SIGN LANGUAGE COMMUNICATION BETWEEN JAPANESE-KOREAN AND JAPANESE-PORTUGUESE USING CG ANIMATION

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ABSTRACT

In this paper we propose a sign language communication between different languages such as Japanese-Korean and Japanese-Portuguese using CG animation of sign language based on the intelligent image communication method. For this purpose sign language animation is produced using data of gesture or text data expressing sign language. In the production process of CG animation of sign language, MATLAB and LIFO language are used, where MATLAB is useful for three-dimensional signal processing of gestures and for displaying animation of sign language. On the other hand LIFO language, which is a descendant of the LISP and FORTH language families, is developed and used to produce live CG animations, resulting in a high-speed interactive system of designing and displaying sign language animations. A simple experiment was conducted to translate Japanese sign language into Korean and Portuguese sign languages using the developed CG animation system .

1. INTRODUCTION

Sign language has a potentiality to communicate between different languages under the condition that verbal communication is limited because of lack of common language. To realize such a sign language communication, we adopt an intelligent image communication technique, where we transmit intelligently coded data, that is, parameters describing gestures or text data expressing meaning of sign language in a certain language, instead of transmitting images or motion pictures themselves. In the intelligent sign language communication, first we analyze images of sign language or gesture, then we describe the images of sign language or gesture using text, parameters and programs. We transmit these intelligently coded data and we synthesize the CG animation of sign language using received text, parameters and programs.

We have investigated such a sign language communication [5], [6] and conducted an experiment of transmitting sign language images using a Japanese communications satellite [1]. We have also investigated a method to analyze the gesture by arms and hand for intelligent communication of sign language [2]. These experimental results suggest that it is necessary to develop a system of generating CG animation of sign language in real time with received data for the communication between sign languages of different countries.

In this paper we focus not the analysis of the images of sign language, but generation and display of the sign language images corresponding to the meaning of sign language. Therefore we are developing such a system to generate sign language images from text and parameter data. Using this system we can translate easily from text data of sign language into CG animation and we confirm the possibility of the sign language communication between sign languages of different languages.

2. DEVELOPMENT OF DISPLAY SYSTEM OF 3-D MODELS FOR PRODUCING SIGN LANGUAGE ANIMATION USING MATLAB

MATLAB was originally developed for matrix manipulation of linear algebra and signal processing. Now MATLAB has convenient GUI (Graphical User's Interface) to display the processed signals. This suggests that we can display the gesture signals using MATLAB without complicated programming as done in programming using C language. In order to construct 3-d limb model, we define a vector which expresses a skeleton of limb or finger as shown in Fig.1. Then we link these skeleton vectors to compose a limb model as shown in Fig.2.

We use commands of GUI of MATLAB for displaying polyhedrons corresponding to the skeleton vectors to gen-

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erate a 3-d human limbs model.Then we move the human limb model according to the given joint angle parameters $\theta 1 \sim \theta 3$ of each joints of limbs or fingers.

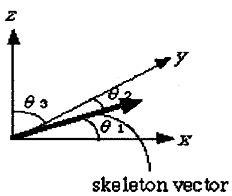

Figure 1: Skeleton vector of a limb

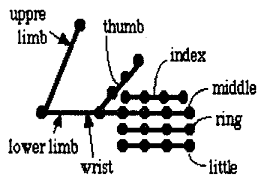

Figure 2: Limb model

Figures 3 a~f show a sequence of generated human limb models, that is an animation of a gesture. The joint angles (in degree) are listed in Table 1, where these joint angles corresponds to the image of Fig.3 e. The joint angles $\theta 4$ and $\theta 5$ in Table 1 are additional joint angles of each finger in local coordinates to describe finger motions.

Table 1 Table of Joint Angles

joint	right & left arm	region of rotation				
		$\theta 1$	$\theta 2$	$\theta 3$	$\theta 4$	$\theta 5$
upper limb	left	-90	130	200		
	right	-100	130	200		
lower limb	left	-110	220	−6		
	right	-80	220	-60		
wrist	left	0	100	70		
	right	180	80	0		
thumb	left	0	70	0	0	0
	right	70	0	15	0	0
index	left	50		0	100	50
	right	-50		0	-100	-50
middle	left	50		0	100	50
	right	50		0	-100	-50
ring	left	50		0	100	50
	right	-50		0	-100	-50
little	left	50		0	100	50
	right	-50		0	-100	-50

3. SIGN LANGUAGE TRANSLATION BETWEEN JAPANESE AND KOREAN

Japan and Korea are neighboring countries and these two countries possesses similar linguistic systems and cultures. This suggests that sign language translation between Japanese and Korean is easier than those of Japanese and other European languages.

Usually sign language is expressed according to the order of words in a sentence. Since the order of words in a sentence is almost same in Japanese and Korean, we exchange gesture images in translating sign languages between two languages.

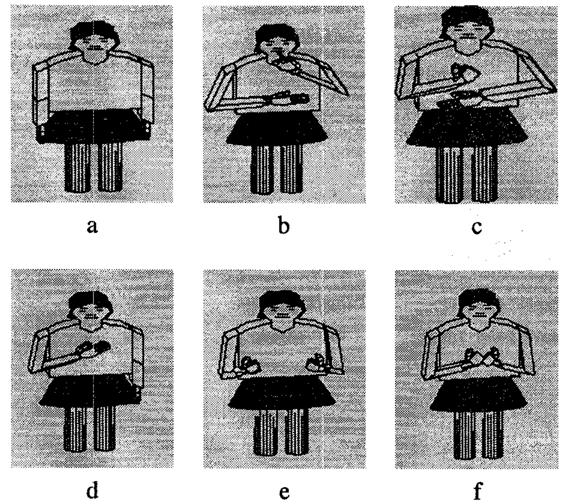

Figure 3: Sign language animation produced by MATLAB, where a $\sim$ c are Japanese sign language images and d $\sim$ f are Korean sign language images

Figures 3 a~c show the animation of Japanese sign language which express a sentence " I am a man ", while Fig.3 d~f show the same sentence in Korean. In the translation process of this Japanese sign language into Korean, we change the sign language images corresponding to the words "I" and "man" of sign language of Japanese into Korean. Japanese is an adhesive language and a postpositional words functioning as auxiliary to main words are frequently used, however, those words omitted in the expression of sign language. Therefore it is not necessary to change the order of the words of sign language images in translating Japanese into Korean or Korean into Japanese. Experiment of translation using simple sentences was conducted and the validity of the method of exchanging the sign language images in translation process between Japanese and Korean was confirmed.

4. DEVELOPMENT OF HIGH-SPEED CG ANIMATION SYSTEM USING LIFO LANGUAGE

The disadvantage of producing animation using MATLAB is its inconvenience of designing animation in interactive method. It take much time to design a gesture with given joints parameter. Therefore we develop a system for designing gestures using LIFO language [3]. The LIFO language is based on the stack manipulation like FORTH language, resulting in high-speed processing of CG animation.

In describing gesture or sign language, we describe the change of hand shapes as follows

```
open
par[[3 thumb] [10 ring] [10 little]]
```

A statement "open" opens a hand, then "par[ ]" description generates a shape of the hand, bending thumb, ring and little fingers with the bending parameters 3, 10 and 10, resulting in index and middle fingers remain stretching.

The command 'open' in turn is implemented as "[RHand < straight]", which reads as: "send the message '< straight' to the global right hand in 'RHand'". The method '< straight' of the hand class itself sends the message '< straight' (in a 'par'-body) to all members (fingers) of the hand object:

```
:<straight(-)[
par[[.thumb <straight][.index <straight]
   [.middle <straight][.ring <straight]
   [.little <straight]]];;
```

The function 'thumb' in the notation "[3 thumb]" above is a convenience function, implemented as "[RHand -> .thumb < ben]", effectively sending the message '< bend' to the '.thumb'-member of the hand.

The following list is a part of source program written in lifo language, where OOP(Object Oriented Programming) is used and classes and subclasses are defined for modeling of limbs.

```
(*** Limb Classes ***)
NIL class Limb
## .model
: <init (-) [nop] ;;
: <tree (- lst) [self llist] ;;
: <straight (-) [1 , { .model ,  ,:
 straight } ,] ;;
: <pitch (num flt -) [abs, { .model
 ,  ,  ,: aRot } ,] ;;
: <yaw (num flt -) [rel, { .model
 ,  ,  ,: zRot } ,] ;;
[Limb] class Thumb
## .ext
: <straight (-) [super  1 ,
  { .ext ,   ,: straight } ,] ;;
: <bend (num flt -) [rel,
{
.model ,  dup -1.2 f* , ,: aRot
.ext ,  -0.9 f* , ,: aRot
} , ] ;;
```

5. PRODUCTION OF CG ANIMATION OF JAPANESE AND PORTUGUESE SIGN LANGUAGE FOR SIGN LANGUAGE COMMUNICATION

In order to achieve real time animation of sign language using LIFO, the modeling of limbs is conducted with 2-d polygons. An arbitrary number of "models" can be painted to the z-buffer image, and then the complete scene can be drawn to the screen. Each model has a recursive structure, consisting of a position vector, a rotation matrix, an arbitrary number of faces (polygon), and an arbitrary number of (sub-) models. For each face two colors (lighter and darker) are defined to allow a kind of relative illumination effect.

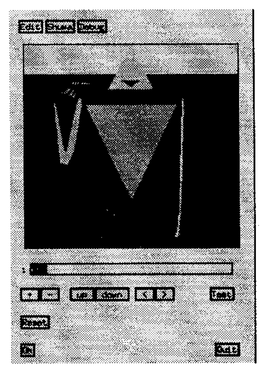

Figure 4: The last image of an animation of sign language of 'sing a song' with two arms.

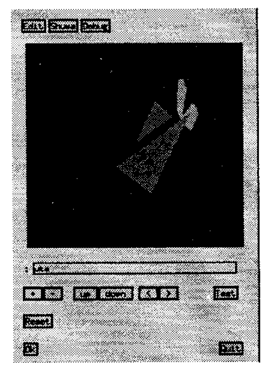

Figure 5: Displayed image of Fig 4 with a different view point.

A sentence of sign language is displayed as an animation by choosing words of sign language and arranging them to make a sentence corresponding to the motion of sign language. Figure 4 and 5 shows the final images of an animation of sign language of 'sing a song' in Japanese sign languae, where positions and angles of view points are different in both images.

In the case where we compose a sign language sentence, we make a sequence of commands (words of sign language) by using an editing function of the system. An animation of the composed sign language sentence is performed by displaying the sequences of animation of motions of arms and hands according to the arranged commands. We can display the animation faster than the real human motion expressing sign language. The speed of display is satisfactory in the developed system.

Figure 6 shows scenes of an animation of the Portuguese word "abencoar" which means "to bless" in English. We produce such an animation by designing interactively by displaying the gesture sequences step by step.

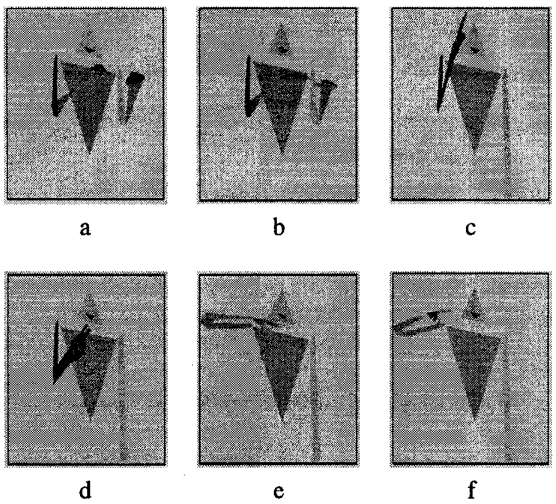

Figure 6: Sign language animation produced by LIFO A Portugese word "abencoar" which means "bless" is displayed as a CG animation.

We tried to translate sign language between Japanese and Portugese by displaying the corresponding sign language in the case where the gestures are similar in both languages, resuting in understanding the meaning of the sign language. However, when the gestures are different in both sign languages, a dictionary system is necessary which translates sign language from one lanugage to the other.

6. FUTURE EXTENSIONS OF SIGN LANGUAGE TRANSLATION

The current research results are only a first step. Development of a dictionary system is necessary as mentioned above. The important part of constructing a dictionary system must be the build-up of a complex gesture library, by designing a set of primitive gesture elements, which is in turn should lead to a powerful and elegant gesture description language. Use of research results on machine translation is promising in sign language translation.

A future version of animation system should either determine machine's speed before the compilation source programs, or execute the individual steps in synhronization with an absolute clock.

In this paper the facial expression is not considered, however, facial expression is important in communicating emotional message. A FACS (Facial Action Coding System) is a promising technique to generate CG face expressing emotion, where AU (Action Unit) is used. Now the facial emotion expression by AU coding is under investigation [4] and the CG technique developed in this research can be applied to add face expression to the gesture expression.

7. CONCLUSION

We proposed a communication with people in different countries using sign language under the circumstance where we have no common language. For this purpose we developed a system to generate CG animation of sign language uing MATLAB and LIFO language. We also discussed the translation of sign language of different language and we demonstrated the translation between sign languages of Japanese and Korean, and Japanese and Portuguese. Though the experiment was in the starting stage, but we confirmed the posibility of the proposed method and the developed CG system.

However many subjects are left for future studies. Since sign languages are different from language to language, it is necessary to develop dictionaries and intemediate language to interpret sign language images and text. International standard of generating sign language is also necessary to utilize the program developed in differnent countries. Experiment on sign language communication using Internet is one of our research targets. Researches on these subjects are now under consideration.

8. REFERENCES

[1] Y. Aoki, S. Tanahashi and J. Xu; Sign Language Image Processing for Intelligent Communication by a Communications Satellite, ICASSP'94, Vol.5, pp.V/197-200(2), April 1994.

[2] Y. Aoki, S. Tanahashi and H. Sugiyama; Tracing of Arm Motion by Matching Video Images with 3D Arm Model for Intelligent Communication of Sign Language, Proc. ICECS'96, Vol. 1, pp. 53-56 , Oct. 1996.

[3] Y. Aoki, S. Tanahashi, A. Burger, H. Hattori and H. Wakoh; Development of a CG-Animation System for Sign Language Communication between Different Language, Proc. ICICS'97, pp. 1668-1671, Sept. 1997.

[4] S. Kim, S.Shin. J. Li and Y. Aoki ; A Facial Expression Mehod for Sign Language Image Communication, IEICE Annual Meeting(1997-09).

[5] J. Xu, Y. Aoki and Z. Zheng; A Method for Synthesizing Animation to Transmit Sign Language by Intelligent Communication, IEICE Trans. Vol.J75-A, No.9, pp.1509-1515 (1992).

[6] J. Xu, S.Tanahashi, Y. Sakamoto and Y. Aoki ; Gesture Description and Structure of a Dictionary for Intelligent Communication of Sign Language Images, IEICE Trans. Vol.J76-A, No.9, pp.1332-1341 (1993).