Some issues on syntax transformation in Vietnamese sign language translation

Thi Bich Diep Nguyen† and Trung-Nghia Phung††,

Graduate University of Science and Technology, Ha Noi, Vietnam
Thai Nguyen University of Information and Communication Technology, Thai Nguyen,Vietnam

Abstract
Sign languages have their distinct syntax and grammar characteristics. In this paper, we summarized linguistic rules in syntax of Vietnamese sign language and proposed a rule-based algorithm for syntax transformation in Vietnamese sign language. The experimental results show that the proposed algorithm is efficient and useful for building automatic Vietnamese sign language translation.
Key words:
Vietnamese sign language, syntax transformation, sign language translation.

1. Introduction

Sign language is the daily language for the deaf performed by using unified hand gestures. Sign languages have been developed in several centuries and recognized as official languages with distinct vocabularies and grammars.

There are some translation services and products built to assist the deaf communicating with normal hearing people. The cores of these systems are the syntax transformation algorithms.

One of the most successful sign language translation systems up to now is the ViSiCAST for English [1]. This system uses an algorithm called as Head-driven Phrase Structure Grammar (HPSG) to convert English written documents into English sign language documents. The core of this system is the use of syntax analysis system CMU to analyze input English documents, and then transform them to correspondent English sign language documents by using declarations in Prolog [1].

TEAM project [2] is an American Sign Language (ASL) translation using other algorithm called as Synchronous Tree Adjoining Grammar (STAG). This system uses a bilingual dictionary between spoken / written English and English sign language [3]. This system also uses a syntax transformation in which input English sentences are analyzed and transformed.

The research in [4] aims to design a statistical machine translation from English written text to ASL. The system is based on the use of Moses tool with some modifications and the results are synthesized through a 3D avatar for interpretation.

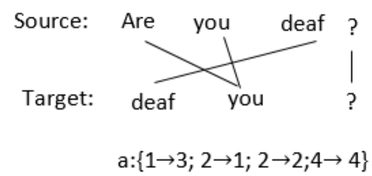

Fig. 1 Examples of IBM defines the translation probability for an English sentence.[4]

One recent research in [5] also proposed a translation between spoken / written English into Indian Sign Language (ISL). The objective of this work is to design a translation machine which can translate English text to ISL glosses. This approach is based on statistical machine translation for ISL by using a corpus. The corpus is prepared by collecting glosses and sentences used in Indian Railways for announcement and conversation in public assistance counters.

Sign : NAYA: ABHI: BACHA: ISKU: L SIKHA: NA:
ISL Gloss: new now child school teach
English : The new (thing is that) children are now taught (sign language) at school.'
Sign : PAHLE SIKHA: NA: MUSKIL.
ISL Gloss: before teach difficult
English : '(Signs) were not taught before; (it was too) difficult.'
Sign : ABHI: SURU: BACHA: SIKHA: NA:
ISL Gloss: now begin child teach
English : 'Now they have started to teach the children.'

Fig. 2 Examples of English to ISL gloss translation [5].

Language grammars are complex issues and largely different between languages. Therefore, researches on ASL or ISL cannot be directly applied for Vietnamese sign language (VSL). Therefore, in this paper, we proposed a syntax transformation algorithm applied in VSL translation system.

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2. Linguistic fundamentals of Vietnamese sign language

One of three most important features of VSL is the syntax. The syntax of VSL has distinct rules and is different with those of Vietnamese spoken / written language [6]. In this section, we present fundamental syntax rules of VSL.

2.1 Sentence forms

- *Simple sentences:*

The structure of spoken / written Vietnamese language is Subject → Predicate → Object. However, the structure of VSL is Subject → Object → Predicate.

Table 1: Simple sentence

	Vietnamese Spoken / Written Language	**Vietnamese Sign Language**
Structure	Subject → predicate → object	Subject → object → predicate
Example in Vietnamese	Cô ấy ăn táo	Cô ấy táo ăn

- *Question sentences:*

The structure of Vietnamese spoken / written sentences and Vietnamese sign sentences are completely different. There is no need to use words Yes / No in yes-no VSL questions. Instead of that, the expression on the face can be used to show the state of question sentences.

In Vietnamese spoken / written language, the positions of ask words in question sentences are not fixed. However, in VSL, ask words are always at the end of the sentences.

Table 2: Question sentences

	Vietnamese Spoken / Written Language	**Vietnamese Sign Language**
Structure	Subject → ask words → predicate → object?	Object → predicate → subject → ask words
Example	Ai ăn táo?	Táo ăn ai?
Structure	Subject → predicate → ask words → object?	Subject → object → predicate → ask words?
Example in Vietnamese	Cường ăn mấy quả táo?	Cường quả táo ăn mấy?

- *Negative sentences:*

Vietnamese has different types of negative sentences including full negative sentences and partial negative sentences.

In Vietnamese spoken / written language, verbal negatives in partial negative sentences precede the main verbs. However, in VSL, negative words always follow verbs and locate at the end of the sentence.

Table 3: Negative sentence forms

	Vietnamese Spoken / Written Language	**Vietnamese Sign Language**
Structure	Subject → predicate → negative word → object	Subject → object → predicate → negative word
Example in Vietnamese	Cường không ăn táo.	Cường táo ăn không.

2.2 Word orders

The word orders of Vietnamese spoken / written language and VSL have significant differences as shown in Table 4 and 5.

Table 4: Nouns and numerals

	Vietnamese Spoken / Written Language	**Vietnamese Sign Language**
Structure	Numeral → Noun	Noun → Numeral
Example in Vietnamese	Hai quả táo	Qủa táo hai

Table 5: Verbs and negative words

	Vietnamese Spoken / Written Language	**Vietnamese Sign Language**
Structure	Negative word → verb	Verb → negative word
Example in Vietnamese	Không ăn	Ăn không

3. Building rule-based syntax transformation trees

Based on the linguistic fundamentals of VSL, we built rule-based syntax transformation trees as the following.

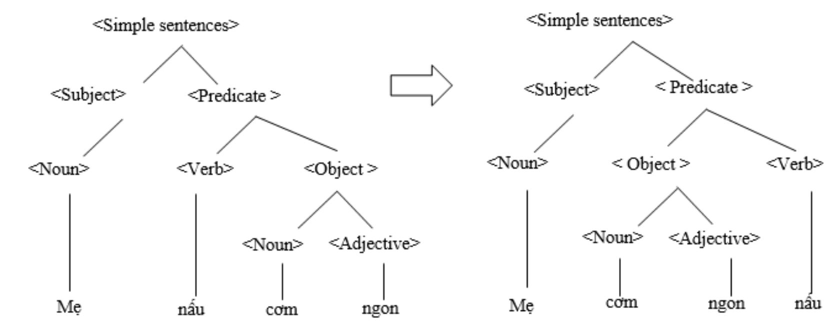

Fig. 1 Structure of syntax tree transforming simple sentences

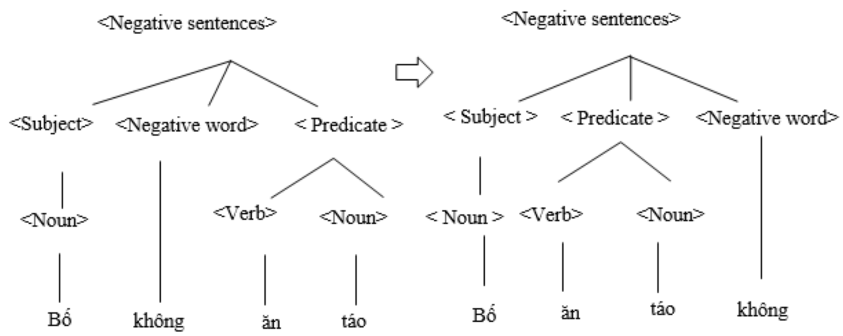

Fig. 2 Structure of syntax tree transforming type 1st negative sentences

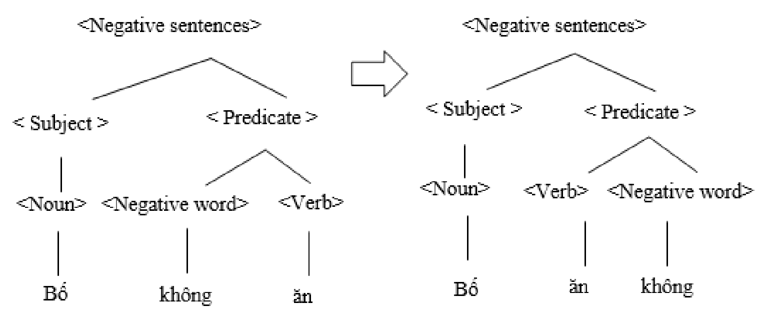

Fig. 3 Structure of syntax tree transforming type 2nd of negative sentences

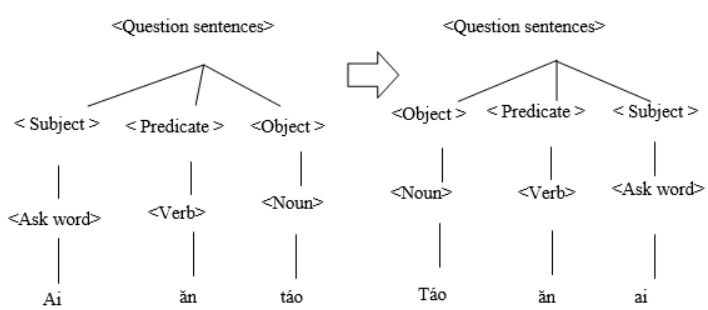

Fig. 4 Structure of syntax tree transforming type 1st of question

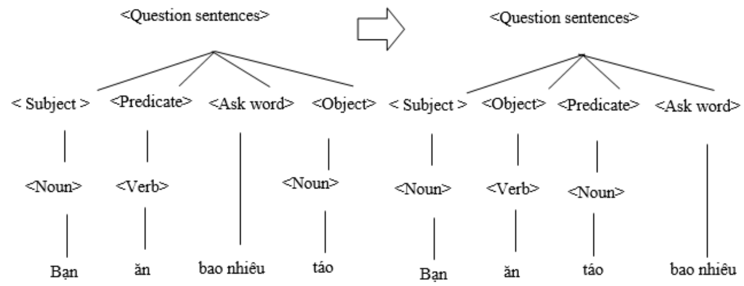

Fig. 5 Structure of syntax tree transforming type 2nd of question

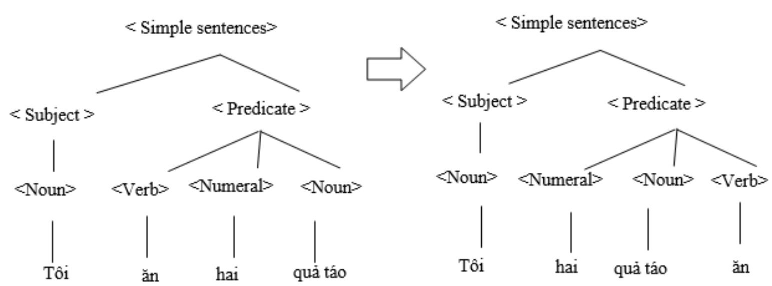

Fig. 6 Structure of syntax tree transforming sentences with numerals

4. Proposed syntax transformation algorithm

Based on the above syntax transformation trees, we proposed a rule-based syntax transformation algorithm for VSL as shown in Fig. 7.

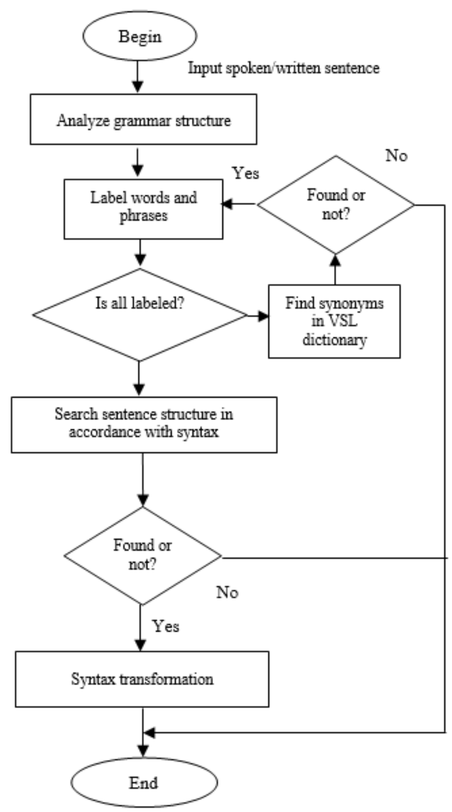

Fig. 7 Syntax transformation algorithm for VSL translation

5. Experiment Results

5.1 Evaluation method

BLEU is a method to evaluate quality of the documents automatically translated my machine, proposed by IBM in 2002 [7] and used as the primary evaluation measure for research in machine translation in [8]. The original ideal of the method is to compare two documents automatically translated by machine and manual translated by linguistic experts. The comparison is performed by statistical analyzing the coincidence of the words in the two documents that takes into account the order of the words in the sentences using n-grams. Specifically, BLEU scores are computed by statistically analyzing the degree of coincidence between n-grams of documents automatically translated by machine and the ones manual translated by high-quality linguistic experts [9].

BLEU score can be computed as follows [11]:

$$score = \exp\left\{\sum_{i=1}^{N} w_i \log(p_i) - \max\left(\frac{\mathrm{L_{ref}}}{\mathrm{L_{tra}}} - 1, 0\right)\right\} \qquad (1)$$

- $P_i = \frac{\sum_j NR_j}{\sum_j NT_j}$
- NR_j: the number of n- grams in segment *j* in the reference translation (by experts) with a matching reference co-occurrence in segment
- NT_j: the number of n- grams in segment *j* in the translation (by machine) being evaluated.
- $w_i = N^{-1}$
- L_{ref}: the number of words in the reference translation (by experts) that is closest in length to the translation being scored.
- L_{tra}: the number of words in the translation (by machine) being scored.

The value of score evaluates the correlation between the two translations by experts and machine, computed in each segment where each segment is the minimum unit of translation coherence. Normally, each segment is usually one or a few sentences. The n-gram co-occurrence statistics, based on the sets of n-grams for the test and reference segments, are computed for each of these segments and then accumulated over all segments. It is clear that the smaller the score, the better the co-occurrence statistics.

5.2 Evaluation results

We built a VSL dictionary with 3000 words and phrases. For evaluation, we used 200 simple sentences extracted from on the textbooks used in the schools for deaf children. After being translated (shortened) by using the proposed method, we computed the BLEU scores between the translated sentences and the corresponding ones conducted by one expert in VSL.

The results of computed BLEU scores are shown in Fig.7. The ratio of sentences correctly translated by using the proposed method (corresponding with BLEU score is zero) is 97.5%. A few sentences incorrectly translated is caused by semantic ambiguity will be solved in our future researches.

Table 5: BLEU Score

ID sentence	Linput	BLEU Score
1	5	1.000
2	3	1.000
3	7	0.253
4	5	1.000
…	…	…
…	…	…
196	6	0.2778
197	7	1.000
198	5	0.5250
199	4	1.000
200	3	1.000

Acknowledgments

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