Prototype Machine Translation System From Text-To-Indian Sign Language

Tirthankar Dasgupta
Indian Institute of Technology, Kharagpur
tirtha@cse.iitkgp.ernet.in

Anupam Basu
Indian Institute of Technology, Kharagpur
Anupam.basu@iitkgp.ac.in

ABSTRACT
This paper presents a prototype Text-To-Indian Sign Language (ISL) translation system. The system will help dissemination of information to the deaf people in India. This paper also presents the SL-dictionary tool, which can be used to create bilingual ISL dictionary and can store ISL phonological information.

ACM Classification Keywords
NLP, Machine Translation, Indian Sign Language, HamNoSys, sign language dictionary

INTRODUCTION
It has been estimated that, one out of every five deaf people in the world is from India. More than 1.5 million deaf people in India use Indian Sign Language (henceforth called ISL) as a mode of communication [2]. 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 [2].

Due to the inherent difficulty in accessing information through common broadcast modes like television and radio, communication for a deaf in places like railway, bank, and hospitals is difficult. Hence, an automatic Text-to-ISL translation system could help to make more information and services accessible to the deaf community. Moreover, the system will not only improve information access, but it can also be used as an educational tool to learn ISL.

Several MT systems from English to foreign SL (like ASL, and BSL) already exist as discussed in [4]. However these systems cannot be directly used for ISL translation, as ISL does not relate to other SLs of either Asia or Europe [3]. This is the prime motivation behind building a generic English Text-to-ISL machine translation system.

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, to republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee.

Research on building ISL MT systems is still in its infancy. This crisis may be due to several reasons like: a) Until late 1970’s existence of ISL was not acknowledged. b) Lack of linguistic research on ISL. c) Unavailability of well documented ISL lexicon and learning tools.

In order to overcome the above mention problems, our objective is to present a prototype English-to-ISL generic machine translation system. Currently the system takes simple English sentences as input and generates ISL-gloss, which may then be converted into the Hamburg Notation System (HamNoSys) [6]. The HamNoSys representation will provide signing instructions to the sign synthesis module, to generate an animated representation of ISL to the user. The paper also focuses on building an ISL dictionary tool, which can be used to create large ISL bilingual lexicon.

ISL LINGUISTIC ISSUES
Indian Sign Language (ISL) is a visual-spatial language which provides linguistic information using hands, arms, face, and head/body postures. A sign is a sequential or parallel construction of its manual and non-manual components. A manual component can be defined by several parameters like hand shape, orientation, position, and movements [8] where as non-manual components are defined by facial expressions, eye gaze, and head/body posture [3]. The ISL open lexicon can be classified as: i) Signs whose place of articulation are fixed, ii) Signs whose place of articulation can change and iii) Directional signs, where there is a movement between two points in space. Apart from the directional signs, ISL morphology is mostly derivational in nature and there are no affixes in signs. The closed lexical class contains classifier hand shapes, discourse markers, and non-manual signs [3]. A classifier hand shape contains specification related to hand configuration that represents the characteristics of a referent. The ISL discourse structure is classified into manual and non-manual markers. Manual discourse markers can occur either in clause final position (as in, “it’s over, what else we can do?”) or in clause initial position (like, “well, I have nothing to say”). The non-manual marker like “head nodding” occurs only in clause final position after the last manual sign of the clause.

Settling for a less than perfect model may be the only way to improve on the current situation.
ISL MT ARCHITECTURE
The system architecture of the proposed English Text-to-ISL MT system is composed of the following four essential modules (see Figure 1):

1. Input text preprocessor and parser
2. LFG f-structure representation
3. ISL Sentence Generation
4. ISL synthesis

ISL Sentence Generation
The English f-structure is converted to ISL f-structure by applying proper transfer grammar rules. The two main operations that are performed during the generation phase are: a) Lexical selection and b) Word order correspondence.

Lexical selection is done using an English-ISL bilingual lexicon. For example, word like “Dinner” in English is replaced by “NIGHT FOOD” in ISL and “Mumbai” is replaced by the sign of “BOMBAY”.

**English:** “I had dinner with Sita”

**ISL:** “I SITA WITH NIGHT FOOD FINISH”

ISL has essentially a Subject-Object-Verb word order (unlike English, which is Subject-Verb-Object). For Example, (2) shows the change in word order from English to ISL.

(2) **English:** “I have a computer”

**ISL:** “I COMPUTER HAVE”.

However, in some cases the sign sentence depends upon the directionality of the verb as in (3).

(3) **English:** “I help you”

**ISL:** “Self HELP Front”

SYSTEM EVALUATION
There are several standard techniques for evaluating a text-to-Text MT system. However, due to the visual-spatial modality of ISL, these techniques cannot be used for Text-ISL MT systems. Our current evaluation is based upon the feedbacks of different ISL experts. The generated output of the system is shown to the ISL experts and is identified as either valid or invalid according to their understandability and quality. The system was evaluated on a set of 208 sentences\(^1\). Table 1.1 summarizes the performance of the system. The overall system performance is around 89%. Most of the errors are due to compound sentences and directional verbs\(^2\).

| Number of Sentences | Accuracy (%) |
|---------------------|--------------|
| Overall Corpus size | 208          | 89.4         |
| Sentences without directional verbs | 193 | 96.37 |
| Sentences without compound constructions | 201 | 92.53 |

Table 1.1: Evaluation Results

\(^1\) Corpus collected from “A’ level Introductory course in Indian Sign Language” Work Book AYJNIHH.

\(^2\) Verbs corresponding to directional signs.
To understand the relative performance of the system on the simple sentences, we conducted two experiments removing compound construction and directional verbs. From the current experimental set up, 7% errors are propagated due to directional verbs and around 4% errors are due to compound constructions.

### SL-DICTIONARY

The research on ISL linguistics and phonological studies is getting hindered due to lack of linguistically annotated and well-documented ISL data. A dictionary of around 1000 signs in four different regional varieties were released [1]. However, these signs are based on graphical icons which are not only difficult to understand but also lacks phonological features like movements and non-manual expressions. Therefore, the need to build an electronic SL dictionary that can associate signs to the words of spoken language, and can also be used to learn a SL, is significant.

Several works has been done on building a multimedia based foreign SL dictionary as discussed in [7]. However no such system is currently available for ISL. Based on the limitations of the current systems, we propose the SL-Dictionary whose main 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 also be used to associate complex SL phonological features like hand shape, palm orientation, locations, movements, and non-manual expressions.

### SYSTEM ARCHITECTURE

The architecture of the SL dictionary tool has been illustrated in Figure 2. The system has two modules: a) Expert module and b) User Module.

The input to the system may be a word, phrase, or a sentence. If the input is a word, the system identifies all possible semantic sense of the word using a wordnet[^3], along with the part of speech (POS)[^4] of that word. In the Visual Data Capture Unit (VDCU), a SL expert records a sign corresponding to a particular word sense. The VDCU is connected through multiple web cams, placed at different angular positions with respect to the signer. This facilitates a user to view the different articulation points of a sign. The input text, the digital video sign, and the phonological parameters defining the sign along with its annotated information are stored with in an XML formatted file. The user module provides both the option of word-sign search as well as sign-word search. In the sign-word search provides sign parameters (like hand-shape, location, and movements) in the form of HamNoSys [6].

![Figure 2: System Architecture of SL-Dictionary](image)

### HAMNOSYS: SL NOTATION SYSTEM

HamNoSys is a phonetic transcription system, used to transcribe signing gestures. A sign can be defined by several parameters like:

- Dominant hand’s shape.
- Location of the dominant hand.
- Extended finger and palm orientation
- Movements (straight, circular, or curved)
- Non-manual signs.

### 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 SL. Moreover he has to remember all the HamNoSys symbols and there corresponding meanings in order to define a sign. The objective behind building a HamNoSys editor is that, it can be used by an ISL expert with little or no knowledge in HamNoSys. The editor provides a set of graphical images (collected from [www.sign-lang.uni-amburg.de/Projekte/HamNoSys](http://www.sign-lang.uni-amburg.de/Projekte/HamNoSys)) for the phonological parameters of a sign. Based on these parameters the system will automatically generate the corresponding HamNoSys of the sign. This HamNoSys string may be given as an input to a signing avatar module to generate animated sign representation.

Figure 3 shows the basic hand-shape classes. Each of these base hand-shapes may contain several derived hand-shapes as defined in HamNoSys (version 4.0). For a particular hand-shape there may exist a specific hand location and

[^3]: [wordnet.princeton.edu](http://wordnet.princeton.edu)
[^4]: [nlp.stanford.edu/software/tagger.shtml](http://nlp.stanford.edu/software/tagger.shtml)
finger or palm orientation, which may be identified as shown in Figure 4 and Figure 5.

Due to its symbolic structure, HamNoSys is easy to write, and understand. However, there are some drawbacks on this notation system which makes it difficult to be used universally for all sign languages. For example, HamNoSys uses some fixed set of symbols to define a sign. However, it is possible that a particular sign in a sign language cannot be defined by the fixed set of symbols. For example, HamNoSys does not have well defined symbols for non-manual expressions.

CONCLUSION AND FUTURE WORKS

The first part of the paper presents a prototype text to ISL translation system. The approach uses LFG f-structure to represent ISL syntax. As ISL does not have any written form, there is no standard source of ISL corpus. Hence, statistical MT methods are not feasible under such a condition. The sign synthesis module using an animated avatar has not been developed yet. We generate ISL output using pre-recorded ISL videos. Further morphological functionalities like, discourse, directionality, and classifier predicates are handled minimally.

In the next stage of our work, we will try to develop the sign annotation tool and finally, a larger corpus will be built for a better evaluation and results.

REFERENCES

1. Vasishta M., Woodward J., DeSantis D., 1998, “An Introduction to Indian Sign Language”, All India Federation of the Deaf (Third Edition).
2. Zeshan U., 2003, “Indo-Pakistani Sign Language Grammar: A Typological Outline”, Sign Language Studies – Vol. 3, Number 2, pp. 157-212
3. Zeshan U., Vasishta M., Sethna M. 2004, “implementation of indian sign language in educational settings”- Vol. 15, Number 2, Asia Pacific Disability Rehabilitation Journal, pp. 15-35
4. Huenerfauth M. 2003. A Survey and Critique of American Sign Language Natural Language Generation and Machine Translation Systems. Technical Report MS-CIS-03-32, Computer and Information Science, University of Pennsylvania.
5. Lin D. 1998. Dependency-based evaluation of minipar. In Workshop on the Evaluation of Parsing Systems, Granada, Spain,
6. Prillwitz S.,Leven R.,Zienert H.,Hamke T. and Henning J.1989. HamNoSys Version 2.0: Hamburg Notation System for Sign Languages: An Introductory Guide, vol. 5 International studies on sign language & communication of the deaf. Hamburg, Germany,
7. 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.
8. Stokoe W. C. 1960. Sign language structure: An outline of the visual communication systems of the American deaf. 2nd edition.