Finger spelling recognition using distinctive features of hand shape

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ABSTRACT

The authors have been developing a glove based input device, called "Stringlove", recognizing finger shapes by adapting for several shapes pointing an angle of each finger joint. A research group reports on the sign language linguistics features to distinguish finger shapes, and advance to make it practicable to engineering. This paper mentions that the method of recognition of finger shapes was examined by using the developing equipment. According to a preliminary experiment, it has been suggested that the present method has a good possibility to improve a rate of recognition of finger shapes.

1. INTRODUCTION

The communication barrier is serious problem for the hearing impaired in their social lives. To overcome the problem, several kinds of recognition methods or sign language recognition system have been developed. However, to recognize sign language, it is necessary to capture movements or hand shape of sign language. Thus, a motion capture system uses to obtain motion data or hand shape data of sign language.

The glove-based input device, one of component of motion capture system, use to measure hand shape or flexion/extension of hand or fingers. This glove sensor has been utilized in sign language recognition researches. However, such a motion capture systems with high performance are very expensive. Therefore, their sensor's cost prevents groups of researchers from developing the sign recognition system, sign information system, translation system between sign language and phonetic language.

We have developed a glove-based input device, called "Stringlove" to realize the consumer price of glove sensor (Kuroda et al 2004). The glove sensor equips 24 inductcoders and nine contact sensors. It can measure joint flexion/extension of fingers and thumb, adduction/abduction angles of fingers and thumb, and wrist's flexions, and also detect the contact position between fingertips of fingers and one of thumb. It also encodes finger shape into sign notation code by using embedded DSP. This function could decrease CPU load of computer as it seems that the processing of sign language recognition is heavy CPU load for main computer. However, this function cannot recognize hand shape but finger shape.

To improve this function of Stringlove, this paper describes a method to recognize hand shape of finger spelling with the distinctive features of hand shape of Japanese Sign.

2. RELATED WORK

Many researchers have proposed different methods to recognize hand shapes of gesture or finger spelling. These studies use either vision-based methods or glove-based methods.

A vision-based recognition system has advantages that user does not use special device such as glove, or that user's motions are not limited comparing with the use of glove. But, this recognition system also has a problem such as light condition. To overcome the difficult problem, there are several kinds of researches

In vision-based approaches, the hidden Markov model (Kirsti Grobel et al 1997, Thad Stamer et al 1998) or Dynamic Programming (Phillippe Dreuw et al 2006) was used to recognize sign words. A group of researchers proposed the method to recognize sings by using the depth data obtained from a time-of-flight camera (Fujimura et al 2006). A group of Canadian researchers proposed the method to recognize hand gesture by using sign linguistics of Stokoe (K. G. Derpanis et al 2004). Their proposed method with Stokoe's linguistic system showed a high recognition rate. It seems that information of sign linguistic is effective for hand shape recognition.

On the other hand, a glove-based recognition system is approaches to recognize hand shape or hand motion of sign language as it can operate under severe light conditions. It also obtains a hand motion or a hand shape directly, though, it is necessary to put on a glove-based input device or motion capture system.

In glove-based approaches, the method using Fussy-Min-Max neural network and Data-glove (J.S.Kim et al 1996) was proposed. A group of researchers developed a new glove-sensor and proposed the application to learn Korean Finger spelling by using K-mean method and their developed glove-sensor (Y.Lee et al 2007).

Though finger spelling recognition method is different, finger language recognition system with neural network for the handicapped aphasiacs was proposed (Y.F.Fu et al 2007). The finger language is not finger spelling but hand shape predefined a meaning sentence. To use input device of wearable computer, a new glove-based input device was proposed, and the application was developed to control some device, such as light by using the proposed glove-sensor (K.Tsukada et al 2004).

3. DISTINCTIVE FEATURES OF HAND SHAPE OF JAPANESE SIGN

A group of Japanese sign linguistic engineering researchers reported about distinctive features of hand shape of Japanese Sign (D.Hara et al 2006). The distinctive features have the following elements.

1) Hand shape consists of finger shapes and thumb shape in Japanese Sign Language (JSL). It defines that PIP and DIP become the same joint's state, flexion or extension. The finger shape and thumb shape are classified into four shapes because of joint structures of finger and thumb. That is, hand shape consists of finger shapes selected from the above four shapes in the distinctive feature of sign linguistic knowledge. Table.1 shows the four classified shape of finger and thumb. Here, MCP is Metacarpal Phalangeal joint, PIP is proximal interphalangeal joint and DIP is distal interphalangeal joint.

2) Finger and thumb, which is component of hand shape, are referred to as either "dominant finger" or "non-dominant finger". Here, "dominant finger" is defined as a group of important finger to compose hand shape of JSL. "non-dominant finger" is defined as a group of finger except finger in "dominant finger". Figure 1 shows an example of "dominant finger "and "non-dominant finger".

A hand shape of finger spelling in Figure.1 consists of finger shape and thumb shape. To compose of the hand shape, finger shapes of index, middle, ring and pinkie are important elements, because the changes of their finger shape show difference hand shape or difference finger spelling. Therefore, their fingers are referred to as "dominant finger" in sign linguistics, and thumb as "non-dominant finger".

Table.1. *Four classified shape of fingers and thumb.*

Joint (states)	MCP (flexion)	MCP (extension)
PIP,DIP (flexion)	finger shape of "CLOSE"	finger shape of "BEND"
PIP,DIP (extension)	finger shape of "FLAT"	finger shape of "OPEN"

3) The shape of fingers in "dominant finger" is all the same shape. The one of finger in "non-dominant finger" is also the same shape. For example, when one finger of "dominant finger" shows finger shape of "OPEN" in Table.1, the others of "dominant finger" also shows "OPEN".

4) The finger shape in "non-dominant finger" selects either finger shape of "OPEN" or one of "BEND" in Table.1.

The above features are a method to compose of hand shape of finger spelling under sign linguistics. It seems that the distinctive features are available to recognize hand shape of finger spelling using computer.

Therefore, the authors make use of these distinctive features of hand shape of JSL, and propose a hand shape recognition method based on the distinctive features in sign linguistics.

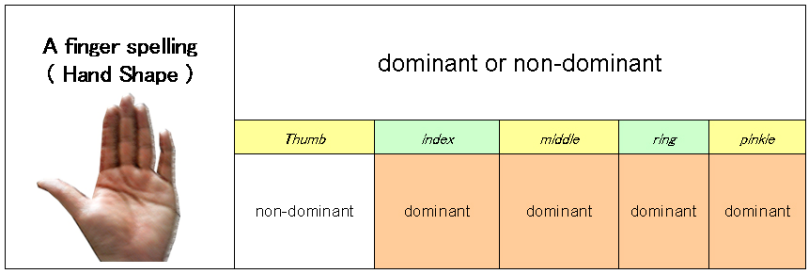

Figure 1. *Example of "dominant finger" and "non-dominant finger".*

4. METHOD

The authors only use notation codes obtained from Stringlove, and use a recognition method that the recognition system matches between the obtained notation codes and notation codes of a hand shape. However, in this case, the recognition rate of hand shape depends on the recognition rate of finger shape in Stringlove. The authors propose the method as shown Figure.2. Figure.2 shows a process flow of proposed method.

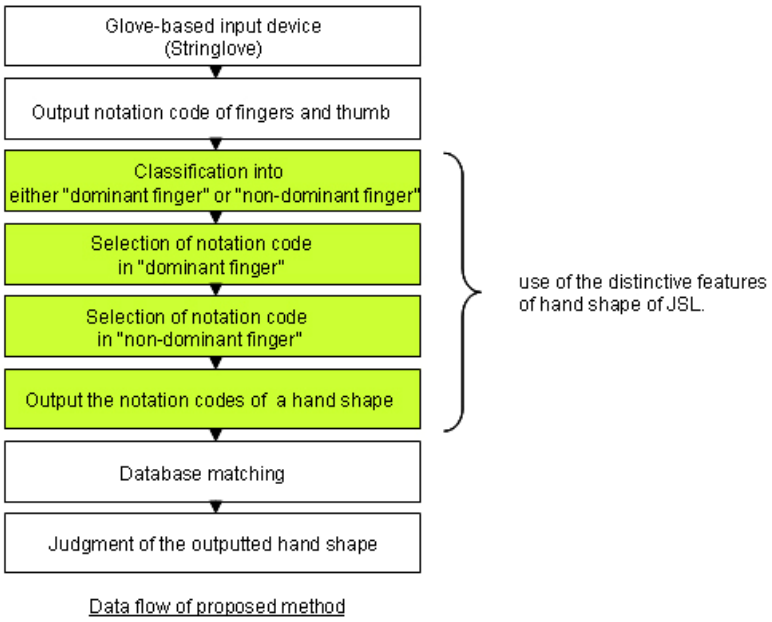

Figure 2. *Flow chart of proposed method to recognize hand shape with distinctive features.*

4.1 Classified into either "dominant finger" or "non-dominant finger"

Index finger is important finger under distinctive features of hand shape. A group of Japanese researchers classifies hand shapes in sign language into three patterns on the basis of index finger shape (Ichida 2005). There, the authors subjectively investigated number of fingers included in "dominant finger" and number of fingers included in "non-dominant finger" from all hand shapes of Japanese finger spelling.

The subjective investigation showed that index finger in "dominant finger" was 31 %, middle finger was 29%, ring finger was 19%, pinkie was 11% and thumb was 10%. From this investigation result and Ichida's research, it seems that index finger is included in "dominant finger" frequently. Whereat, the proposed method classifies finger shapes into either "dominant" or "non-dominant" on the basis of index finger shape. Each finger is classified into "dominant finger" in the following. It compares a shape of index finger with one of other fingers and the fingers of the same shape are included in "dominant finger" between shape of index finger and one of other fingers.

4.2 Selection of Notation Code in "dominant finger"

The proposed methods select notation code of "dominant finger" from the classified fingers as "dominant". It performs the following steps.

i) It compares finger shape of a finger with four finger shapes shown in Table.1.

ii) It confirms whether all finger shape of fingers included in "dominant finger" are the same shape. If all finger shape is same, it outputs the finger shape as a representative of "dominant finger".

iii) If all finger shape is not same, the highest occurrence rate of finger shape in "dominant finger" is outputted as the representative code of "dominant finger".

iv) If the occurrence rates of fingers in "dominant finger" are all same, a shape of index finger is outputted.

4.3 Selection of Notation Code in "non-dominant finger"

The proposed methods select a notation code of "non-dominant finger" from the classified fingers as "non-dominant". It performs the following steps.

i) It compares finger shape of a finger with four finger shapes shown in Table.1.

ii) If all finger shape is both the same shape and finger shape of either "BEND" or "OPEN", its finger shape is outputted as the representative of "non-dominant finger".

iii) If shapes of fingers in "non-dominant finger" are difference, the highest occurrence rate of finger shape is a representative candidate shape of "non-dominant finger". If the candidate one is one of either "BEND" or "OPEN", the finger shape of this candidate is outputted as the representative of "non-dominant finger".

iv) If a finger shape of "non-dominant" is not selected by using the above steps, it uses a combinatorial association between finger shapes in "dominant finger" and ones in "non-dominant finger" and determines the representative of "non-dominant finger".

The combinatorial association between finger shape of "dominant" and one of "non-dominant" is investigated in advance. The authors investigate the combination of finger shapes in 24 letters of Japanese Finger spelling. Figure.3 shows the investigation results. The combination of "CLOSE" in "dominant" and "OPEN" in "non-dominant" occurs with frequently, one of "BEND" in "dominant" and "CLOSE" in "non-dominant" does with slower frequency.

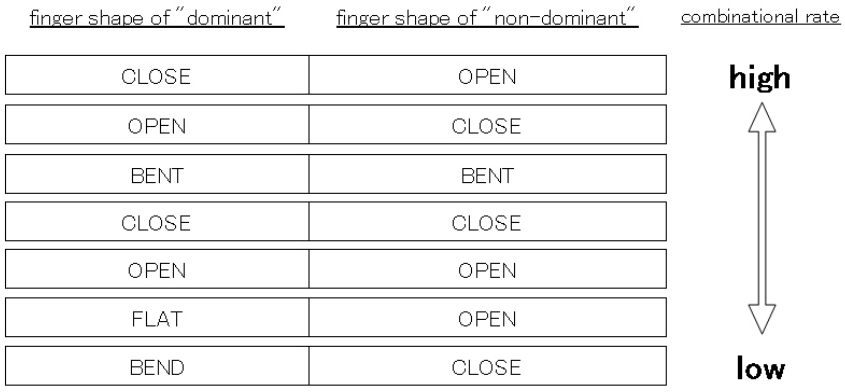

Figure 3. *Combinational rate between dominant finger shape and non-dominant finger shape.*

4.4 Hand Shape Recognition

The proposed method obtains the correct finger shapes of hand shape in Finger spelling from Database and compares the obtained shapes data with finger shapes of both "dominant" and "non-dominant". It outputs the matched hand shape as recognition result, when all finger shapes are matched. Fingure.4 shows the matching rule to recognize hand shape of Finger spelling.

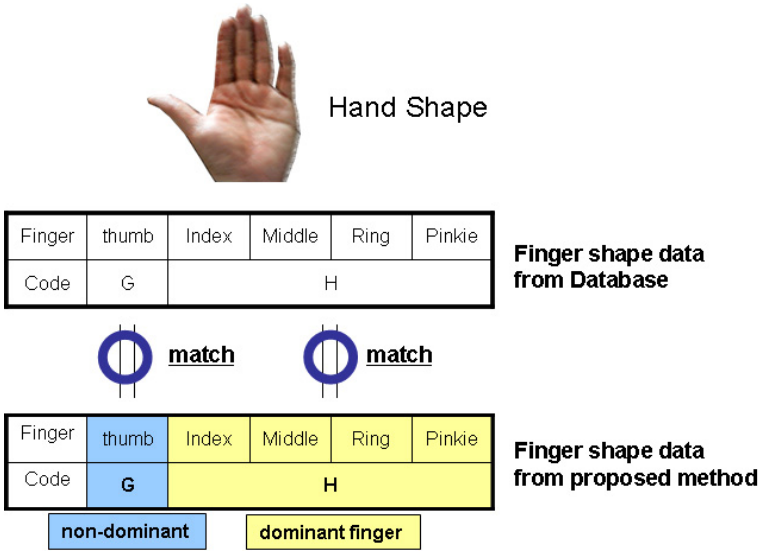

Figure 4. *Matching processing.*

5. PRELIMINARY EXPERIMENT

The proposed method is evaluated in a preliminary experimentation. This experiment compared recognition result without the proposed method, with the recognition result that the proposed method utilized

The preliminary experimentation preformed the following steps. A subject expressed six hand shapes of Japanese finger spelling by using Stringlove. The measurements were performed three times. The proposed method showed the notation codes of a hand shape from the measured data. Japanese finger spellings, which is used in this experiment, are “A”, “U”, “TE”, “FU”, “RO” and “WA”. Subjects are two persons, a male and a female.

Figure.5 shows the matching rates of six hand shapes. Case 1 does not use the proposed method and case 2 uses the proposed method. From the preliminary experiment result, it seems that the proposed method was effective in hand shape recognition of Stringlove.

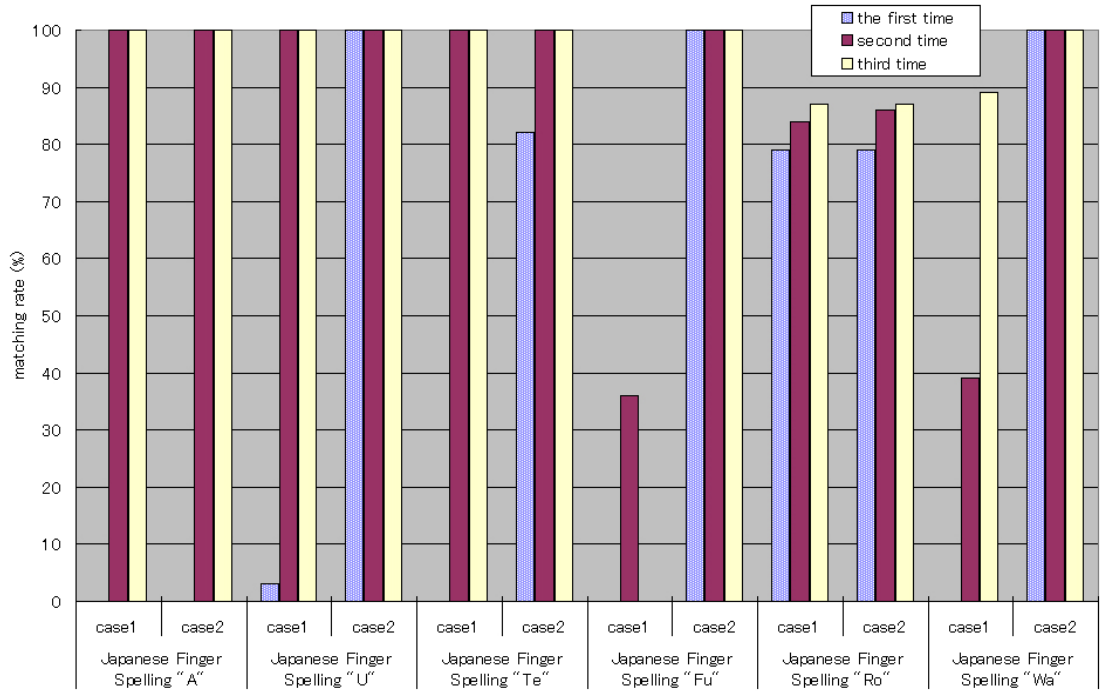

Figure 5. *A comparison result between matching rate of case 1 and one of case 2.*

In addition, the proposed method has the possibility to improve the matching rate of hand shape. In this paper, the progress rate was given by the following equation.

$$\text{progress rate} = \frac{(\text{matching rate of case1} - \text{matching rate of case2})}{\text{matching rate of case1}} \times 100$$

A progress rate became as high as 1.79% in second time of Japanese Finger spelling "Ro", and became as high as about 12% in third time of Japanese Finger spelling "Wa". The recognition rate of Japanese finger spelling except for "A" increased by near 80 %. It seems that the proposed method played a role in revising miss-recognized finger shapes. Therefore, comparing case 1 with case 2, the matching rate would increase in this experiment.

However, some matching rates were approximately same values in Japanese Finger spelling "A" and "Ro". The reason included that the probability of mismatched finger shape was higher than one of correct finger shape. Therefore, it is considered that the proposed method could not distinguish these hand shapes correctly.

6. CONCLUSIONS

This paper proposed the recognition method with distinctive features of hand shape of JSL in order to improve the hand shape recognition of Stringlove. The proposed method used distinctive features of sign linguistics. The proposed method classified the fingers of a hand into two categories; "dominant finger" and "non-dominant finger", and recognized finger shapes in each categories on the basis of distinctive feature of hand posture. The proposed method was evaluated in the preliminary experiment. The experimental result showed that the proposed method was an effective approach to improve the matching rate of Stringlove.

7. REFERENCES

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