Study into Methods of Describing Japanese Sign Language

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Abstract. This paper proposes a new NVSG element model with a focus on the linguistic structure of sign language. Morphemes in sign language consist of elements such as hand shape , movement and line of sight. An NVSG element description method is a method of describing morphological structure in an independent hierarchical structure.

Approximately 1,500 words have been described using the description method. After being described, the hierarchical structure of morphemes becomes easily comprehensible visually at a word level. Describing each element also allows us to search for a word from the word structure.

In the future, we intend to verify the possibility of sign language description in languages other than Japanese.

1 Introduction

Sign language is a visual language with no speech and is composed through manual markers (hand shape, hand movement, hand position, and palm direction) and non-manual markers (such as line of sight and nodding). Morphemes are composed of these multiple elements (articulatory organs).

Our goal is to construct a system that can automatically generate animation of translated sign language from spoken Japanese. To achieve this goal, it is necessary to have a method that can depict sign language and enable its analysis via computer. This paper proposes an NVSG element model, a hierarchical morphological description method that can describe the sign language structure. In this method, each element required to form a word is described independently for each morpheme in sign language.

We investigated means of describing manual markers objectively (including CL). We then described the sign language by using the NVSG describing method and compiled a dictionary that provides word structures.

2 How to Describe Sign Language

Different from spoken language, sign language has no widely used writing system. Known description methods include HamNoSys and SignWriting. However, these

C. Stephanidis (Ed.): HCII 2014 Posters, Part II, CCIS 435, pp. 270–275, 2014.

are iconic and aim to describe phonetic symbols. The NVSG element description method proposed here aims to describe morphological structures of words and generate animation by synthesizing them.

3 NVSG Element Model

In sign language, one word is represented by combining each element. Each element moves independently. To describe words in animation images, it is necessary to analyze how each element moves. Therefore, we decided to independently describe each element of the sign language.

Among elements, manual markers are described in an N element and V element, while non-manual markers are described in an S element and G element. Items related to hand shape, palm direction and hand position are described in the N element, while movement items are described in the V element. Among non-manual markers, line of sight is most important, so items regarding line of sight are described in the S element, while other non-manual markers are described in the G element.

3.1 N Element

In the N element, items related to hand shape, one of the components of manual markers, are described. Hand shape is represented by depicting how the finger shapes have changed. The state after the finger shape has changed is described according to Table 1. Numbers 1 to 4 were assigned to the fingers in order from index to pinky of both hands, with 5 assigned to the thumb.

Table 1. Codes for hand shapes

Hand shape		Code	
Relationship	Change in shape	Typical hand shape	Relaxed hand shape
Flexion of fingers	Extending	H	h
	Curving	B	b
	Folding	A	a
	Bending	F	f
	Standard shape	G	g
Relationship between fingers	Bonding	C	c
	Pinching	P	p
	Pushing the thumb	T	-
	Covering	V	-

The hand position (first position of the hand shape) is also described by using "@"in N element.

Example: {*tokui* (elation)} [1] = [Ns(H45 @nose) Vs(PR)]

[1] Sign language words are represented in {}. Japanese word are represented as italic.

3.2 V Element

In the V element, codes represent movements. Although movements in sign language look complicated, they can be classified as shown in Table 2, and each can be described by using a code. Writing out the movements with code can prevent differences in description from person to person and makes it possible to conduct computer analysis.

Example: {*hana* (flower)} = [NN(b0>h0) V(MV(transposed))]RR(symmetric)
{*atama* (head)} = [N(H1) V(PT >> head)]

Table 2. Codes for movements

Movement		Code
Movement	Shift of position	MV (Move)
	Motion	MT (Motion)
Instruction	Pointing	PT (Pointing)
	Defining the area	PT:AREA
Presentation	Presentation	PR (Presentation)
Trace a Letter	Trace a Letter	TL (Trace a Letter)

4 Word Description in NVSG Element Model

This section covers how to describe specific sign language words by using the NVSG element model.

4.1 Describing Pattern of Manual Markers

The relationship between the V and N element of a manual marker is hard to understand because each element is independently described in NVSG element model. To solve this problem, the means of description were changed depending on the relationship between V and N elements, which makes the relationship between them more understandable. Based on the movement of both hands, the relationships between the V and N elements were classified into seven categories. Table 3 shows the classification and patterns.

The dominant hand, which often plays a significant role in sign language, is considered the strong hand, and the non-dominant hand the weak hand. They are represented by the letters “s” and “w”, respectively. In other words, Ns means strong hand (dominant hand) in the N element and Vw means weak hand (non-dominant hand) in V element.

The structure of words can be clearly determined depending on which pattern is used.

Table 3. Description patterns of manual markers

	Description pattern	Definition
(1)	NsVs	Basic way of writing (when using only one hand)
(2)	[NsVs] [NwVw]	Basic way of writing (when using both hands)
(3)	Nw[NsVs]	When moving the strong hand while using the weak hand as a marker (e.g., when the weak hand is UM [unmarked])
(4)	NsNwV	When moving both hands in combination or symmetrically
(5)	NsVNw	When moving both hands in the same way (symmetrically) though the hand positions differ.
(6)	[NsVs] [&Nw]	When there is remaining shape in the weak hand
(7)	[&Ns] [NwVw]	When there is remaining shape in the strong hand

4.2 Word Description by Morphological Chain

When sign language animation is automatically generated, it is preferable that the movements are closer to those in actual sign language. Therefore, in the NVSG element model we added information that makes morphological chains more natural. Connections between sign language morphemes have specific features such as "remaining shape". Through animation reflects these features, it is expected that connection between morphemes will become more natural.

Remaining Shape. Remaining shape refers to a phenomenon that can occur when representing words with multiple morphemes: while a part of the previous morpheme remains, the next morpheme has already started. It is observed more frequently in the weak hand, which often plays a less important role than the strong hand.

Remaining shape is represented with the ampersand (&). For example, if it occurs in a weak hand, it is described as [&Nw].

Example: {*kazoku* (family)} = {*ie* (house)} + {*hitobito* (people)}
= [NN(C0) V(PR)]RN(touch),RR(symmetry) + [Ns(H45) Vs(MT(wave),MV(>out))] [&Nw]

5 CL (Classifier)

CL is an abbreviation for classifier, which means to make a classification. Considering that CL is required when creating a new word, we also reviewed the CL (classifier) of Japanese sign language. CL in sign language has a different definition depending on the researcher[1],[2]. In this report, CL is defined: What classifies the concept without any meaning; words in any word class can be CL. Studies have shown that CLs are found in manual markers (N and V element). We have made efforts to streamline the CL classification so that it does not include too many categories.

5.1 CL of Hand Shape

Since sign language is a visual language, external features of something, such as its size and shape, are represented as faithfully as possible. In this report, sign language for representing external features is conceptually classified focusing on hand shapes. Classification was carried out objectively, so it was possible to avoid ambiguity from one classifier to another.

CL of hand shape was classified into 10 categories in total. Table 4 shows the classification. Since this classification was implemented so that it does not include too many CL categories, one category has multiple hand shapes. The classification depended on what the hand shape means. For example, "man" and "woman" were put together as "CL:one". These two words seem to be considered as falling under a separate category of "man" and "woman" in terms of meaning, but categorization was based on the concept of hand shape without meaning. Thus, these two words have been classified in one category because they both are represented as "one being that stands straight" by the movement of holding up a finger.

Example: {*dansei* (man)} = [Ns(CL:one(H5)) Vs(PR)]
{*aruku* (walk)} = [Ns(CL: two(H12)it) Vs(MV(>$per2))]

Table 4. CL of hand shape

Category	Hand shape and body part	Meaning
one	H1	one straight line
	H5	man or human
	H4	woman
two	H12	two straight lines
	H45	two protrusions (tools)
many	h0	many things or unmarked
	H0	straight and stand, and many things
plate	C0	flat thing
circle	p1H234	round thing (2D)
	B15	circular and round thing
cylinder	p0	roll and round thing (3D)
	B(C1234)5	something whose diameter is longer that things represented by category "p"
square	F15	small square
ball	B0	spherical form
thickness	A15	thickness (thick)
	P1	thickness (thin)
stick	HN (head & neck)	head (G) & neck (arm)
	LF (leg & foot)	leg

5.2 CL of Movement

In CL of movement, semantic concepts like a gesture received from the sign language movement were classified. There are four resultant categories, as shown in Table 5. LVL means {*takai* (higher)} or {*ookii* (larger)} compared to a certain standard. ACT is a representation of mimicry, such as {*tenisu* (tennis)}. MAP is a representation of a movement or a state expressed by hand movements, such as {*aruku* (walk)} and {*yuki* (snow)}. GRP is a representation of a unity by a circular motion, such as {*zenbu* (all)} and {*tomodachi* (friends)}.

Example: {*ookii* (larger)} = [[NN(C1234H5)] V(CL:LVL(out))]
{*tenisu* (tennis)} = [Ns(G) Vs(CL:ACT(tennis))]

Table 5. CL of movement

Category	Meaning
LVL (Level)	change from a certain standard
ACT (Action)	mimicry, gesture
MAP (Mapping)	movement
	state
	shape trajectory
GRP (group)	unity

6 Conclusion and Future Issues

This paper is a study on how to write the language structure of sign language. A sign language morpheme dictionary was compiled by using our proposed NVSG description method. Approximately 1,500 words have been described. Three-dimensional motions for these 1,500 words were acquired through an optical motion capture system. The morpheme dictionary will be used for generating and synthesizing materials for linguistic analysis as well as sign language animation.

The NVSG element model is a method of describing the morphological structure of sign language in a hierarchical structure. Describing sign language makes computer analysis easier.

Codes are used in description. Doing so makes it possible to classify the sign language representations, and makes computer analysis easier. It was also shown that sign language movements that are seemingly complicated can be roughly categorized by using codes. CLs have also been defined and classified and can be utilized in generating new words.

In the future, we intend to investigate whether the NVSG description method can be used in sign language other than Japanese.

References

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