A Multilingual Multimedia Indian Sign Language Dictionary Tool

Tirthankar Dasgupta
IIT, Kharagpur
tirtha@iitkgp.ernet.in

Sambit Shukla
NIT, Rourkela
sks.at.nit@gmail.com

Sandeep Kumar
NIT, Allahabad
mnnit.sandeep@gmail.com

Synny Diwakar
NIT, Suratkal
sunny.diwakarnitk@gmail.com

Anupam Basu
IIT, Kharagpur
Anupam-bas@gmail.com

Abstract

This paper presents a cross platform multilingual multimedia Indian Sign Language (ISL) dictionary building tool. ISL is a linguistically under-investigated language with no source of well documented electronic data. Research on ISL linguistics also gets hindered due to a lack of ISL knowledge and the unavailability of any educational tools. Our system can be used to associate signs corresponding to a given text. The current system also facilitates the phonological annotation of Indian signs in the form of HamNoSys structure. The generated HamNoSys string can be given as input to an avatar module to produce an animated sign representation.

1 Introduction

A sign language is a visual-gesture language that uses hand, arm, body, and face to convey thoughts and meanings. It is a language that is commonly developed in deaf communities, which includes deaf people, their friends and families as well as people who are hard of hearing. Despite common misconceptions, sign languages are complete natural languages, with their own syntax and grammar. However, sign languages are not universal. As is the case in spoken language, every country has got its own sign language with high degree of grammatical variations.

The sign language used in India is commonly known as Indian Sign Language (henceforth called ISL). However, it has been argued that possibly the same SL is used in Nepal, Sri Lanka, Bangladesh, and border regions of Pakistan (Zeshan et al., 2004). Different dialects of ISL with broad lexical variation are found in different parts of the Indian subcontinent. However, the grammatical structure is same for all dialects (Zeshan, 2003).

The All India Federation of the Deaf estimates around 4 million deaf people and more than 10 million hard of hearing people in India (Zeshan et al, 2004). Studies revealed that, one out of every five deaf people in the world are from India. More than 1 million deaf adults and around 0.5 million deaf children uses Indian Sign Language as a mode of communication (Zeshan et al, 2004). However, an UNESCO report (1980) found that only 5% of the deaf get any education in India. The reason behind such a low literacy rate can be due to the following reasons: a) Till the early 20th century, deafness in India, is considered as a punishment for sins and signing is strictly discouraged (Zeshan et. al, 2004). b) Until the late 1970’s, it has been believed that, there were no such language called ISL. c) Lack of research in ISL linguistics. d) Unavailability of well documented and annotated ISL lexicon. e) Unavailability of any ISL learning tool. f) Difficulties in getting sign language interpreters.

Linguistic studies on ISL were started around 1978 and it has been found that ISL is a complete natural language, instigated in India, having its own morphology, phonology, syntax, and grammar (Vasishta et. al, 1978; Zeshan et.al, 2004). The research on ISL linguistics and phonological studies get hindered due to lack of linguistically annotated and well documented ISL data. A dictionary of around 1000 signs in four different regional varieties was released (Vasishta et.al,
However, these signs are based on graphical icons which are not only difficult to understand but also lack phonological features like movements and non-manual expressions. As it has been specified above, ISL is not only used by the deaf people but also by the hearing parents of the deaf children, the hearing children of deaf adults and hearing deaf educators (Zeshan et al, 2004). Therefore the need to build a system that can associate signs to the words of spoken language, and which can further be used to learn ISL, is significant. Further associating signs of different SL (like ASL\textsuperscript{1}, BSL\textsuperscript{2} and ISL) to a word will help the user to learn foreign SLs simultaneously.

Several works have been done on building multimedia-based foreign SL dictionaries as discussed in (Buttussi et. al., 2007). However no such system is currently available for ISL. moreover, most of the current systems suffer from the following limitations:

- Most of the systems are native language specific and hence, cannot be used for ISL.
- Most of the systems provide a word-sign search but very few systems provide a sign-word or sign-sign search.
- Very few systems are cross platform.
- Systems lack sophisticated phonological information like hand-shape, orientations, movements, and non-manual signs.

In order to overcome the above mentioned crisis, and based on the limitations of the current systems, our objective is to:

- Build a cross platform multilingual multimedia SL-Dictionary tool which can be used to create a large SL lexicon.
- This tool can be used to associate signs to the words, phrases, or sentences of a spoken language text.
- The sign associated with each word is composed of its related part-of-speech and semantic senses.
- The input text (word, phrase, or a sentence) may be in any language (like English or Hindi) and the associated sign can be in any standard sign language (ASL or ISL).
- This tool can also be used to associate complex SL phonological features like hand shape, palm orientation, locations, movements, and non-manual expressions.

The organization of the paper is as follows: Section 2 gives a brief introduction to ISL phonology. Section 3 presents related works on ISL Dictionary. Section 4 presents the overall system architecture of the SL-dictionary tool. Section 5 and 6 presents a brief discussion related HamNoSys representation, and the HamNoSys editor. Section 7 presents conclusion and future work.

### 2 ISL Phonology

Indian Sign Language (ISL) is a visual-spatial language which provides linguistic information using hands, arms, face, and head/body postures. The signer often uses the 3D space around his body to describe an event (Zeshan, 2003). Unlike spoken languages where the communication medium is dependent on sound, in sign language, the communication medium depends upon the visual channel. In spoken language, a word is composed of phonemes. Two words can be distinguished by at least one phoneme. In SL, a sign is composed of cheremes\textsuperscript{3} and similarly two signs can differ by at least one chereme (Stokoe, 1978). A sign is a sequential or parallel construction of its manual and non-manual cheremes. A manual chereme can be defined by several parameters like:

- Hand shape.
- Hand location
- Orientation.
- Movements (straight, circular or curved)

\textsuperscript{1} ASL: American Sign Language.
\textsuperscript{2} BSL: British Sign Language.
\textsuperscript{3} The term chereme (originally proposed by William Stokoe (Stokoe, 1978)) in Greek means “hand”. It is equivalent to the phonemes of spoken languages.
Non-manual cheremes are defined by:
- Facial expressions.
- Eye gaze and Head/body posture (Zeshan, 2003).

However, there exist some signs which may contain only manual or non-manual components. For example, the sign “Yes” is signed by vertical head nod and it has no manual component.

ISL signs can be generally classified into three classes: One handed, two handed, and non-manual signs. Fig. 1 shows the overall Indian sign hierarchy.

One handed signs: the one handed signs are represented by a single dominating hand. One handed signs can be either static or movement related. Each of the static and movement signs is further classified into manual and non-manual signs. Fig. 2 shows examples of one handed static signs with non-manual and manual components.

Two hand signs: As in the case of one hand signs, similar classification can be applied to two handed signs. However, two handed signs with movements can be further distinguished as:
- Type0: Signs where both hands are active (see Fig 3).
- Type1: Signs where one hand (dominant) is more active compared to the other hand (non-dominant) as shown in Fig 3.

3 Related works on ISL dictionary

Linguistic studies on ISL are in their infancy as compared to other natural languages like English, Hindi, or Bengali and also to other SLs. Linguistic work on ISL began during late 1970’s. Before that, the existence of ISL was not acknowledged. In 1977 a survey was conducted (see Vasistha et al., 1998 for documentation) and it was revealed that ISL is a complete natural language instigated at the Indian subcontinent. Vasistha collected signs from four major states of India (Delhi, Mumbai, Kolkata, and Bangalore) and released four dictionaries of ISL regional varieties. The Ramkrishna Mission vidyalaya, Coimbatore has published another ISL dictionary in 2001. However, all these dictionaries are based on iconic representations of signs. As a result some of the important phonological information like, movements and non-manual expression gets lost. No other work of its kind has so far been reported (Zeshan, 2004). Several works have been done in building ASL and BSL dictionary tools. Some of the systems are briefly discussed below:
- (Wilcox et al., 1994) developed a multimedia ASL dictionary tool, which prerecorded digital video frames.
- (Geitz et al., 1996) developed a VRML based ASL finger spelled system, which ran on internet.
- Sign Smith (VCOM3D, 2004) is a 3D illustrated dictionary of ASL. It is also used as educational software as well as an authoring tool to create ASL content.
- (Buttussi et al., 2007) proposes an Italian Sign Language dictionary tool. This tool uses H-animator to generate signing avatar. This tool provides multiple search functionality like word-sign, sign-word, and sign-sign search. This tool also facilitates association of one or more SL for a given input word.
4 SL-Dictionary

The primary objective of the SL-dictionary tool is to provide an easy to use GUI to create a multilingual multimedia SL dictionary by which a user can associate signs as well as the parameters defining a sign, corresponding to a given text. The overall architecture of the system is shown in Fig. 4. The system has been divided into two modules: a) Expert module and b) User Module.

The expert module has got three main units: a) Input Text Processing Unit b) Visual Data Capture Unit (VDCU) c) Sign Storage Unit and d) HamNoSys Editor.

*Input Text Processing Unit*: In this unit a SL expert chooses the input spoken language (like, English, or Hindi) and the target sign language (like, ISL, or ASL) and then enters a text. The input to the system may be word, phrase, or sentences. If the text is a word the system generates all possible meanings, with the help of WordNet\(^4\), along with the part of speech (POS)\(^5\) of that particular word. In order to get the exact part-of-speech of a word, the SL expert has to enter an example sentence corresponding to that word. This sentence is given as an input to the POS-tagger to get the correct POS of the word. A word may have multiple senses as returned by WordNet. The user can select one or more senses from the list.

*Visual Data Capture Unit*: Sign corresponding to a word sense is signed by the user which is captured by the Visual Data Capture Unit (VDCU). The VDCU is connected through multiple webcams, placed at different angular positions with respect to the signer. As a result different articulation points of a signs are getting stored with in the database. This will enable the SL learner to understand a particular sign easily. Fig.5 shows how a sign from multiple angles is getting captured.

*Storage Unit*: The input text along with its annotated information, the digital video sign, and the phonological parameters defining the sign are stored with in a database which is further exported into an XML formatted file (see Fig. 6). The phonological parameters are expressed in the form of HamNoSys (discussed in section 5).

---

\(^4\) wordnet.princeton.edu/

\(^5\) We have used the Stanford Part-of-Speech tagger (nlp.stanford.edu/software/tagger.shtml)

*Searching*: The search engine of the current system takes a spoken language text as input parses the XML formatted dictionary and sequentially searches the dictionary. If a match is found, then
the sign corresponding to the lexical entry is being displayed.

5 Sign language notation systems

As it has been mentioned above, Sign language does not have any written form. Hence, in order to define a sign we need some notation system. There are a number of phonological notation systems for the representation of SL as discussed in (Smith et.al, 2003). One of the popular among them is Stokoe notation (Stokoe, 2003; Smith et.al, 2003). Stokoe defines a sign by three parameters: a) Hand-shape or designator (dez) b) location or place of articulation with respect to the body (tab) and c) movements or signation (sig).

HamNoSys (Prillwitz et. al, 1989) is a phonetic transcription system, based on Stokoe notation, used to transcribe signing gestures. It is a syntactic representation of a sign to facilitate computer processing. HamNoSys extends the traditional Stokoe based notation system by further expanding sign representation by some more parameters. These parameters can be defined as:

- Dominant hand’s shape.
- Location of the dominant and the non-dominant hand with respect to the body.
- Extended finger orientation of both dominant and non-dominant hand.
- Palm orientation of both hands.
- Movements (straight, circular, or curved)
- Non-manual signs.

Fig. 7 shows examples of different HamNoSys symbols and their descriptions.

| Symbol | Description                  |
|--------|------------------------------|
| d      | index finger stretched       |
| e      | extended finger ahead        |
| 0      | palm oriented left           |
| 5      | location shoulder height     |
| e      | fully stretched out          |
| t      | hand move ahead              |
| r      | hand move right              |

Fig. 7: HamNoSys symbols and their descriptions

Fig. 8 shows an example where HamNoSys representation of the word “WOMAN” is explained. Here, the parameters like movement and non-manual signs are not present, as the sign “WOMAN” in ISL does not have these expressions. Fig. 9 shows the ISL representation of “WOMAN”.

6 HamNoSys Editor

Transcribing a sign by HamNoSys is not a trivial task. A user who is transcribing a sign should be an expert in both HamNoSys as well as ISL. Moreover he has to remember all the HamNoSys symbols and their corresponding meanings in order to define a sign. In India it is very difficult to find such a person. Hence our main goal behind building a HamNoSys editor is that, it can be used by an ISL expert with little or no knowledge in HamNoSys. The tool should provide an easy to use GUI that can be used to transcribe phonological information of a sign.

The HamNoSys editor provides a set of graphical images (most of the images are collected from www.sign-lang.uni-amburg.de/Projekte/HamNoSys) for most of the phonological parameters of a sign, like, Hand-shape, orientation, location and movements. Based on the parameters, an ISL expert can choose a set of images and the system will automatically generate the corresponding HamNoSys of the sign. This HamNoSys string can be given as an input to a signing avatar module to generate animated sign representation.

A signing avatar is a virtual human character that performs sign language. However, this character needs a set of instructions which will guide its movement. These instructions can be provided in the form of HamNoSys (Marshall and Sáfár, 2001).
Fig. 10: HamNoSys Parameters

Fig. 11: Twelve basic hand-shape classes

Fig. 12: GUI to express finger and palm orientations

Fig. 13: GUI to choose various hand locations near the human face
Fig.10 shows the five basic parameters of HamNoSys. For each of these parameters there exist interfaces through which a SL expert can choose the desired parameters to define a sign. For example, the right hand side of Fig.11 shows the twelve basic hand-shape classes. Each of these base hand-shapes may contain several derived hand-shapes as defined in HamNoSys (version 4.0). If a particular hand-shape is selected, then the HamNoSys symbol corresponding to the hand-shape gets stored in the XML database (see Fig.6). Similarly, separate interfaces have been provided to identify palm orientation (see Fig.12), hand location (see Fig.13), movements (see Fig.14), and non-manual signs.

Due to its symbolic structure, HamNoSys is fairly easy to write, and understand. However, there are some drawbacks on this notation system that make it difficult to be used universally for all sign languages (Smith and Edmondson, 2004). For example, HamNoSys uses some fixed set of symbols to define a sign however it is possible that a particular sign in any sign language may not be defined by the fixed set of symbols. For example HamNoSys does not have well defined symbols for non-manual expressions. Consider the sign “BITTER”, in ISL the representation is shown in Fig.15. It can be observed that it is very difficult to represent the facial expressions like eyebrow by HamNoSys. Currently we have a collection of around 979 sign icons (published by Vasistha et. al 1998), which we are trying to transcribe in HamNoSys. Out of these, 16% of the signs contain non-manual features which we are unable to represent in HamNoSys.

**Fig.15: ISL representation of "BITTER"**

### 7 Conclusion and Future works

The paper presents an approach towards building a multimedia SL dictionary tool. This tool can be used to prepare a well documented ISL dictionary. The system is intended to take any Indian language text as input and can store signs in any SL. Currently the system takes English, Hindi and Bengali texts as input and can store signs in ISL only. The system also provides an easy to use GUI.
to include phonological information of a sign in the form of HamNoSys string. The generated HamNoSys string can then be used as an input to the signing avatar module to produce animated sign output.

In the next phase of our work we will improve the system so that it can associate signs in any other SL (like, ASL and BSL). Further, WordNet as well as POS Tagger corresponding to Hindi and Bengali languages should also be integrated with the system. Also, support has to be built so that system can perform sign-to-word and sign to sign search. We will also perform proper evaluation of the HamNoSys editor in order to understand its utility to the SL user.

References

Buttussi F., Chittaro L., Coppo M. 2007. Using Web3D technologies for visualization and search of signs in an international sign language dictionary. Proceedings of the twelfth international conference on 3D web technology. Perugia, Italy Pages: 61 – 70 Year of Publication: 2007 ISBN:978-1-59593-652-3

Geitz, S., Hanson, T., Maher, S. 1996. Computer generated 3-dimensional models of manual alphabet handshapes for the World Wide Web. In Assets ‘96: Proceedings of the second annual ACM conference on Assistive technologies, ACM Press, New York, NY, USA, 27–31.

Marshall I. and Sáfár Ő. 2001.Extraction of semantic representations from syntactic SMU link grammar linkages.. In G. Angelova, editor, Proceedings of Recent Advances in Natural Language Processing, pp: 154-159, Tzigov Chark, Bulgaria, September.

Prillwitz P., Regina Leven, Heiko Zienert, Thomas Hamke, and Jan Hemming. 1989. HamNoSys Version 2.0: Hamburg Notation System for Sign Languages: An Introductory Guide, volume 5 of International Studies on Sign Language and Communication of the Deaf. Signum Press, Hamburg, Germany,

Smith G., Angus. 1999. English to American Sign Language machine translation of weather reports. Proceedings of the Second High Desert Student Conference in Linguistics.

Smith,K.C., Edmondson, W. 2004. The Development of a Computational Notation for Synthesis of Sign and Gesture, GW03(312-323).

Speers, A. 1995. SL-Corpus: A computer tool for sign language corpora., Georgetown University.

Stokoe W. C., 1960. Sign language structure: an outline of the visual communication systems of the American deaf. 2nd edition, 1978. Silver Spring, MD: Linstok Press.

VCOM3D,2004. Sign smith products. http://www.vcom3d.com.

Wilcox, S., Scheibman, J., Wood, D., Cokely, D., and stokoe, w. c. 1994. Multimedia dictionary of American Sign Language. In Assets ’94: Proceedings of the first annual ACM conference on Assistive technologies, ACM Press, New York, NY, USA, 9–16.

Vasishta M., Woodward J., DeSantis S. 1998, “An Introduction to Indian Sign Language”, All India Federation of the Deaf (Third Edition).

Zeshan U., 2003,”Indo-Pakistani Sign Language Grammar: A Typological Outline”, Sign Language Studies - Volume 3, Number 2, , pp. 157-212

Zeshan U., Madan M. Vasishta, Sethna M. 2004, “implementation of indian sign language in educational settings”- Volume 15, Number 2, Asia Pacific Disability Rehabilitation Journal, , pp. 15-35