experiment. Then, the FCM algorithm is applied to classify finger language patterns and its performance is 83% (consonants) and 88% (number patterns).Some patterns are exactly the same (as a language they are used with context to diminish the ambiguity.) or too similar to distinguish in their characteristics.

Thus, the proposed method is limited to obtain higher accuracy in pattern recognition in such cases because it is context dependent or finger language design problem itself. However, the method could be advanced to minimize the reflection effect or faster in recognizing in real time in the future.

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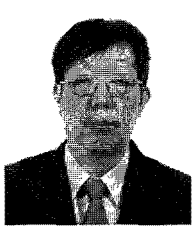
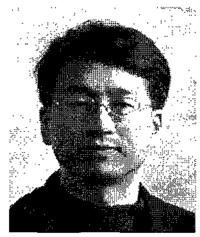
Kwang_Baek Kim
Received his M. S. and the Ph.D. degrees in Department of Computer Science from Pusan National University, Busan, Korea, in 1993 and 1999, respectively. From 1997 to present, he is a professor, Division of Computer and Information Engineering, and Silla University in Korea. His research interests include Fuzzy Neural Network and Application, Bioinformatics, Image Processing.



Doo Heon Song
Received his B.S. degree from Seoul National University in 1981, M.S. degree from KAIST in 1983 in Computer Science. He also finished the requirement of Ph.D. candidate from University of California at Irvine in Computer Science in 1994. He has been a professor of Yong-in SongDam College since 1997. He currently serves as a vice president of Korea Multimedia Society for International Affairs. His research interest covers all aspects of machine learning and application of machine learning technology to computer vision and computer game.



Young Woon Woo
Received the B.S. degree, M.S. degree and Ph.D. degree in electronic engineering from Yonsei University, Seoul, Korea in 1989, 1991 and 1997, respectively. Since 1997, he has been a professor in Department of Multimedia Eng., Dong-Eui University, Busan, Korea. His research interests are in the area of artificial intelligence, image processing, pattern recognition and medical information.