

AN ELECTRONIC DICTIONARY OF JAPANESE SIGN LANGUAGE: DESIGN OF SYSTEM AND ORGANIZATION OF DATABASE

Yumiko Fukuda*, Wako Ikehara**, Emiko Kamikubo**, Shizuo Hiki***

*Research Institute, National Rehabilitation Center for the Disabled,
Namiki, Tokorozawa 359, Japan

Graduate School of Human Sciences, *School of Human Sciences, Waseda University,
Mikajima, Tokorozawa 359, Japan

ABSTRACT

The design of a system and the organization of a database for an electronic dictionary of Japanese sign language is discussed, as part of a study concerned with language supplements to compensate for disabilities in using speech. The sign language vocabulary used in this dictionary is a set of about 900 sign words which are highly frequent in daily use of Japanese sign language. Each of the selected sign words was labeled with a descriptive system which consisted of a new combination of symbols for shape, position and movement of hands and arms, as well as phonetic and orthographic descriptions of corresponding speech. Pictures of these words, signed by a female native signer, were recorded on a laser disc. These recorded pictures were linked to a computer program through a computer controlled laser disc player, so that the corresponding pictures in the sign language vocabulary could be retrieved instantaneously from any of the descriptive items in the database. The system is being used to analyze details of sign gestures, and to refine the descriptions. The possibility of coordinating traditionally used descriptive symbols in different sign languages with kinematic properties of hand and arm movements is also investigated.

VIDEO-RECORDING OF SIGN GESTURES

Sign language vocabulary

The vocabulary which is proposed in this electronic dictionary system as a basic Japanese sign language for its standardization in public use is a set of about 900 words highly common among Japanese signers. They were selected from more than 9,400 words which were found in 18 kinds of textbooks in daily use in sign language currently available in Japan. The number of textbooks in which the word is used commonly was taken into account for the selection (Figure 1).

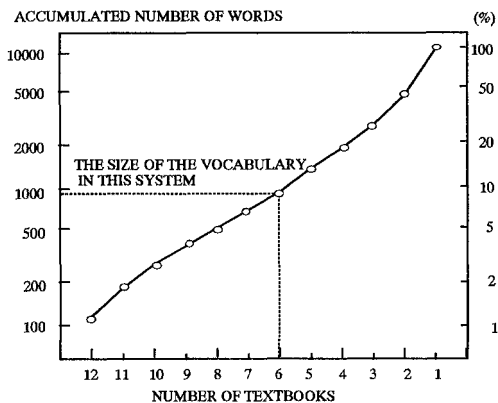


Figure 1. Number of textbooks in which the words used

The words in the set include nouns, verbs, adjectives, adverbs, and particles, if they were described in traditional orthography.

Pictures

The words in the set were signed by a female native signer who is considered to use standard Japanese sign language, and pictures of the front view of the upper body of the signer were recorded on a laser disc using a conventional recording unit.

Time duration of the signing of most of the words ranged from one to three seconds. The pictures took about 60 minutes long in total. They were stored on two sides of a laser disc. Playback of the pictures can be controlled by specifying the address on the laser disc through an interface program between a playback unit and a personal computer (Table 1).

Table 1. Specification of the equipment

Personal computer: NEC PC-9801RX
40MB hard disc + 1 MB cache memory
Computer display: NEC PC-HD882
Laser disc player: Panasonic TQ-3200F
Search time: 0.7 sec on average
Disc cartridge: Panasonic TQ-FH301
Memory capacity: Still picture: 54,000 frames (Normal mode) Moving picture: 30 minutes
Video monitor: Sony KV-14GP1
Database software:
Ashton Tate dBase III Plus
Control Library for Laser Disc Player LV-Y102

DESCRIPTION OF SIGN GESTURES

Items in the database

Each of the 900 words was matched with a description of sign gestures in terms of shape, position and movement of left and right hands and arms and their mutual relationship, in addition to their phonetic and orthographic descriptions.

The description of the sign gestures in this system is partly based on previous studies, such as the representation for American Sign Language (Stokoe, 1979, Friedman, 1977, The Sign Font Hand Book, 1989), and a phonological representation of Japanese sign language (Yonekawa, 1984, Kanda and Atari, 1991). But, this electronic dictionary system uses a new set of symbols for shape, position and movement of hands and arms, plus supplemental notes when it is necessary to describe specific gestures (Table 2).

This description of the sign vocabulary was utilized to construct a framework of the database, using the multi-dimensional nature of each signword, to enable its retrieval.

Table 2. Items matched with each of the words

1. Word code number
2. Orthographic description
3. Frequency in daily use
4. Use of one hand/both hands
Same/different in case of both hands
Symmetrical/parallel in case of same
Mutual relationship in case of different
5. Shape of right hand (and left hand in case of different)
Direction of right palm
(and left palm in case of different)
Direction of the right hand
(and left hand in case of different)
6. Parts of hands and body to be touched each other
7. Position of hands
8. Movement of right hand
(and left hand in case of different)
9. Supplemental notes if necessary
(e.g. Imitative expression, sequence of movements)
10. Beginning and end address on laser disc
11. Volume and page number in The Glossaries of Japanese Sign Language

Linkage of pictures and descriptions

These descriptions of the sign gestures for each of the words are installed as a database in the hard disc memory of the personal computer, so that they can be linked to their pictures on the video disc (Figure 2).

As the recorded pictures of the sign words can be retrieved and played back by inputting either their orthographic representation or the symbols for shape, position or movements of hands and arms, the system is effectively used for analyzing details of the sign gesture, and refining the structure of the set of symbols for their description.

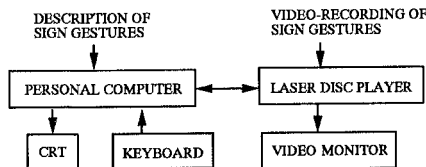


Figure 2. Schematic diagram of the electronic dictionary

ANATOMICAL STRUCTURE MODELS
Rotation of the joints

By analyzing the kinematic properties of hand and arm movements, the possibility of coordinating traditionally used descriptions of sign gestures in different languages is investigated. For this purpose, the sign gestures were described in terms of anatomical structure of hands and arms, taking into account the constraints of direction and range of rotation around the joints involved.

Movement of the upper extremities on each side of the body consisting of the upper arm, the forearm and the hand is described in three dimensional space, with the shoulder joint as its origin, under constraints on the direction and range of change in the angle of the shoulder joint for extension/flexion, abduction/adduction and internal/external rotation, the elbow joint for extension/flexion and internal/external rotation, and the wrist joint for extension/flexion and radial/ulnar deviation (Figure 3).

The origin of all those movements is shifted by elevation/depression and protraction/retraction of the sternoclavicular joint.

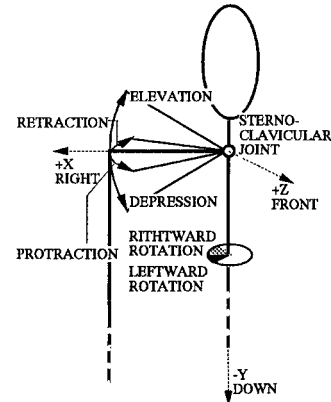
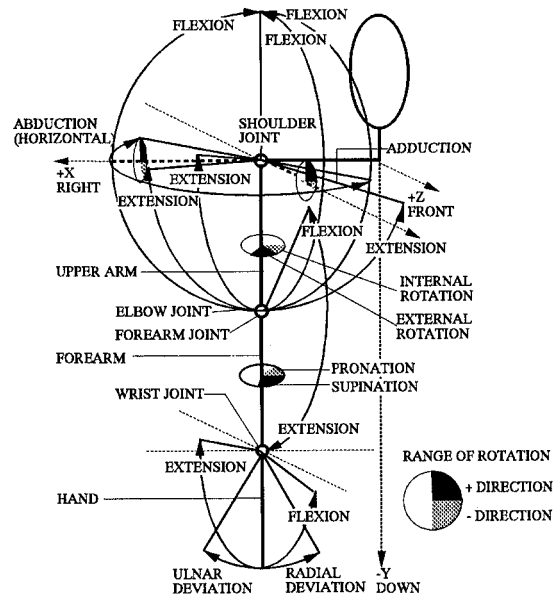


Figure 3. Direction and range of rotations of joints

Hand movement

The detailed hand model which describes extension/flexion and abduction/adduction of the five fingers, namely, finger 1 (thumb), 2 (index), 3 (middle), 4 (ring) and 5 (little), and especially the pronation/supination of finger 1, is added to the model of the upper extremities (Figure 4).

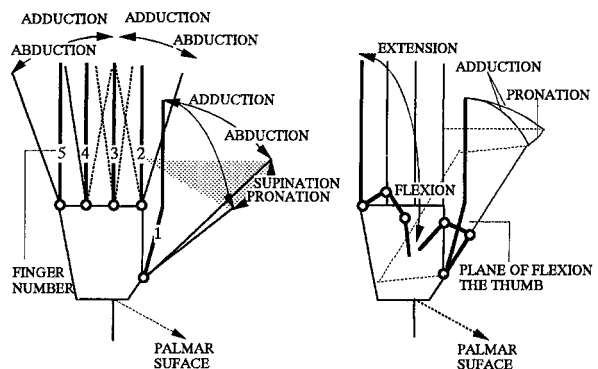


Figure 4. Actions of the fingers

Direction of the palm

The direction of the palmar surface and the dorsal surface of the hand is derived using this model under the constraints of the mechanisms of the shoulder, elbow and wrist joints (Figure 5).

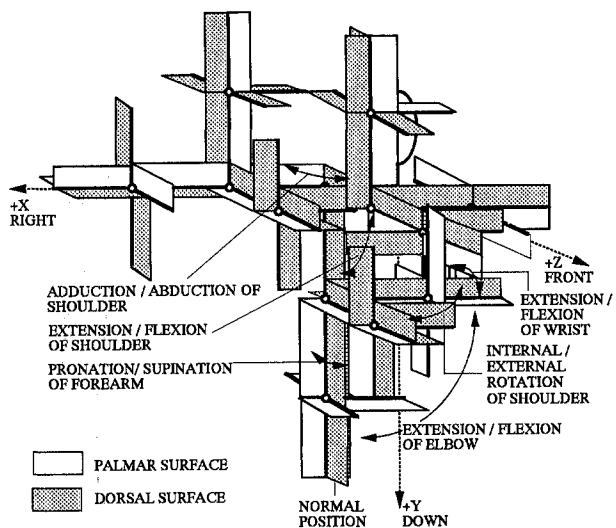


Figure 5. Direction of the palm

Hand shapes

Hand shapes in signing were classified based on the combination of actions of the five fingers, such as abducted, adducted, crossed, pronated, extended and flexed. Flexed is subdivided into clenched, half-clenched, ringed and angled (Figure 6 and Table 3).

About 180 kinds of combination of those actions which are possible to manipulate cover most of the hand shape in finger spelling and signing.

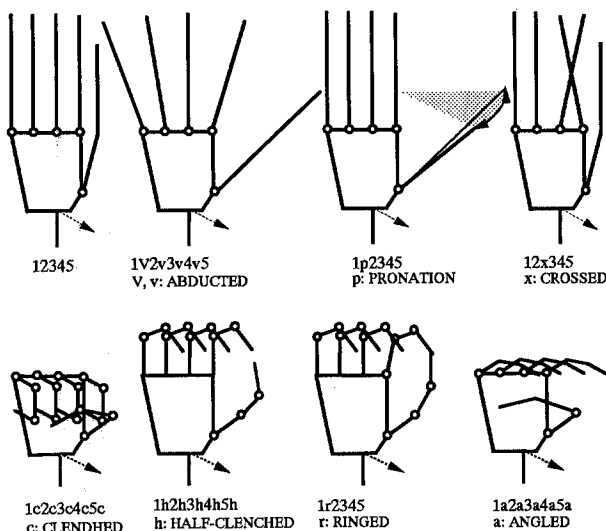


Figure 6. Hand shapes classified by finger actions

Parts of the body

Parts of the body to be touched by the hands, and parts of the hand to be touched by the other hand, are categorized by considering the constraints of movement of the upper extremities (Figure 7).

Table 3. Hand shape chart

FINGERS EXTENDED								
1	1V(p)	2	3	4	5			
1	1	1V						
v	1h							
ir								
a								
a	12a3a4a5a							
x								
2	12	1V2	2					
v	1h2h	2h						
h		1r345						
ir	2a	2a						
a	123a4a5a	23a4a5a						
a	1x2							
x	13	1V3	23					
v	1h3h	2v3	3h					
h		2h3h	1r245					
ir	3a	1r45	3a					
a	12a3a4a5a	23a4a5a	2a3a4a5a					
a		2x3						
x		24						
3	14	1V4	34	4				
v	1h4h	2v4	3v4					
h		2h4h	3h4h	4h				
ir	4a	1r35	1r25	1r235				
a	12a3a4a5a	2a4a	3a4a	4a				
a		23a4a5a	2a3a4a5a	2a3a4a5a				
x		23a4a5	3x4					
4	15	1V5	25	45	5			
v	1h5h	2v5	3v5	4v5	5h			
h		2h5h	3h5h	4h5h	5r234			
ir	5a	1r34	1r24	1r23	5a			
a	12a3a4a5	2a5a	3a5a	4a5a	2a3a4a5			
a		23a4a5	2a3a4a5	2a3a4a5	2a3a4a5			
x			4x5					
0					0			
v					1c2c3c4c5c			
h								
ir					1r2345			
a								
a					2a3a4a5a			
x								
FINGERS CLENCHED								
1	2	1V(p)	3	1V(p)	4	1V(p)	5	1V(p)
1	2345	345	245	235	234	234	234	234
v	2v3v4v5	3v4v5	2v4v5	2v3v5	2v3v4	2v3v4	2v3v4	2v3v4
h	2h3h4h5h	3h4h5h	2h4h5h	2h3h5	2h3h4h	2h3h4h	2h3h4h	2h3h4h
ir	1r2	1r3	1r3	1r4	1r5	1r5	1r5	1r5
a	2a3a4a5a	3a4a5a	2a4a5a	2a3a5a	2a3a4a	2a3a4a	2a3a4a	2a3a4a
a		2a345	23a45	23a45	2345a	2345a	2345a	2345a
x								
2	1345	1V345	145	1V45	135	1V35	134	1V34
v	1V3v4v5	1V34v5	1V4v5	1V3v5	1V3v4	1V3v4	1V3v4	1V3v4
h	1h3h4h5h	1h3h4h5h	1h4h5h	1h3h5h	1h3h4h	1h3h4h	1h3h4h	1h3h4h
ir								
a	3a4a5a	4a5a	4a5a	3a5a	3a4a	3a4a	3a4a	3a4a
a	12a345	12a345	12a345	12a34a5	12a34a5a	12a34a5a	12a34a5a	12a34a5a
x								
3			1245	1V245	125	1V25	124	1V24
v			1V2v4v5	1V2v5	1V2v4	1V2v4	1V2v4	1V2v4
h			1h2h4h5h	1h2h4h	1h2h4h	1h2h4h	1h2h4h	1h2h4h
ir								
a			2a4a5a	2a5a	2a4a	2a4a	2a4a	2a4a
a			123a45	123a4a5	123a4a5a	123a4a5a	123a4a5a	123a4a5a
x								
4					1235	1V235	123	1V23
v					1V2v3v5	1V2v3	1V2v3	1V2v3
h					1h2h3h5h	1h2h3h	1h2h3h	1h2h3h
ir								
a					2a3a5a	2a3a	2a3a	2a3a
a					1234a5	1234a5a	1234a5a	1234a5a
x								
5							1234	1V234
v							1V2v3v4	1V2v3v4
h							1h2h3h4h	1h2h3h4h
ir								
a							2a3a4a	2a3a4a
a							12345a	12345a
x								
0							0	1V(p)
v							12345	1V2345
h							1V2v3v4v5	1V2v3v4v5
ir							1h2h3h4h5h	1h2h3h4h5h
a								
a							2a3a4a5a	2a3a4a5a
x								

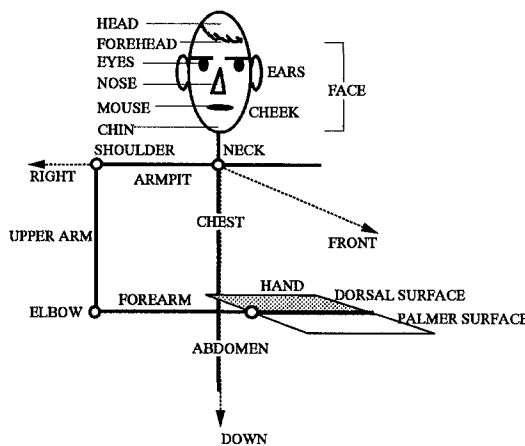


Figure 7. Parts of the body to be touched by the hands

Movement of the hands

Movements of the hands are categorized basically in terms of the directions of their linear or circular movements (Figure 8). Supplemental notes for the directions include aspects such as touching/separating, wiggling, twisting and repeating.

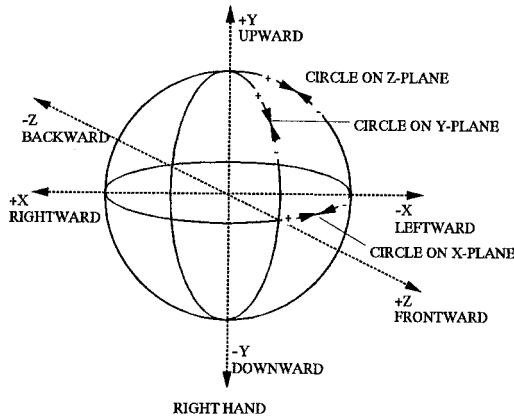


Figure 8. Directions of movement of right hand

APPLICATIONS

Examples of the description

The class of hand shapes and the category of the parts of the body are combined with the basic data of the sign gesture of the words in the vocabulary involved in the database of Japanese sign language (Table 4 and Figure 9).

It is expected to produce a more accurate, language-independent method of describing the nature of visually transmitted information by signing, through computer simulation of the arm and hand movement under the constraint of organization of the neuromotor commands for the contraction of muscles involved in this anatomical structure model.

Self-learning

For the application of this system to self-learning of sign language by beginners, it is planned to provide a simpler method of inputting the symbols on a screen display.

It is also planned to introduce to the database syntactic information to coordinate each word with other words. In addition to the concatenation between the gestures for successive words, the organization of phrase and sentence structure, assisted by prosodic features such as time duration of the words, pause, and facial expression is to be utilized in this stage.

REFERENCES

An English Dictionary of Basic Japanese Signs, Japanese Federation of the Deaf, Tokyo, 1991.
 Friedman, L.A., Formational properties of American Sign Language, On the Other Hand, Academic Press, New York, 1977.
 Kanda, K. and Atari, H., Phonological notational system for Japanese Sign Language, Japanese Journal of Sign Linguistics, 2, pp. 31-39 (in Japanese), 1991.
 Sign Font Hand Book, Edmark Corporation, Bellevue, Washington, 1989.
 Stokoe, W.C., Sign Language Structure, Linstok Press, Inc., Silver Spring, Maryland, 1979.
 Yonekawa, A., A Study on Description of Sign Language, Meiji Shoin, Tokyo (in Japanese), 1984.

Table 4. Examples of the items in the database

1. 1198	40071	30124-1	13049
2. Older sister	Parents	Want	Like
3. 14	9	9	16
4. One hand	One hand	One hand	One hand
5. 2	2→15	2	1V2→1r2
	Backward	Backward	Backward
	Upward	Upward	Upward
6.	Tip of 5	Tip of 2	Tips of 1 and 2
	Check	Right corner	Chin
		of the lips	
7. Space		Lips	Chin
8. Upward	Leftward	Downward	Downward
9.	Separating		Separate
10. A2881	B39241	B28351	A44911
	/2970	/28440	/45000
11. 1-19	8-12	3-115	1-124

1. 1009	1055	1031	1268
2. Greeting	Autumn	Meet	Thank(s)
3. 11	15	13	13
4. Both hands	Both hands	Both hands	Both hands
	Symmetry	Symmetry	Right hand on
			the left hand
5. 2→2g	1V2v3v4v5	2	12345
	Leftward	Backward	Leftward (Downward)
	Upward	Leftward	Upward
6.			Lateral edge
			of the right hand
			Dorsal surface
			of the left hand
7. Chest	Shoulder	Chest	Chest
8. Hold	Backward	Leftward	Upward (Hold)
9.	Repeat	Touching	Separating
10. A61	A1081	A631	A3871
	/151	/1170	/3960
11. 1-171	1-241	1-171	3-71

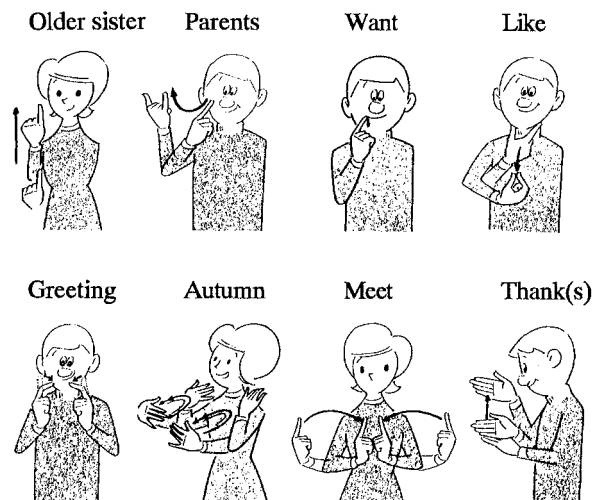


Figure 9. Sign gestures of the example words (from An English Dictionary of Basic Japanese Signs, 1991)