A Novel Approach for Translating English Statements to American Sign Language Gloss

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Abstract. In this paper, we present a study on the relationship between American Sign Language (ASL) statements and English written texts toward building a statistical machine translation (SMT) using 3D avatar for interpretation. The process included a novel algorithm which transforms an English part-of-speech sentence to ASL-Gloss. The algorithm uses a rule-based approach for building big parallel corpus from English to ASL-Gloss using dependency rules of grammatical parts of the sentence. The parallel corpus will be the input of the translation model of the SMT for ASL. The results we obtained are highly consistent, reproducible, with fairly high precision and accuracy.

Keywords: Sign Language Processing, Hybrid Machine Translation, Artificial Corpus, Gloss Annotation System.

1 Introduction

Machine translation for Sign language (SL), although has been explored for many years, are still a challenging problem for real practice. In fact, Sign Languages (SL) are very specific; they are actually very close to spoken language in the structural aspect and expression. Also, they use the same cognitive schema in their structure [2]. The need to go through an abstract level of structural representation languages is essential. And a main initial part of the project WebSign [6] that aims to design an avatar interpreter of an input text to sign language using statistical machine translation approach [11]. WebSign is the main framework of many other applications as MMSSign [7] for accessibility of Deaf to mobile technology and the tool described in [5] for sign language recognition. In this work, we propose an improved approach for generating the American Sign Language Gloss (ASL-gloss) from dependency grammar rules [12].

In fact, we will present a new approach for generating statements of American Sign Language toward translating an English text and at the same time build a parallel corpus between these two languages. In a previous paper presented in ViSiCAST project [1] [16] authors presented the the syntactic level of their approach. In this paper, we include more than 52 grammatical relations when generating dependencies. This has also allowed us to generate non-manual

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components. Research on lexical analysis, syntactic, morphological and semantic English text is very advanced, and there are several tools that deliver results with accuracy rates close to 98% and a recall (recall) close to 90%. Our approach is divided into two main parts: the first is the full automatic text processing of input data and its representation in the form of a semantic graph. The second step is the generation of transcription-Gloss using XML API.

In section 1, we detail the grammatical components of American Sign Language. Section 2 provides the details of our approach to generate ASL statements from an English sentence. Section 3 briefly discusses the evaluation method. We conclude the paper with an overview of the work.

2 Grammatical Components of ASL

2.1 Verbal Core

The main grammatical component [9] in American Sign Language (ASL) is the verbal core. The verb in ASL is the primary entity for the construction of the statement taking into account the dependencies with other signs of speech. Using the example shown in Figure 1, the word 'ASK' has two different signs, the first configuration of the hand facing the person who is in front of the signer. For the second, the index of the dominant hand is facing the signer.

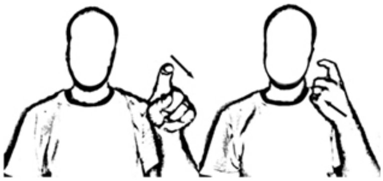

Fig. 1. Two forms of the verb 'ASK' in ASL. The left corresponds to the phrase 'I ASK YOU' and the right is the phrase 'YOU ASK ME'.

The phenomenon shown in Figure 1 has been observed in several languages like ASL [13], the Australian sign language [8], Brazilian Sign Language [14], British Sign Language [17], Dutch Sign Language [15], Japanese Sign Language [4] and others. The verb agreement generally refers to some systematic covariance between a formal or semantic property of an element and a formal property of another, for example between the object and the subject. Corbett [3] extends this definition stating that there are four main elements of the systematic covariance: Controller and target and Domain and Functions. A fundamental question concerning the phenomenon shown in Figure 1 is how to achieve the consent of the subject-verb and object, and if that is the case, what are the relevant characteristics to achieve. Several approaches have been proposed in the linguistic research of American Sign Language. We can cite for example the R-locus analysis proposed by Lillo and Klima in 1990 [10].

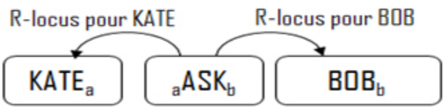

Fig. 2. R-locus relation in the sentence 'Kate asked Bob a question'

2.2 Other Components of ASL

In the example of Figure 2, the R-locus relationship is made to specify agreements with the word 'ASK'. According to this analysis, the relationship is described as an agreement between a noun phrase and a verb in the sense that they share a repository index, which is constructed as an open R-locus. In ASL, we have many components like:

- The time component (see Figure 3) is used when signing events and time, ASL uses Time-Topic-Comment structure. Signs with time indications or time periods are found in the beginning of the sentence ;
- Classifiers or Modifiers: are signs that use handshapes that are associated with specific categories (classes) of size, shape, or usage. They are used to express position, stative description, and how objects are handled manually. For example, the '1-Handshape' is used for individuals standing or long thin objects ;
- Pronouns : the index or forefinger handshape is used to indicate the pronouns "me," "you," "he-she-it," "we," "you-all," and "they". Using pronouns in ASL is the same as in English but we need to refer to a noun before using a pronoun ;
- Construction of a statement or word order: there exist three aspects of word order: a functional aspect, where the order of items provides information about the combination of words and which, in turn, provides guidance on how to interpret the sentence. And, an articulatory aspect which arises because generally, it is impossible to articulate more than one sign at a time. And, the presumption of the existence of a basic word order;
- Sentence types in ASL : are used to make an assertion, ask a question, to give an order, to express an emotion, etc. Sentence types develop grammaticalized forms associated to these conversational uses ;
- Negation : the expression of sentential negation in ASL features many of the morphological and syntactic properties attested for spoken languages. However, non-manual markers of negation such as headshake or facial expression have been shown to play a central role and they interact in various interesting ways with manual negatives and with syntactic structure of negative clauses ;
- Coordination and subordination : involves the combining of at least two constituents which are basically interpreted with non-manual signs ;
- Coreference (see Figure 4) : occurs when two or more expressions in a text refer to the same person or thing.

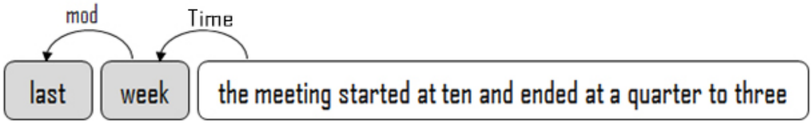

Fig. 3. Temporal dependence in 'Last week, the meeting started at ten and ended at a quarter to three'

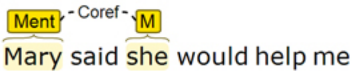

Fig. 4. The relationship of coreference in the sentence 'Mary said she would help me'

2.3 Relationships between ASL Components

The study of relations between grammatical dependencies between the words in a sentence in English, shows that from these relationships, we can generate structures in ASL. Therefore, given a sentence as input, can we build a statement in ASL? To answer this question the deaf use their cognition for the interpretation of a fast and implicit way. First of all, the brain directs the signs (for example: $tense \rightarrow subject \rightarrow verb \rightarrow object$). Then, the deaf created its space of designation by placing the different subjects and objects taking account semantic relationships between the objects. In the previous section, we show that syntactic, morphological and semantic analysis are very important and will be our starting point in our automatic translation system into sign language from from the dependencies rules between the extracted signs of grammatical relations.

3 Our Approach

The organization levels of linguistic processing of our system is similar to the triangle model of Vauquois. Thus, as shown in Figure 5, the system is organized in three main levels: lexical, syntactic and semantic levels which are a chain of linguistic processing

The set is built around several modules supervised by a control module. These modules contain the various data on which the analysis and the generation of the message will be made:

- Data for segmentation: Sentence boundaries detection and tokenization ;
- Monolingual lexicons with morphological information ;
- Word-to-word translation from a dictionary ;
- Chunking grammar to separate grammatical components like nominal group, prepositional phrases, verb groups, etc. ;
- Dependency grammar for syntactic relationships between words ;
- Translation based on grammatical function ;

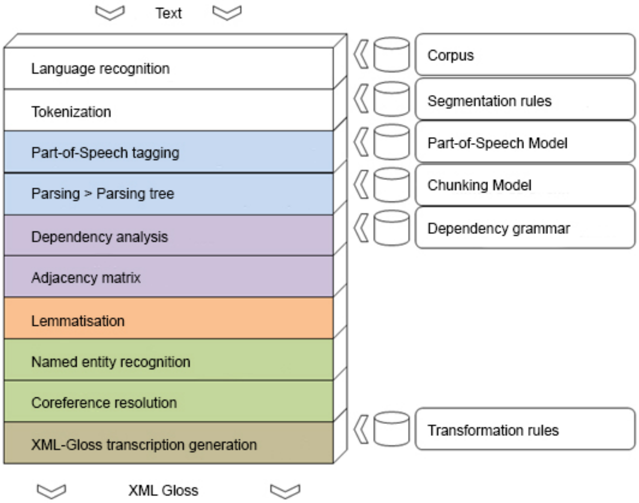

Fig. 5. Architecture of the proposed system

- Semantic construction rules, to refine the relevance of syntactic relations and retain only those emitting a sense ;
- Graph transformation rules for the reformulation.

The main stages of the analysis is done in a conventional manner according to the scheme shown in Figure 5. Thus, after a segmentation step, morphological, syntactic and semantic information retrieval of each word of the source statement are sought in a lexicon. A dependency grammar is then used to build the tree representing the syntactic structure of the utterance. The tree obtained for the analysis of a sentence like "Kate gave chocolate for each boy, yesterday" is given by Figure 6. Indeed, the structure of the target sentence in ASL is $Tense \rightarrow Subject \rightarrow Verb \rightarrow Object$. The first step is applied directly to the input sentence pretreatment followed by an analysis of dependence between words which will be described in the following sections. After this step, the system analyzes the semantic structures between words. Following this analysis, the system generates a specific ASL syntactic structure. Then, we proceed to the linearization and formatting according to the transcription system XML-Gloss.

As mentioned earlier, our approach is based on the dependency relationships of grammatical parts of the English input sentence (see Figure 7). From the dependency relationships, we define a finite graph G with n vertex, which n is the number of words of the input sentence. The edge between two vertex i and j is noted (Vi, Vj). The set of edges is V. In our example, figure 6 is an illustration of the dependency graph. After that, we generate the adjacency matrix A which is determined from G.

Thereafter, to build the ASL statement, we define the output rule. For example, in our case, we follow the TSOV rule $tense \rightarrow subject \rightarrow verb \rightarrow object$. This rule will be useful to extract word from adjacency matrix.

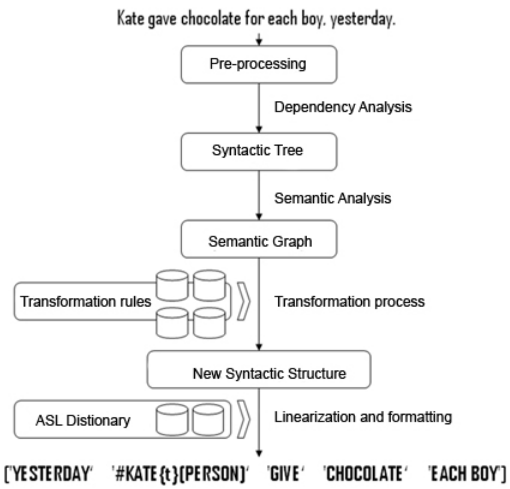

Fig. 6. Overview of how the proposed translation system

At the end, we implement the existing tool to recognize named-entity and to detect coreference in the input sentence toward adding sematinc information to the ASL statement like classifier and pronouns references.

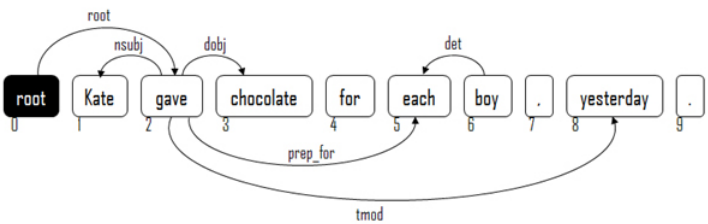

Fig. 7. Dependency links for the sentence 'Kate gave chocolate for each boy, yesterday'

4 XML-Gloss Transcription Generation Process

Generating the XML-Gloss transcription is a simple task, just browse entities resulting from algorithms to build ASL statement and make a call of specific methods from API-XML-Gloss. For example for the sentence "YESTERDAY #KATE{t} GIVE CHOCOLATE EACH-BOY", the output is shown in Figure 9.

5 Evaluation

To evaluate our system, we began by comparing manually each sentence to its transcription and the generated transcript. However, this task is a huge time

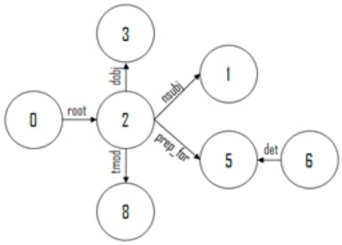

Fig. 8. Dependency graph of the sentence 'Kate gave chocolate for each boy, yesterday'

$\overline{}^{t}$
YESTERDAY #KATE GIVE CHOCOLATE EACH-BOY

Fig. 9. Gloss annotation of the sentence 'Kate gave chocolate for each boy, yesterday'

consuming since that the number of sentences exceeds $100k$. Our solution is to evaluate only the transfer between the two languages (English and ASL) rules such that, we reduced significantly the time and cost of the evaluation. Otherwise, we take one sentence e in English and its matrix of adjacency M. We define a transfer rule $R(i \Rightarrow j)$ as:

For our system, we evaluate 820 transfers rules extracted from the books of learning ASL. The accuracy rate is equal to 82% for 6720 phrases calculated from the formula:

$$T(precision) = \frac{count(validsentences)}{count(sentences)} \tag{1}$$

6 Conclusion

The approach of generating speech in ASL from dependency grammatical rules presents an interesting solution for automatic translation of text to sign language transcript. The overall architecture of the generation system has been described as well as its main modules. The experimental results are very promising and currently we are integrating this system in the WebSign framework in order to improve its translation efficiency.

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