Articulatory Analysis of the Manual Parameters of the French Sign Language Conventional Signs

Annelies Braffort

LIMSI/CNRS, Orsay, France
Campus d'Orsay, Bat. 508, BP133, F-91403 Orsay cedex
annelies.braffort@limsi.fr

Abstract

This paper presents results of the analysis of French Sign Language (LSF) conventional signs that have been extracted from a LSF dictionary, in order to help the design of LSF processing systems. The signs (more than 1200) have been described, regarding manual parameters from an articulatory point of view. The movement parameter has been considered regarding the moving articulator: hand, wrist, and forearm. Thus, handshape, orientation and location parameters have been considered to be static or dynamic. The descriptions have been stored in a database, allowing us to compute quantitative data for each parameter and for the links between the parameters. Our analysis on this database gives us clues to design new description systems of lexical signs for SL processing, for automatic recognition or generation with the aim to design more accurate and synthetic representations.

1. INTRODUCTION

In most SL dictionaries (Moody, 1986), databases or other description systems, the lexical signs are described by means of four manual parameters, which are handshape, location, orientation and movement, and facial expressions, where each parameter is systematically specified, in a uniform way.

This is generally not suitable for processing systems dedicated to SL, neither for analysis by means of image processing (Bowden et al., 2004 ; Lenseigne & Dalle, 2005), nor for automatic recognition (Braffort, 1996) or generation (Hanke, 2000; Huenerfauth, 2004). Most of these systems need to integrate more precision on each parameter and on their inter-relations.

To help the design of such systems, we have conducted a study on LSF lexical signs, by describing the pictures contained in the first volume of a LSF dictionary (Moody, 1986) one by one, that is to say 1257 signs.

Each sign has been described according to visual features. In order to be able to obtain quantified information, descriptions have been stored in a data base (OpenOffice Base). The exploitation of the database enables us to obtain quantified information on the frequency of the values of each feature and the relation between values of various features.

This paper describes the chosen point of view while defining the parameters, especially regarding the movement parameter, and gives some results on the handshape, location and orientation parameters.

It describes the methodology and sketches out the potential observations that can be provided by this kind of mixed annotation.

2. DEFINITION OF MOVEMENT

The muscles which make it possible to move the fingers are different from those which move the hand around the wrist axes, and are different from those which make it possible to move the arm. Thus, differently to what is considered in linguistics studies, we burst the description of the movement in the description of the three parameters of handshape, orientation and location. The handshape can be static or dynamic, just as the orientation and the location. That makes it possible to account for the articulatory phenomena better, and especially the fundamental difference which exists between the movement and the other manual parameters: From an articulatory point of view, there are always a configuration, an orientation and a location of the hand, but not always a movement. These three parameters are described with visual criteria, from the point of view of the signer.

For example, we describe the sign $[\text{WORM}]_{\text{LSF}}$ (Figure 1), in the following way (only the active hand is described):

- The handshape is dynamic, the index has an wiggling movement, alternating from an extended position to a semi-bent position, the other fingers being bent.
- The location varies in a neutral zone located in front of the signer. The trajectory is linear, in a horizontal frontal axis, and the movement is directed towards the left.
- The orientation is static: The hand axis is directed towards the left, the palm is directed to the bottom and the wrist is not bent;

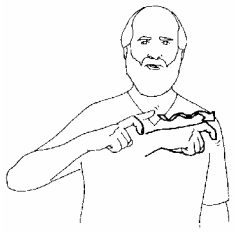

Figure 1: $[\text{WORM}]_{\text{LSF}}$ (Moody, 1986)

Thus, the specificity of this description is that the index movement is dissociated from the arm movement,

unlike the schematic description given in the dictionary, in which the movement is represented by only one symbol: A horizontal wavelet, concatenation of the index and arm movements.

This paper presents results of an analysis on handshape, location, orientation and on more global aspects.

With such a corpus, linguists and computer scientists can study the same video together, so as to perform complementary analysis.

3. CONFIGURATION

The study has shown that there is a great diversity of handshapes (139 different configurations), static or dynamic. We indexed them and calculated the percentages of occurrence for each of them in the dictionary. Only 65 handshapes appear more than twice. Table 1 lists the most frequent handshapes and their occurrences.

Out of the 1257 signs, 62.5% are bimanual and 37.5% are monomanual.

A finer study was undertaken on the handshape occurrences of the strong hand according to whether the sign is bimanual (index, mitt, s, flat, 5, v, angle, 1, beak, key, clip, x, ball, y) or not (index, flat, 1, v, y, s). When the sign is bimanual, we measured the handshape occurrences of the weak hand (mitt, flat, s, index, 5, angle, 1, beak, ball). For more of 75% of the bimanual signs, the two handshapes are identical (index, mitt, 5, flat, s, angle, 1, ball). When the handshapes are different, the handshape of the weak hand is simple (mitt, flat, s, index).

Name	index	flat	mitt	s	5
					
Occur	122	78	71	69	59
.Name	1	v	angle0	y	beak
					
Occur	52	52	40	38	36
Name	key	ball	clip	x	u
					
Occur.	35	31	30	30	24
Name	bent2	c	hook	bmiddle	5p/beak
					
Occur	23	22	22	20	18

Table 1: Most frequent handshapes in LSF.

The dynamic handshapes raised in the dictionary are handshapes for which at least one of the finger joint undergoes a variation during the sign. Nearly 20% of the signs present a dynamic handshape, corresponding to 12% (152) of closing handshape (at least a finger joint is inflected during the sign) and 6% (75) of opening handshape (at least a finger joint undergoes an extension during the sign). More details on closing and opening handshapes can be found in (Braffort, 1996). Less than 3 % of the signs present more complex finger movements from an articulatory point of view. All in all, one can say that the more complex the dynamic aspect is, the more the handshape is simple.

Generally, we can note that the articulatory realization of a handshape always remains in an acceptable level of complexity: There exists few dynamic handshapes and they consist of an initial and a final simple handshape. The most frequent handshapes seem to correspond to the proforms used in LSF (Cuxac, 2000). This last property must be validated with statistics on LSF corpora from which the proforms are annotated.

Regarding these tables, representations of handshape in automatic recognition systems can be simplified and optimized, like in (Braffort, 1996), in order to enhance discrimination between the different handshapes.

4. LOCATION

Hand location can be described on two levels of granularity: First of all on a *global level*, in order to distinguish the zone in which the sign is carried out, and then, on a *finer level*, to analyze the variation of the location within this zone, when the arm undergoes a movement.

Location values correspond to zones in space, more or less wide. For most of the studied signs (more than 60%), hand location is in the neutral zone placed in a half-sphere in front of the signer. We found 48 different locations, 14 corresponding to more than 92% of the signs. In 96% of the cases, even if we observe a motion of the arm, the signs are carried out within only one zone.

Describing the trajectory of the wrist in space specifies motions. In order to differentiate all the types of motions, their trajectories are defined compared to the various axes and planes of a 3d coordinate system centred on the signer. It is illustrated in Figure 2.

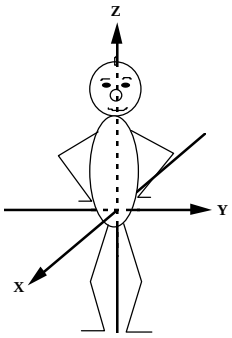

Figure 2: The 3d coordinate system centered on the signer.

Some results are presented in a synthetic way here. More details can be found in (Braffort, 1996).

More than 40% of the signs trace a straight trajectory; 82% of these signs are parallel to one of the three axes, and nearly 15 % are parallel to a plane formed by two of the axes. Nearly 88% of the signs present a curved trajectory included one of the three main planes. Nearly 92% of the signs whose trajectory is a circle are parallel to one of the three main planes.

In vertical movements, the signs for which only one arm is moving are frequent. For the lateral movements, the signs for which two arms are moving with opposite motions are frequent. For the horizontal and sagittal movements, the signs for which two arms are moving in a parallel way are frequent. Moreover, in a general way, when the two arms are moving, they always have symmetrical movements (parallel, opposed or shifted).

The global result is that the simplest movements to realize are also the most frequent, which goes in the same direction as the observations concerning the handshape parameter.

This analysis also gives us clues for the definition of macro representation of one-handed or two-handed arm motion primitives for automatic generation.

5. ORIENTATION

The description of the hand orientation is very tricky. It is often described in an absolute way, compared to the 3d coordinate system presented above, such as in HamNoSys (Prillwitz & Leven, 1989). The orientation of the hand is defined in this type of system by three items:

- The state of the wrist (extended or bent, at rest or in rotation),
- The direction of the hand axis,
- The direction of the hand palm.

This system is well adapted to describe signs such as [TABLE]$_{LSF}$ or [CEILING]$_{LSF}$ (Figure 3) because these signs draw in space salient iconic features for which absolute and static orientation of the hands is necessary.

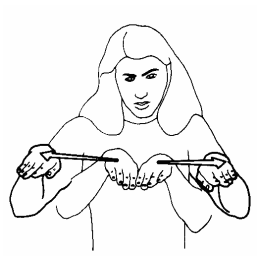

Figure 3: [TABLE]$_{LSF}$ (Moody, 1986)

Figure 3: [CEILING]$_{LSF}$ (Moody, 1986)

Compared to the 3d coordinate system, the hand orientation can vary during the sign if at least one of the directions varies or if the wrist undergoes a motion around one of its joint axes. For gestures for which the orientation undergoes a variation during the sign, such as [CORRIDOR]$_{LSF}$ (figure 4), the use of an absolute coordinate system is not easy.

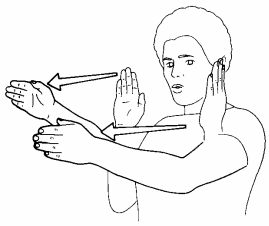

Figure 4: [CORRIDOR]$_{LSF}$ (Moody, 1986)

For these signs, a system based on a relative coordinate system fixed on the forearm of the signer and specifying the state of the elbow (flexion, extension, rotation) would be perhaps more suitable.

Moreover, for most of the studied signs, hand orientation seems to be a consequence of the various joint movements, rather than an intentionally selected orientation in the signer coordinate system.

The description of the hand orientation remains an open question that does not have a satisfying solution at the present time, synthetic enough for an implementation in a processing system.

6. INTERDEPENDENCES

The database is also used to study the relations and interdependences between the various parameters:

- Relations between the handshape and the movement: In the bimanual signs, we observed that when the two arms are moving, the two handshape are identical, while when only the arm of the strong hand is moving the two handshapes are different.
- Relation between the movement and the orientation: According to the type of hand trajectory, the behaviour of the orientation is different. For linear or circular trajectories, the orientation most of the time is static. On the other hand, for arched trajectories or when the hand does not move, the orientation is rather dynamic.

Many other results can be obtained from this database. For example, it is possible to observe the correlation between the complexity of the handshape and the complexity of the arm motion. As one could expect it, the more the arm motion is complicated, the more the handshape is simple and reciprocally.

Here also, the analysis of the database can give us clues for the definition of macro representation of gestural units combining two or more articulators for automatic generation and recognition.

7. CONCLUSION

From the study we have conducted on 1257 lexical sign in a LSF dictionary, we have obtained several kinds of result.

The first one is related to the status of the classical four manual parameters. In the context of dictionaries, if handshape and location can be described by giving a value chosen in a predefined list, even considering the dynamic side of these parameters, this is not the case of the orientation. That means that this parameter cannot be considered at the same level than the others and much more work must be done on this topic.

The second kind is related to the occurrences of the values for each parameter. This allows us to design our processing tools in an iterative way, beginning to represent the most frequent phenomena, and to design more discriminante representations.

The third one is related to the interdependences between the parameters. The properties of interdependency that we can extract from the database can be of great help in the design of constraints, allowing us to design a simpler description of signs in a processing system by the way of macro representations combining two or more articulators.

Finally, this study give us the feeling that new studies should be achieved on the description of lexical signs, allowing a more accurate and synthetic representation for SL processing, such as in (Filhol, 2006).

This database is being extended to allow more descriptions on other articulatory phenomena, regarding the elbow and the shoulder, and more descriptions about the iconic intent in the realization of signs.

8. REFERENCES

Bowden R, Windridge D, Kadir T, et al.. (2004). A Linguistic Feature Vector for the Visual Interpretation of Sign Language, In Pajdla, Matas (Eds), Proc. 8th European Conference on Computer Vision, ECCV04. LNCS3022, Springer-Verlag, Volume 1, pp391- 401.

Braffort, A. (1996). Reconnaissance et compréhension de gestes, applicationà la langue des signes. Thèse de Doctorat en Informatique (PhD thesis). Université Paris-sud, Centre d'Orsay.

Cuxac, C. (2000). La Langue des Signes Française (LSF). Les voies de l'iconicité. Faits de Langues n°15-16, Ophrys.

Filhol M. & Braffort A. (2006). A sequential approach for Sign Description. LREC 2006, Workshop proceedings : Representation and processing of sign languages (in these proceedings).

Hanke, T. (2004). HamNoSys for representing sign language data in language resources and language processing contexts. In: Streiter, Oliver / Vettori, Chiara (eds): LREC 2004, Workshop proceedings: Representation and processing of sign languages. Paris : ELRA - pp. 1-6

Huenerfauth, M. (2004). Spatial Representation of Classifier Predicates for Machine Translation into American Sign Language. In: Workshop on the Representation and Processing of Signed Languages, LREC 2004, Portugal.

Lenseigne, B. and Dalle, P. (2005). A tool for Sign Language Analysis through Signing Space representation. In: Sign Language Linguistics and the Application of Information Technology to Sign Languages, Milan, Italie

Moody, B. Moody B. (1986). La langue des signes. Dictionnaire bilingue élémentaire. vol.2, IVT, Paris.