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Generating Glosses of Indian Sign Language from English Texts: A proposed Hybrid Machine Translation Method

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Abstract- Sign languages are the primary mode of communication within the community of deaf and hard of hearing people. Generation of dynamic signs from texts can be communicated to these community of a society by implementing the machine translation technology now a days. This paper proposes a hybrid machine translation mechanism by integrating rule based and phrase based machine translation methods to generate aligned Indian Sign Language glosses from corresponding English sentences. This new methodology will solve the problem of phrase generation of the subject, object in a sentence by introducing part of speech tagging and named entity recognition before phrase based machine translation is applied. We have restricted our work up to aligned gloss generation of Indian Sign Language as the generation of signs are only mapping of glosses to corresponding signs.

Keywords- Sign Language, Machine Translation (MT), Indian Sign Language (ISL), The words which represents an Indian sign for a word or, a phrase of English sentence (ISL Gloss)

I. INTRODUCTION

Sign language is a natural language [1] which is used by deaf or, hearing challenged community all over world. Unlike other spoken languages, the sign language uses movement and orientation of body parts like hand, arm, fingers and facial expressions to convey the feeling, idea or thoughts. The manual signs are made by using hand shapes or, orientation of hand, arm and fingers whereas the facial expressions are called non-manual signs. As the sign languages are rich and complex in their morphology, phonology, syntax and semantics like oral languages, the linguistics accept the sign languages as natural language. Some of the popular sign languages are American Sign Language(ASL) [2], British sign language (BSL), French Sign Language (LSE), Australian Sign Language (AUSLAN) etc. The sign language used in India is known as Indian Sign Language (ISL).

The ISL is proved to be complete natural language [1] as it has its own grammar, phonology, morphology & syntax. Due to the unavailability of linguistically annotated and well documented data on Indian Sign Language, the linguistic and phonological research has not been flourished. The expression of sign language is different from spoken & written languages as in making signs the hand shape or, movement of fingers and palm are required along with the facial expressions which is non-manual sign and is a challenging task to generate dynamic signs.

Translation of one language to other is a concern for societies since thousands of years, but the automatic translation of languages through computers are as old as the computer technology itself. Now a days MT (Machine Translation) is used to translate a natural language to other or, translation in both the directions and this field of research is conducted for various purpose in academia, society and industries. Most of the investigations in Indian Sign Language are reported to be conducted by using rule based methods. We are proposing a hybrid method by integrating rule based translation with phrase based alignment model to translate the English sentences to ISL glosses. The phrases to be identified are not the linguistic phrases of English. The phrases are considered to be a word or, multiple words found from the bilingual corpus after a statistical computation.

Translation of sign languages are challenging due to its typical nature and the nature varies from one sign language to other. We should also consider the limitation of sign languages also. As the signs are limited in a particular domain, but there is no limitation of vocabulary used to express a sentence of a verbal language. Let's consider following example in which an English sentence is translated to the corresponding ISL gloss.

English : "I had dinner with Radha"
ISL Gloss : "I RADHA WITH NIGHT FOOD FINISH"

In the above example, we can find that in ISL there is no helping verb, the subject verb object (SVO) of English [7] is converted to subject object verb (SOV) pattern. According to the morphology analysis the word "dinner" is replaced with two words i.e. "NIGHT FOOD". Another new word "FINISH" is included in ISL gloss whereas it is not mentioned in the English text. From the above example it is clear that the grammar will be different along with some morphological changes in the words as well as some more words either included or, deleted to transfer the

actual meaning of the sentence. This makes the translation process difficult and challenging specially for rule based machine translation systems.

II. MACHINE TRANSLATION OF SIGN LANGUAGES

Machine translation is the subfield of Natural Language Processing (NLP) which deals with the translation of text or, speech of a source language to text or, speech of a target language through computers. The machine translation systems designed for two specific languages is called bilingual, and for more than two languages is called multilingual systems. Both kind of systems may be unidirectional or, bidirectional. Most multilingual systems are bidirectional whereas bilingual systems are unidirectional. Following machine translation techniques are implemented in Sign Language translations from different languages.

2.1. Rule-based Approach

The foremost methodology for machine translation was Rule-Based Machine Translation(RBMT). The process of translation follows the principles of Analysis-Transfer-Generation (ATG). The different phases are making a bilingual word to word transfer, part-of-speech-tagging, chunking, named entity recognition, syntactic parsing, source to target transliteration, morphological generation of target language, structural transfer and target lexicon reordering following both the source and target language rules. There are three basic category of rule- based machine translation i.e. Direct MT, Transfer based MT & Interlingua MT.

2.1.1 Direct Translation

The direct translation is designed for a specific source and target language pair where the texts of source language is analyzed morphologically. A source-target language dictionary has to be prepared which will be used for word by word translation with morphological analysis. [6] The authors proposed a multimedia multilingual (ISL, ASL, BSL) dictionary tool which can be used for associating signs and its parameters corresponding to a given text.

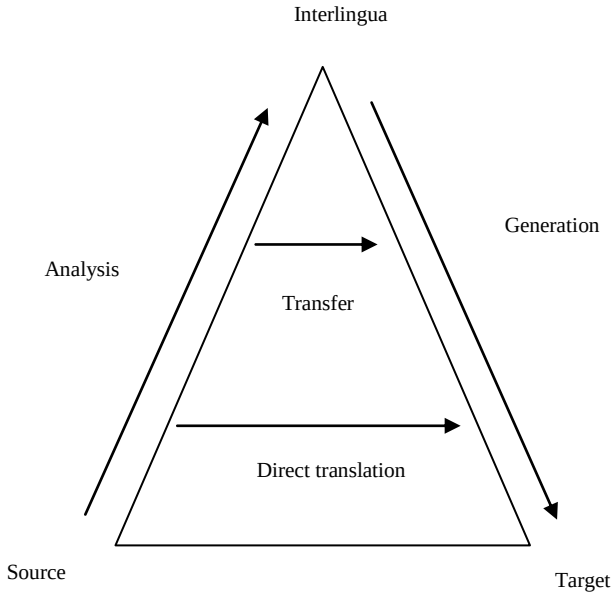

Figure-1: Rule Based Machine Translation

2.1.2. Interlingua Based Translation

This approach of machine translation is based on the concept of converting the source language to an intermediary or, a language independent form which is known as Interlingua. There are two phases of translation, i.e.

1. Representation of the source text to intermediate text
2. Representation of target text from intermediate text

The advantage of the interlingua are:

As the interlingua is in language independent form, it can be translated to multiple target languages.

The meaning of the source is transferred to the target language irrespective of structure, syntax and semantics.

The disadvantage of this process is generating interlingua for the source text is very difficult.
A Fluid construction Grammar [19] developed on the basis of procedural semantic approach designed for open ended dialogue. [18] is also a methodology proposed on the basis of interlingua approach for Russian text to Russian Sign Language translation system. [14] is the implementation of interlingua approach in the system Zardoz for translation of English to Sign language translation. The different phases of translation are: preprocessing of incoming text, idiomatic reduction, parsing, interlingua frame structure, schematization, anaphora resolution, mapping of sign.

2.1.3. Transfer Based Translation
Languages differ structurally. This method of translation is based on the knowledge about the difference between two languages. The translation undergoes three phases:
1- Analysis
2- Transfer
3- Generation
The transfer bridges the gap between the outcome of source language and the input to the generator of target language. A proposed system [13] is a speech to gesture translation architecture for translation of Spanish to Spanish Sign Language (LSE) in which semantic analysis followed by a gesture sequence generation for gesture playing is designed. [8] The translation from Greek to Greek Sign Language (GSL) is proposed by structural transfer. It also incorporates non manual elements of sign information.

2.2. Statistical-based Approach
The most popular approach of machine translation is statistical machine translation now a days. In this approach a large parallel bilingual or, multilingual corpora is prepared. A statistical table is made from the corpora based on the algorithms. The statistical table contains statistical information about the correlation between the source and target languages. This information is used for translation of the input text and is known as decoding. The statistical MT techniques are of three types: Word-based SMT, Pharse-based SMT and Hierarchical phrase based SMT.
As proposed [16], the Czech Text to Czech Sign synthesis based on the probabilistic theory i.e. Baysian rule. [15] In TESSA project a part of the system deals with the translation of English to BSL in the Post Office of U.K. The methods used are based on Hidden Markov Model and n-gram for speech recognition & sign generation.

2.2.1. Word Based Translation
The translation process progresses with word by word of an input sentence. A source word may require one or, more than one or, no words of the target language due to complex words, morphology or, idioms. The order of the words of the target language follows a pattern which was already learnt. [20] Greek sign language synthesis based on transfer based translation on the morphological analysis of words of Greek.
The word based machine translation of the example taken above can be represented as:

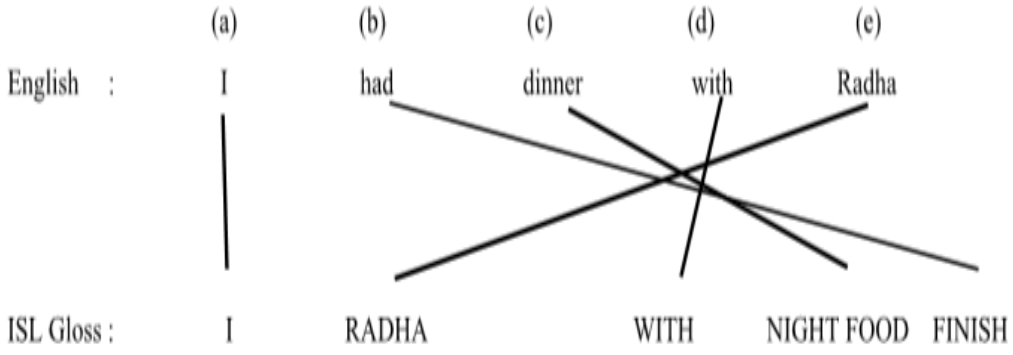

Figure-2: Word alignment

The source to target word alignment: { (a,1), (b,6), (c,4), (c.5), (d,3), (e,2) }
The methodology consists of two phases. The suitable words are selected from the corpus for the source words and then in the second phase the words are aligned according to the language model.

2.2.2. Phrase Based Translation

The phrase based SMT is more accurate than the word based approach. Here instead of taking each word for translation, a group of words called as phrase is taken. The phrases are not linguistically phrases but they are phrasemes which are used from corpora. For the alignment of phrases the same method of word based approach is followed. [10] In VANESSA system the machine translation of English to British Sign Language (BSL) is performed on the basis of phrase based translation. This system is assistance for eGovernment for hearing challenged people.

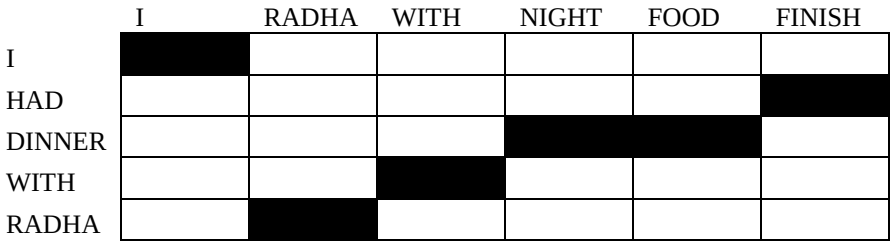

Figure-3: Phrase extraction

2.2.3. Hierarchical Phrase Based model

Instead of taking the phrases, in hierarchical phrase base model the recursive structure of phrases are considered so as to provide higher level of abstraction for more accuracy.

2.3. Hybrid-based Translation

Hybrid based translation is the amalgamation of both the advantageous features of the machine translation techniques. The researchers have proved that this new technique is giving more accurate results. The rule based technique may be used for preprocess the input data or, can be used for post-processing of statistical output. Researchers are also going for hybridizing other translation techniques. A bilingual dictionary (used in Rule based systems) and a monolingual corpus in the target language is used in METIS-II machine translation system. The authors [13] proposed a hybridization of rule based, statistical and stochastic transducer approaches for speech to Sign language translation for Spanish language. The sign error rate is found to be 32.0% and a 0.5780 BLEU (Bilingual Evaluation Understudy). [9] The literature addresses a hybrid translation technique for the Greek to Greek Sign Language (GSL). The phases of translations are tagging, lemmatizing, parsing for syntactic chunk and prototype based sign generation for GSL.

III. PROPOSED HYBRID MACHINE TRANSLATION METHODOLOGY

The Phrase Based Machine Translation method is completely based on the data driven approach. In a sentence the subject, objects may be found as proper nouns, concrete nouns or, common nouns. The PBMT systems don't bother about the type of nouns used. A target phrase has to be generated from the parallel corpora and the language model. The sign languages have limited number of vocabulary i.e. signs. The nouns for which a sign is not found in the parallel corpora then the word is spelled and signs for each alphabet will be selected. This means that the nouns in a phrase if not found in parallel corpora then it can't be ignored but need to be present in the target phrase. Another requirement of these nouns is the alignment of phrases according to the sign language grammar. As we have observed in our previous example that the ISL follows the principle of SVO (subject-object-verb) in a statement then it is necessary to keep the subject and object in its proper place. Since the phrase generation is not dependent on subject and objects of the sentence in a PBMT, it is required to identify the subject and objects of a sentence and need to be arranged in phrase alignment process.

We therefore propose a new methodology by following the rule based system up to named entity recognition and producing an intermediate sentence in which the subject and objects are symbolically represented. This new intermediate sentence will be given as the source text for the PBMT systems. The output of the PBMT system will be the aligned translated phrases and then the symbolic representation is reverted back to the original representation of subject and objects.

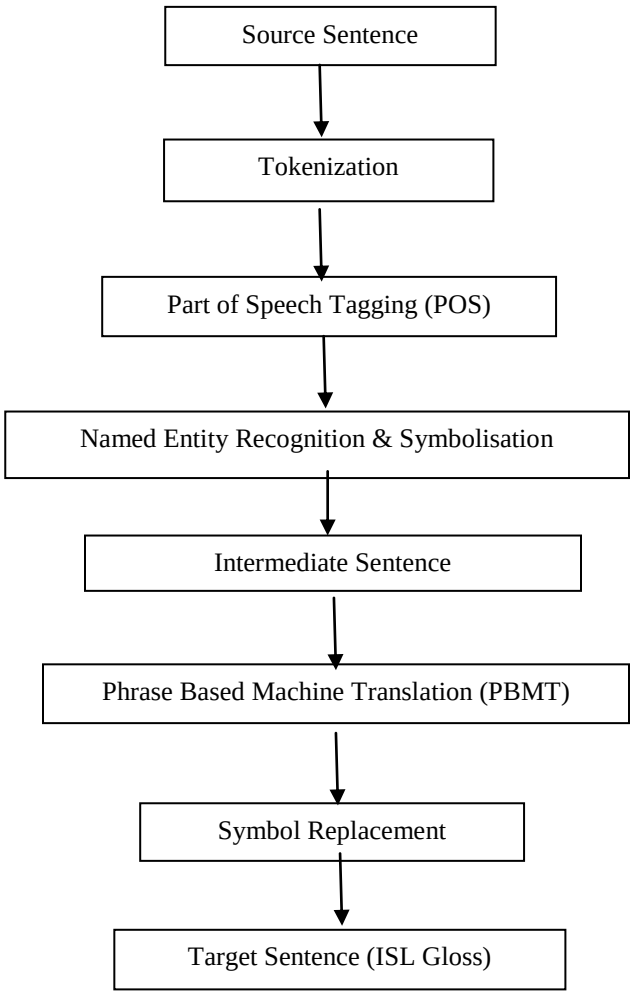

Figure-4: Proposed Hybrid translation model

In the proposed method a new bilingual corpora of containing translated English to ISL to be prepared which understands the symbolic representations of entities and the probabilistic model could be applied on the corpora. The new methodology aims to take the advantage of named entity recognition and avoids further analysis of linguistic structure of RBMT by introducing PBMT. Since the PBMT provides better performance in terms of phrase error rate (PER), the overall result is expected to be high. To achieve the desired result a large bilingual corpora is required and can be prepared by the help of a dictionary of 6000 signs is released by Indian Sign Language Research and Training Centre (ISLRTC), Department of Empowerment of Persons with Disabilities, Divyang, Ministry of Social Justice & Empowerment, Government of India on 27th February, 2019 [21].

IV. CONCLUSION

Language translation through computers has been a challenging task. The translation for multimodal translation like sign language translation is even more challenging. This also requires expertise linguistic knowledge along with heavy computing capability systems. The proposed methodology is prepared for English text machine translation to ISL gloss but this method can also be implemented for the languages following the principles of SOV and the subject and object need to be reflected in a proper order in the target sentence.

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