

Automatic Translation of English Text to Indian Sign Language Synthetic Animations

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Abstract

This article presents the prototype for English Text to Indian Sign Language conversion system using synthetic animations in real domain. The translation system consists of parsing module which parses the input English sentence to phrase structure grammar representation on which Indian sign language grammar rules are applied to reorder the words of the English sentence (as the grammar of English language and Indian sign language is different). Elimination module eliminates the unwanted words from the reordered sentence. Lemmatization is applied to convert the words into the root form as the Indian sign language does not use the inflections of the words. All the words of the sentence are then checked into lexicon which contains the English word with its HamNoSys notation and the words that are not in the lexicon are replaced by their synonym. The words of the sentence are replaced by their counter HamNoSys code. In case the word is not present in the lexicon, HamNoSys code will be taken for each alphabet of the word. The HamNoSys code is converted into the SiGML tags and this SiGML tags are sent to animation module which converts the SiGML code into the synthetic animation using avatar.

The proposed system is innovative as the existing working systems uses videos rather than synthetic animations. Even the existing systems are limited to conversion of words and predefined sentences into Indian sign language whereas our proposed system converts the English sentences into Indian sign language in real domain.

1 Introduction

There are approximately 7105 known living languages in the world divided in 136 different language families. Sign language is one of these 136 families which is used by hearing impaired people to convey their message. This family of the language contains 136 sign languages all over the world depending upon the region of the world. Out of nearly 7 billion people on earth, nearly 72 million are deaf and hard of hearing. Out of such a big number approximately 4.3 million such people use Sign language. Rest of nearly 67 million deaf and hard of hearing people do not use any sign language to communicate. Thus nearly 90% deaf have a very limited or no access to education and other information [1, 2].

Sign language is used by hearing impaired people using hand shapes, fingers, face expressions, gestures and other parts of the body [1]. It is a **visual-spatial** language as the signer often uses the 3D space around his body to describe an event [5]. As sign languages do not have well defined structure or grammar therefore there is no or very less acceptability of these signs outside their small world. Sign languages until the 1960s were not viewed as bona fide languages, but just collections of gestures and mime. Dr. Stokoe's research on American Sign Language proved that it is a full-fledged language with its own grammar, syntax, and other linguistic attributes. To prove the same for other sign languages, there are some efforts including Indian Sign Language [3].

In spoken language, a word is composed of phonemes. Two words can be distinguished by

at least one phoneme (while speaking a pause and while writing a space). In SL, a sign is composed of cheremes (equivalent to phoneme in a spoken language) and similarly two signs can differ by at least one chereme [6]. 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, Hand Orientation, Hand Movements (straight, circular or curved). Non-manual cheremes are defined by parameters like Facial expressions, Eye gaze and Head/body posture [5].

However, there exist some signs which may contain only manual or only non-manual components. For example the sign “Yes” is signed by vertical head nod and it has no manual component. SL signs can be generally classified into three classes: One handed, two handed, and non-manual signs. Figure shows the overall Indian sign hierarchy.

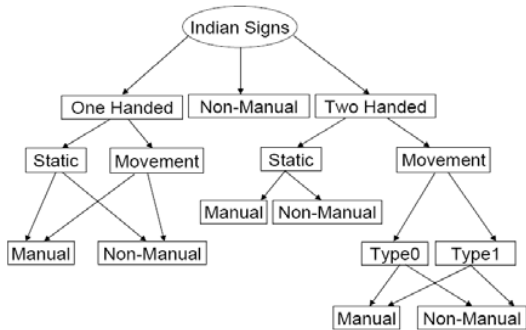


Figure 1. ISL Type Hierarchy

One Handed Signs: The one handed signs are represented by a single dominating hand. One handed signs can be either static or dynamic (having movements). Each of the static and movement signs is further classified into manual and non-manual signs. Figure shows examples of one handed static signs with non-manual and manual components.



Figure 2. One Handed Static Manual Sign (Ear) and Non-Manual Sign (Headache)

Two Handed Signs: The two handed signs are represented by both the hands of the signer. As in the case of one handed signs, similar classification can be applied to two handed signs. However, two handed signs with movements can be further distinguished as: Type0 and Type1 signs.

Type0 signs are those where both hands are active

Type1 signs are those where one hand (dominant) is more active compared to the other hand (non-dominant) as shown below.

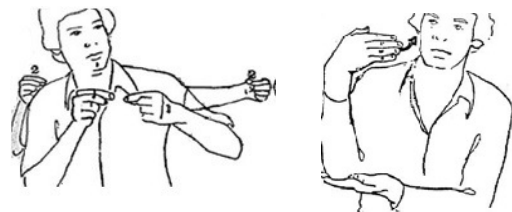


Figure 3. Two Handed Sign "long"(both the hands are moving) and "Flag" (only the dominant right hand is moving)

Communication for the hearing impaired people in common places like railway stations, bus stands, banks, hospitals etc. is very difficult because a hearing person may not understand the sign language used by the hearing impaired person to communicate. Also, a hearing person cannot convey any message to hearing impaired person as he/she may not know the sign language.

To make the communication between hearing impaired and hearing community, the language translation is must that may include,



Figure 4: Communication between Hearing and Hearing Impaired Community

This is worth mentioning here that Sign languages are not “Natural languages represented through signs” or not even **translated word to word** in signs. For example, the word light in English has different meanings. Light means not heavy, or

we say light color i.e. not dark or switch on the light. Here, we represent these different meanings in English with same word 'light' but in sign language, we will represent these different meanings with different signs. So, Sign language is not representation of word as it is but rather the meanings are represented using Sign language.

So we interpret that Sign language and **Signed Language** are different. Signed Language is any other natural language for which signs are created for every word. Signed English has word order of English only and every word of English is represented using signs. The problem with this approach is that it is very slow because signing every word takes time and if speech and the Signed English both are being communicated at the same time, Signed English will be much behind the actual words spoken in English [3]. Another type of sign mechanism exists, known as **Sign Supported English**. Sign Supported English does not display sign for each word and only signs are displayed for some important words of the speech and rest of the sentence is spoken only.

Yet another type is **Finger Spelling** where instead of having the symbols for words, fingers are used to show the letters, which make the word. This form is merged with any other form of Sign Language because of limited dictionary of Sign Language.

An alternative to Sign Language is **Cued Speech**. It uses hand shapes and placement with mouth movements to show the sounds. Considered to be visible counterpart of spoken language, cued speech works by combining visible hand and mouth movements to represent sound just like phonemes are combined in any other natural language. Cued speech represents the individual sounds of words via a system of visual phonetics where as sign language is used to represent a whole word. One advantage cued speech over sign language systems is that the number of different signs to remember is far less than in a sign language because only a few phonemes are to be represented using signs and rest all the words are made up of these phonemes' signs only [4].

2 Facts about Indian Sign language

Sign language is natural language which has some facts with which the people are not aware off. Some of the facts of the sign language are:

- NOT the same all over the world.
- NOT just gestures and pantomime, but do have their own grammar.
- Have much smaller dictionary than the other spoken natural languages.
- Finger-spelling for the unknown words.
- Words may be joined e.g. to represent dinner, one might show the sign of Night and then Food.
- Most of the sign languages put the adjective after the noun e.g. Car Red.
- Never use am/is/are/was/were/ (linking verbs).
- Never use word-endings/suffixes.
- Always sign in the Present Tense.
- Do not use articles. (a, an, some, the).
- Do not use I, but uses me.
- WH-questions are at the END e.g. "You go where?"
- Have no gerunds. (-ing).
- Use non-manual expressions as well e.g. use of eye brows, eye lids, facial expressions, head and shoulders movement.
- NOT been invented by hearing people.

3 Overview of Overall System

The success of the translation system from English text to Indian sign language required lexical and syntactic knowledge of Indian sign language. The lexicon has been created for English word – ISL sign as discussed in the next section. The overall architecture of the system is shown in the figure below. The system consists of 7 modules:

- *English parser for parsing the English text*
- *Sentence reordering module based on ISL grammar rules*

- *Eliminator for eliminating the unwanted words*
- *Lemmatization for getting the root word of each word and Synonym replacement module to replace the unknown word with its synonym counterpart*
- *Word to SiGML conversion using HamNoSys*
- *Synthetic Animation module.*

The input to the system is written English text which is parsed to get the phrase structure grammar representation of the sentence. The parsed sentence is then sent to the conversion module which reorders the words of the English sentence according to the rules of ISL grammar. Reordering is required as English uses SVO order where as ISL uses the SOV order along with some other variations for interrogative and negative sentences. After getting the sentence as per ISL grammar, unwanted words from the sentence are removed. This is because the ISL used only the words which have some meaning and all

the helping words like linking verbs, articles etc are not used. The output is sent to the lemmatization module which converts the words in their root form. This is again because the sign language uses the root form of each word irrespective of other languages which uses suffixes, gerund, past and futures words in their sentences. Because of limited dictionary of ISL, the unknown words in the sentence are replaced with their synonym counterpart, in case the synonym is not available, finger spelling of the word is performed character by character. At this stage, the sentence is ready to animate. Each word of the sentence is replaced by its equivalent HamNoSys (Writing notation of the sign)[8] from the English Word-HamNoSys dictionary and the HamNoSys string is converted to SiGML (Signing gesture markup language) code using SiGML rules. This SiGML code is sent to SiGML animation tool which plays the synthetic animation.

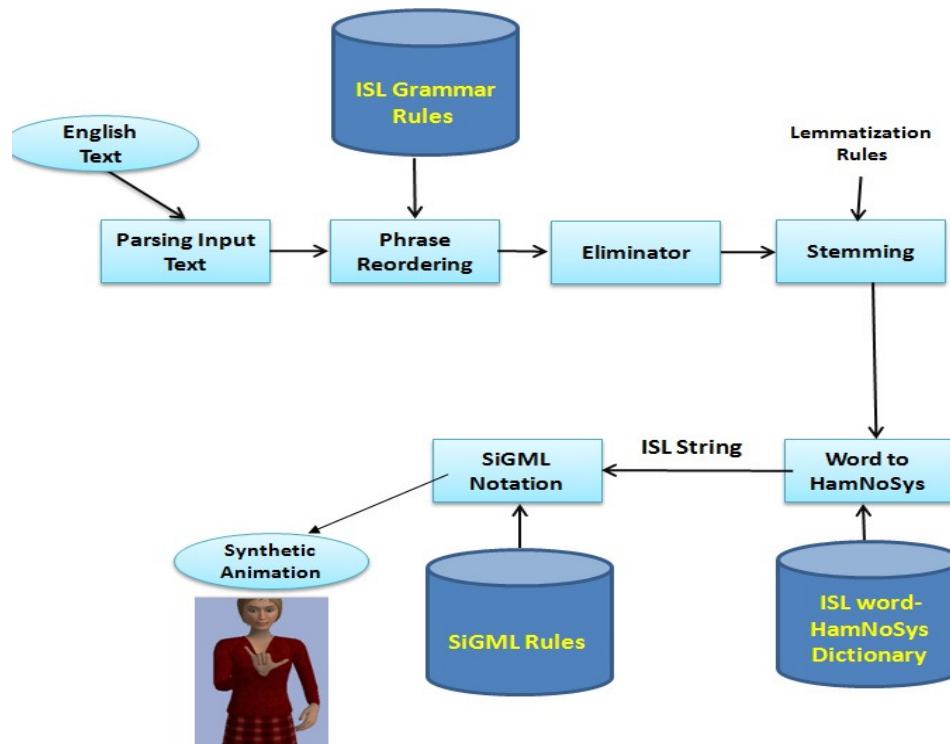


Figure 5: Architecture of English Text to ISL Synthetic Animation System

4 English-ISL Lexicon

Translating from a source language to target language requires a bilingual dictionary. Translating English text to ISL, bilingual dictionary of English and Indian Sign Language is created which contains the English word and its equivalent Indian sign. Here, the English word's counterpart Indian

sign can be taken as the real human video, sign picture, coded sign language text, or synthetic animation. All the approaches have their own pros and cons but the synthetic animations are well suited for the translation of spoken language to sign language. A comparison of all the media has been given in the table as shown:

Table 1: Comparison of Different Media for Representing the Sign

Kind of Media	Pros	Cons
Video Signs	<ul style="list-style-type: none"> • Realistic • Easy to create 	<ul style="list-style-type: none"> • Time consuming to create • High memory consumption • Not supported by translation system
Pictures	<ul style="list-style-type: none"> • Very less memory consumption 	<ul style="list-style-type: none"> • Time consuming to create pictures • Not realistic as compared to videos • Not supported by translation system
Coded Sign Language Text	<ul style="list-style-type: none"> • Minimal Memory consumption • Supported by translation system as it is the written form and can be processed very easily 	<ul style="list-style-type: none"> • Very difficult to read and understand • Required to be learnt
Synthetic Animations	<ul style="list-style-type: none"> • Very less memory consumption • Can be easily reproduced • Supported by translation system • Avatar can be made different according to choice 	<ul style="list-style-type: none"> • Not as realistic as human videos.

Because synthetic animation is supported by the translation system are much realistic as compared to pictures and coded text so synthetic animations have been produced for corresponding English word in this translation system.

To create the animation of each English word, a written form of the sign is taken. Though a 3D sign cannot be written but researchers have put their efforts to create the notation system

with which a 3D sign can be expressed in written form. Some of the written forms for 3D sign are Stokoe Notation[11], SignWriting[12], Hamburg notation System[8] etc. We have used HamNoSys (Hamburg Notation System)[8] notation for creating the dictionary. HamNoSys has an alphabet of about 200 symbols (Unicode of this notation system is available)[8] which covers almost all the hand shapes, Hand location, Hand/palm orientation, Hand movement, and non-Manual

part of the sign. The basic structure of the HamNoSys is:

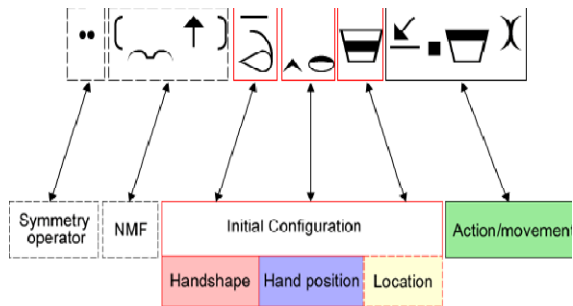


Figure 6: Structure of HamNoSys Code

Later this HamNoSys can be converted into SiGML code which can be animated by an animation tool using an Avatar as shown in the following architecture:

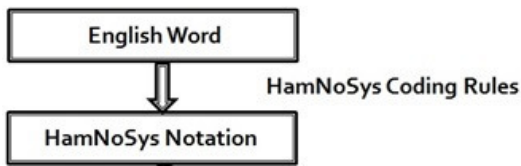


Figure 7: Architecture to produce the animation from English word.

A list of 1818 most commonly used English words[10] used by the differently abled people is taken for creating the bilingual dictionary of English word and HamNoSys notation. The words are categorized in part of speech and a count of 1510 words are coded into HamNoSys as shown in the table[10]:

Table 2: Statistics of Words Implemented

Word Category	No. of Words	No. of Words Implemented
Adjectives	185	177
Adverb	54	54
Conjunction	3	3
Determiner	12	12
Noun	1136	855
Preposition	32	32
Pronoun	33	32
Verb	359	333

5 Parsing of the Input English Sentence

For rule based conversion of one language to another language, grammatical structure of the source language is required so that the words of the source sentence can be reordered as per the grammar rules of the target language. Parsing is the answer to know the grammatical structure of the sentence. To get the grammatical structure of the sentences of English language, parsing is done using third party software. We have used the Stanford parser[7] for this purpose which uses unlexicalized PCFG(probabilistic context free grammar) with output accuracy of 86.36%. Probabilistic parser is trained on the hand-parsed sentences and the knowledge gained is used to parse the new sentences. Stanford parser is capable to produce three different outputs, part-of-speech tagged text, context free phrase structure grammar representation, and type dependency representation. Stanford parser uses Penn Tree tags for parsing the English sentence. In this project, we have used phrase structure grammar representation as in rule based approach, the grammatical structure of the English sentence was required to convert it into the sentence as per the grammatical structure of target language (Indian sign language).

6 Grammar Rules for Conversion of English Sentence to ISL Sentence

Translation of one spoken language to another spoken language is complex task if both the languages have different grammar rules. The complexity is increased many folds when source language is spoken language and the target language is sign language. For translating English text to Indian sign language, a comparison of grammar of both the languages is must:

Table 3: Comparison of Grammar of English and Indian Sign Language

English language grammar	Indian sign language grammar
English grammar is well structured and a lot of research work has been carried out to define the rules for it. English grammar follows the subject-verb-object order.	ISL is invented by deaf and a little work has been done to study the grammar of this language. The structure of sentences of ISL follows the subject-object-verb order[13].
English language uses various forms of verbs and adjectives depending upon the type of the sentence. Also, a lot of inflections of the words are used in English sentences.	ISL does not use any inflections (gerund, suffixes, or other forms), it uses the root form of the word.
English language has much larger dictionary	Indian sign language has a very limited dictionary, approximately 1800 words[10].
Question word in interrogative sentences is at the start in English	In Indian sign language, the question word is always sentence final[1].
A lot of helping verbs, articles, and conjunctions are used in the sentences of English	In Indian sign language, no conjunctions, articles or linking verbs are used

For conversion of English sentence to a sentence as per ISL grammar rules, all the verb patterns (20 patterns)[15] are studied and rules are formed to convert English sentence into ISL sentence. The parsed sentence is the input to this module where the noun phrase and the prepositional phrase are freezed but if there is

any verb phrase present in the sentence, it is checked recursively because the verb phrase may further be composed of noun phrase, prepositional phrase, verb phrase or even the sentence. Some of the rules of conversion are given in the table:

Table 4: Examples of Grammatical Reordering of Words of English Sentence

Verb Pattern	Rule	Input Sentence	Parsed Sentence	Output Sentence
verb + object	VP NP	go school	(VP (VB Go) (NP (NN school)))	school go
subject + verb	NP V	birds fly	(NP (NNS birds)) (VP (VBP fly))	birds fly
subject + verb + subject complement	NP V NP	his brother became a soldier	(NP (PRP\$ his) (NN brother)) (VP (VBD became) (NP (DT a) (NN soldier)))	his brother a soldier became
subject + verb + indirect object + direct object	NP V NP NP	i lent her my pen	(NP (FW i)) (VP (VBD lent) (NP (PRP her)) (NP (PRP\$ my) (NN pen)))	i her my pen lent

subject + verb	subject + verb	show me your hands	(VP (VBP show) (NP (PRP me)) (NP (PRP\$ your) (NNS hands))	me your hands show
<i>subject + verb + direct object + preposition +prepositional object</i>	NP V NP PP	she made coffee for all of us	(NP (PRP She)) (VP (VBD made) (NP (NN coffee)) (PP (IN for) (NP (NP (DT all)) (PP (IN of) (NP (PRP us)))))))	she coffee for all of us made
<i>subject + verb + indirect object + direct object</i>	V NP PP	show your hands to me	(VP (VB show) (NP (PRP\$ your) (NNS hands)) (PP (TO to) (NP (PRP me))))	your hands to me show
<i>subject + verb + preposition prepositional object</i>	NP V PP	we are waiting for suresh	(NP (PRP we)) (VP (VBP are) (VP (VBG waiting) (PP (IN for) (NP (NN suresh)))))	we for suresh are waiting

7 Elimination of Unwanted Words

Indian sign language sentences are formed of main words. All the words like linking verbs, suffixes, articles are not used. After applying the grammar rules, the ISL sentence is generated of which all the unwanted words are required to be removed. The part of speech which are not the part of ISL sentence are detected and eliminated from the sentence. Out of 36 POS tags, the various part of speech which do not form the part of ISL sentence are

TO, POS(possessive ending), MD(Modals), FW(Foreign word), CC(coordinating conjunction), some DT(determiners like a, an, the), JJR, JJS(adjectives, comparative and superlative), NNS, NNPS(nouns plural, proper plural), RP(particles), SYM(symbols), Interjections, non-root verbs. These above mentioned unwanted words are removed from the ISL sentence. Below is the table of examples in which unwanted words are removed.

Table 5: Elimination of unwanted words

Input English Sentence	Sentence after reordering	Output ISL Sentence(After elimination)
go school	school go	go school
birds fly	birds fly	birds fly
his brother became a soldier	his brother a soldier became	his brother soldier become
i lent her my pen	i her my pen lent	i her my pen lent
show me your hands	me your hands show	me your hand show
she made coffee for all of us	she coffee for all of us made	she coffee all we made
show your hands to me	your hands to me show	your hand me show
we are waiting for suresh	we for suresh are waiting	we suresh waiting

8 Lemmatization & Synonym Replacement

Indian sign language uses the root words in their sentences. All the words used must not contain suffixes, gerund or it should not be an inflexion of a word. If a word in the ISL sentence is not root word, it is converted into the root word after passing it to the stemmer and applying lemmatization rules. The porter stemmer [16] is used for stemming.

After converting the inflections of the words to their respective root words, the ISL sentence contains only the root words. Now, each root word is checked for availability in the English-ISL dictionary. Though this dictionary contains only 1478 words, a list of synonyms is created to make the system robust and increase the hits in the dictionary. An indirect approach is used rather than creating a list of all the synonyms of English language. We have collected the synonyms of only 1478 words (the words which are in our bilingual dictionary) A total of approximately 4000 synonym words are included in our database. It was taken care to remove the duplicacy of the words as well the part of speech of each word was taken care. For example, the word *inaugural is an adjective*, its synonym is taken as *opening as adjective* otherwise the word *opening* is used as verb also. The word *anger(v)* has the synonyms *irate, insense, enrage, infuriate* which all are verbs. Also the word *angry(n)* has the synonyms as *annoyance, irritation, fury, rage, resentment, antagonism* which all are noun. In case, no word is found in the dictionary or synonym list, the word is spelled. Here, spelling the word means finger spelling i.e. each character of the word is taken whose sign will be produced. Signs of all the alphabets of English have also been maintained in the database increasing the dictionary size to approximately 6000 words. All the personal nouns(names of persons, buildings etc) are finger spelled.

9 Sign Animation using Avatar

After all processing done on the English sentence to convert to ISL sentence, it is ready to be animated. As already discussed, the synthetic animation(using a computer

generated character known as Avatar) is best suitable for producing the sign. To animate the sentence, we have used an animation tool SiGML Player[17]. To generate the animation through this tool, the input must be the tags of SiGML(Signing Gesture Markup Language) and the output of this tool is animated character.

To get the SiGML tags, each word of the ISL sentence is replaced with its corresponding HamNoSys code. For the words which are not in the English-ISL dictionary database, each character (alphabet) of the word is replaced with the corresponding HamNosys code. Now, we have the HamNosys code of the whole ISL sentence. The HamNoSys code is now converted to SiGML tags using HamNoSys-SiGML conversion rules. As soon as we get the SiGML tags for the whole sentence, it is sent to the animation tool which plays it as the animated character.

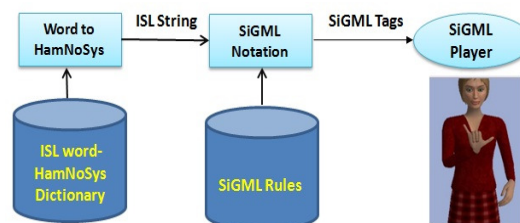


Figure 8: Architecture to produce the Animation from English word

10 Conclusion

In this paper, a translation system for English text to Indian sign language has been presented. The automatic system is the first ever translation system for Indian sign language in real domain. The major components of the system are conversion module(converts the English sentence to ISL sentence based on the grammatical rules), Elimination module(eliminates the unwanted words from the ISL sentence), Synonym and Lemmatization module(converts each word of the ISL sentence to root word), and Animation module(converts the ISL sentence to synthetic animation). Currently, the system has been created for context free conversion of English text to synthetic animations. A lot of time is

consumed to create the dictionary of English word to Indian sign in which non-manual component of each sign is taken care as well as the lips of avatar are animated so that it a hard of hearing person can read the lips also. Overall conversion accuracy has been checked by demonstrating the system in various deaf schools. The work has been very much appreciated by the interpreters and students. In future, the dictionary of sign language can be enhanced adding more words in it. Also, the context can be taken care while converting the English sentence to ISL sentence.

References

1. Ethnologue: Languages of the World. (2015). Retrieved July 10, 2016, from <http://www.ethnologue.com/>
2. WFD | World Federation of the Deaf - World Federation of the Deaf, WFD, human rights, deaf, deaf people. (2015). Retrieved July 10, 2016, from <https://wfdeaf.org/>
3. Zeshan, U., Vasishta, M. N., & Sethna, M. (2005). Implementation of Indian Sign Language in educational settings. *Asia Pacific Disability Rehabilitation Journal*, 16(1), 16-40.
4. Setting Cued Speech Apart from Sign Language - Accredited Language Services. (2016). Retrieved March 21, 2016, from <https://www.accreditedlanguage.com/2016/08/17/setting-cued-speech-apart-from-sign-language/>
5. Zeshan, U. (2003). Indo-Pakistani Sign Language grammar: a typological outline. *Sign Language Studies*, 3(2), 157-212.
6. Stokoe, W. C. (2005). Sign language structure: An outline of the visual communication systems of the American deaf. *Journal of deaf studies and deaf education*, 10(1), 3-37.
7. Klein, D., & Manning, C. D. (2003, July). Accurate unlexicalized parsing. In *Proceedings of the 41st Annual Meeting on Association for Computational Linguistics-Volume 1* (pp. 423-430). Association for Computational Linguistics.
8. Hanke, T. (2004, May). HamNoSys-representing sign language data in language resources and language processing contexts. In *LREC* (Vol. 4).
9. Goyal, L., & Goyal, V. (2016). Development of Indian Sign Language Dictionary using Synthetic Animations. *Indian Journal of Science and Technology*, 9(32).
10. Dictionary | Indian Sign Language. (n.d.). Retrieved July 15, 2016, from <http://indiansignlanguage.org/dictionary>
11. Stokoe, W. C. (1978). Sign language structure.
12. Sutton, V. (1995). *Lessons in sign writing*. SignWriting
13. Sinha, S. (2003). A skeletal grammar of Indian sign language. *Unpublished master's diss., Jawaharlal Nehru University, New Delhi, India*.
14. Aboh, E., Pfau, R., & Zeshan, U. (2005). When a wh-word is not a wh-word: The case of Indian Sign Language. *The yearbook of South Asian languages and linguistics*, 2005, 11-43.
15. Wren, P. C., & Martin, H. (1999). High school English grammar and composition.
16. Porter, M. F. (2001). Snowball: A language for stemming algorithms.
17. JASigning. (2015). Retrieved June 15, 2016, from <http://vh.cmp.uea.ac.uk/index.php/JASigning>