Building a Bidirectional English-Vietnamese Statistical Machine Translation System by Using MOSES

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Abstract: In this paper, we describe an attempt at constructing a bidirectional English-Vietnamese statistical machine translation system using MOSES, an open-source toolkit for statistical machine translation. The quality of a statistical machine translation system depends on the bilingual sentence alignment data called parallel corpus. However, Vietnamese is an under-resourced language that is largely left out of initial corpus building efforts. Therefore, we concentrate on building Vietnamese corpora which consist over 880,000 English-Vietnamese sentence pairs and over 11,000,000 Vietnamese monolingual sentences to train the statistical translation model and the language model respectively. According to the obtained BLEU scores, the proposed system outperforms the Google translator and the Microsoft Bing translator in both English to Vietnamese and Vietnamese to English translating.

Key words: English-Vietnamese bilingual corpus, MOSES, statistical machine translation.

1. Introduction

Automatic translation of text written in a language into another one by using the computer is referred to Machine Translation (MT). Over the past 50 years of research and development, MT has achieved acceptable results when it is applied to several pairs of popular languages such as English, German, French, Spanish, and Japanese. However, MT has not been invested in under-resourced languages sufficiently. For instance, Vietnamese is one of those world languages that are largely left out of initial corpus building efforts [1]. Although, Vietnamese is spoken by over 93 million national speakers [2] and about 1.55 million Vietnamese who live in United State where Vietnamese are the 4th largest of all Asian groups living in the US [3], research on MT of Vietnamese is very rare.

The earliest English-Vietnamese MT system was developed by Logos Corporation for translating aircraft manuals during the 1970s [4]. Until now, there are four main groups that research on MT for English-Vietnamese [5]. Among them, the first commercial English-Vietnamese translation system was named EVTran that was used rule-based approach [6]. Then, the using of Bitex Transfer Learning (BTL) [7] and word-order transfer [8] to improve the rule-based MT system quality was also proposed. And the first phase of statistical machine translation system EVSMT1.0 [9] was developed. However the results are still modest.

During the development of MT period, many different paradigms have been introduced: direct translation, Interlingua, transfer, statistical... The direct translation, interlingua, transfer approaches are the rule-base method that makes use of a set of rules or grammars extracted from linguistic knowledge by human has its

domination in the past. Whereas the statistical or data-driven approach for MT called Statistical Machine Translation (SMT) is based on the use of statistical models and translated examples. First idea of SMT was proposed by Warren Weaver in 1947, but it was abandoned because of computation complexity. This is the basic for the fundamental approach for SMT proposed by Brown [10] in the early 1990s using Noisy Channel Model. SMT approach has been continuously developed and become the dominant research paradigm in recently years.

In this research, we describe an attempt at constructing a bidirectional English-Vietnamese SMT system using MOSES [11] system. MOSES is an open source toolkit which includes a decoder and a set of software (word alignment, language model estimation and corpus preparation) to build a complete SMT system. Such an approach requires a parallel bilingual corpus to build statistical translation model for source-target languages and a monolingual corpus to build statistical language model for target language. Then the two models and a search module (decoder) are used to decode the best translation [12]. Although there are several projects for building an English-Vietnamese corpus for particular purposes, such as word sense disambiguation [13], [14], web mining [15], resources for VLSP project [16] and English-Vietnamese MT [17], most of these corpora are not public. Thus, the first task is to build a high quality English-Vietnamese parallel corpus.

The paper is organized as follows: In Section 2 we describe SMT system. In Section 3 we describe the bidirectional English-Vietnamese SMT model and then we present our experimental results in Section 4. Finally, we conclude in Section 5.

2. Bidirectional English-Vietnamese SMT Model

The purpose of SMT is to find the target sentence t in the target language that matches to the source sentence s by maximizing the posterior probability $P(t/s)$:

$$f = \arg \max P(t / s) \quad (1)$$

This probability can be represented as formula by Bayes rule:

$$\begin{aligned} P(t / s) &= \frac{P(s / t)P(t)}{P(s)} \\ &= P(s / t)P(t) \end{aligned} \quad (2)$$

As the probability $P(s)$ is known with given source language s , the problem turns into finding the target sentence t that maximize $P(s/t)P(t)$. Where, $P(s/t)$ is the translation model probability to measure the quality of source sentence is translated given target sentence. The $P(t)$ is the language model probability, which is used to evaluate the frequency of produced sentence occurs in target language.

The main resources for constructing such SMT system are source/target parallel corpus and target monolingual corpus that are used to train translation model and language model respectively. The Decoder that bases on these models finds the highest scoring sentence in the target language corresponding to a given source sentence. The general architecture of the proposed SMT system is shown in Fig. 1.

2.1. Translation Model

The translation model finds out the correspondence between the source sentence and the target sentence in source/target parallel corpus. The basic unit of the correspondence is word. The finding out the word correspondence between the source sentence and the target sentence is called word-alignment. GIZA++ [18]

is one of the most common toolkits to establish a word-alignment. This toolkit is an implementation of the original IBM models [10] that started statistical machine translation research. In fact, the alignment between the source word and the target word can be one-to-one, one-to-many or one-to-zero. For instance, translating English to Vietnamese, each word in English could be produced one, zero or more Vietnamese words. This is a limitation in word-based model is that the translation system can be able to produce multiple words from a single word, but not vice versa.

Fig. 1. Architecture of SMT system.

One of the ways to accomplish this task is to use phrase-based translation which is the state-of-the-art SMT at the moment. The basis of phrase-based translation is to fragment the input sentence into phrases (sequences of consecutive words) and then translate these phrases into the target language [12]. These translated phrases in the target language may be re-ordered. The translation process is broken up into the following three mapping steps that were shown in Fig. 2.

Fig. 2. An example of phrase-based translation.

2.2. Language Model

The language model should be trained on the huge amounts of monolingual corpus in target language. Typically, language model estimation starts with the collection of n-grams and their frequency counters. Then, smoothing parameters are estimated for each n-gram level; infrequent n-grams are possibly pruned and, finally, a language model is created containing n-grams with probabilities and back-off weights. However, n-gram language models cannot handle long-range information such as might be encoded in syntax. Syntactic language model and factored language model [19] are gaining attention in language model research.

2.3. Decoder

The decoder's task is aimed to find the best translation in target language for the given input sentence by the statistical methods that count on the translation model and the language model. The original decoder

for phrase-base model was developed by implementation of greedy hill-climbing algorithm [20], but it was insufficient for noun phrase translation on MOSES system [12]. The MOSES phrase-base decoder has been developed employs a beam search algorithm [21] to produce a set of candidate translations which is called n-best list generation for each input sentence. Then, the using of additional features such as word graphs [22] and forest structures over parse trees [23] to re-rank and choose the best translation from this n-best list.

3. Corpus Collection

Despite Vietnamese is the 16th widely-used language in the world [24], there are no such kind of corpus available for Vietnamese language processing. There are several projects for building an English-Vietnamese corpus for particular purposes, such as word sense disambiguation [13], [14], web mining [15], resources for VLSP project [16] and English-Vietnamese MT [17], however, most of these corpora are not public. Hence, we have to build a high quality English-Vietnamese parallel corpus and a huge amounts of Vietnamese monolingual corpus.

3.1. Parallel Corpus

Parallel corpus which is employed to train the translation model plays an important role in SMT. To build English-Vietnamese (E-V) corpus, we collected E-V sentence pairs manually from diversified resources: phrase and sentence examples from LacViet Dictionary that is the most popular E-V dictionary; articles from Watchtowers, Awake, Multicultural Rainbow magazine, and BBC NEWS; common idioms from VOA NEWS and sample E-V corpus of Ngo Q. H. [17]. After normalizing (remove long sentences, remove the duplicate, re-correct splitting of sentence) such collected corpus, we obtain exactly 882,000 E-V sentences pairs which is arranged for training, tuning and testing process, as are shown in Table 1.

Table 1. Collected E-V Parallel Corpus

	Training	Tuning	Testing	Total
Size	877,821	2,089	2,090	882,000

3.2. Monolingual Corpus

Monolingual corpus is employed to train the language model in target language. For translating from English to Vietnamese we need a Vietnamese monolingual corpus and vice versa we need an English monolingual corpus.

To build the Vietnamese monolingual corpus, we downloaded Vietnamese text from 3 resources: all the articles available until July 30, 2015 on www.vnexpress.net website that is one of the most famous NEWS websites in Vietnam; Vietnamese e-books (business, medicine, history, culture, literature, psychology); VNTQ corpus which is collected by Luu and Nguyen available for download (<http://viet.jnlp.org>). After normalizing (remove long sentences, remove the duplicates, re-correct splitting of sentence), we obtain exactly 11,758,352 Vietnamese sentences. For English monolingual, we extracted the only English sentences from the collected parallel corpus, which consists 882,000 English sentences, as are shown in Table 2.

Table 2. Collected Monolingual Corpora

	Vietnamese	English
Size	11,758,352	882,000

3.3. Preprocessing

3.3.1. Corpus normalization

One task in preprocessing a corpus is normalizing data which deals with the problem of special symbols and character. It also re-corrects the splitting of sentences and stores each sentence as one line in disk file. In the training pipeline process, the long sentences or empty sentences cause the problem of system crash. Thus, we need to remove them before making the training process. In here, we define the long sentence that is the sentence consists more than 80 words and the empty sentence is a sentence which does not consist any word but consists some special symbols or individual characters. The corpus was collected from many resources, sometimes, the duplicated sentences occur. They need to be removed for cleaning corpus.

3.3.2. Word segmentation

Unlike English, Vietnamese is a monosyllable language that is one word is composed by one or more syllables. In Vietnamese, blank spaces are not only used to separate words, but they are also used to separate syllables. Hence, we cannot use the blank space to determine the word boundaries. In this research, we used the open-source tool *vnTokenizer* [25] to segment words in Vietnamese text.

3.3.3. POS tagger

In Factored phrase-based translation model, the surface form is augmented with part-of-speech tag as the factors in order to model the differences between source language and target language. We applied the well-known open source Stanford Log-linear Part-Of-Speech Tagger [26] to English sentences in both parallel corpus as well as monolingual corpus.

4. Experimental Result

For experiments, MOSES toolkit has been downloaded and compiled on Linux version 3.16.0-4-amd64. It is written in C++ and Perl and released under the LGPL license with both source code and binaries available. The system implements GIZA++ used for word alignment and IRSTLM used to build 3-gram and 4-gram language model.

For translation evaluation, we use BLEU (Bi-Lingual Evaluation Understudy) that is currently one of the most popular methods of automatic machine translation evaluation. The translated output of the test set is compared with different manually translated references of the same set. The BLEU scores that are summarized in Table 3 were obtained when translating a test set with 2,090 sentences by the proposed system MOSES, Google translator and Microsoft Bing translator.

Table 3. Comparison of BLEU Scores

	English to Vietnamese						Vietnamese to English					
	BLEU	p1	p2	p3	p4	BP	BLEU	p1	p2	p3	p4	BP
Google	8.80	42.1	12.4	5.2	2.2	1.000	9.68	43.9	14.1	6.5	3.2	0.905
Bing	7.62	41.0	11.4	4.4	1.6	1.000	11.04	44.0	14.9	7.6	4.4	0.906
MOSES	10.08	45.4	14.7	6.1	2.6	0.998	11.33	41.3	14.5	7.4	4.1	0.978

p_n is the n -gram precision and BP is the brevity penalty to prevent very short translations. They are computed as follows [27]:

$$p_n = \frac{\sum_{C \in \{\text{Candidates}\}} \sum_{n\text{gram} \in C} \text{Count}_{\text{clip}}(n\text{gram})}{\sum_{C \in \{\text{Candidates}\}} \sum_{n\text{gram} \in C} \text{Count}(n\text{gram})} \quad (3)$$

$$BP = \begin{cases} 1 & \text{if } |c| > |r| \\ e^{(1-|r|/|c|)} & \text{if } |c| \leq |r| \end{cases} \quad (4)$$

where, $Count(ngram)$ is the number of n-grams in the candidate translation; $Count_{clip}(ngram)$ is the maximum number of *ngrams* co-occurring in a candidate translation and a reference translation; $|c|$ is the length of the candidate translation and $|r|$ is the length of the reference translation. The BLEU formula is then written as follows, in which N is set at 4 and w_n , the weighting factor, is set at $1/N$.

$$BLEU = BP \bullet \exp \left(\sum_{n=1}^N w_n \log p_n \right) \quad (5)$$

According to the obtained BLEU scores, the proposed system using MOSES outperforms the Google translator and the Microsoft Bing translator in both English to Vietnamese and Vietnamese to English translating. Especially, in case English to Vietnamese translation, the proposed system's BLEU score is higher than Google's BLEU score 14.5% and higher than Bing's BLEU score 32.3% since using the huge amount of Vietnamese monolingual corpus with over 11 million sentences to train the Vietnamese language model. Otherwise, in case Vietnamese to English translation, when we only used English sentences that were extracted from parallel corpus to train English language model, the BLEU score is almost the same as Bing's one and higher than Google's score 17%.

5. Conclusion

In this paper, we have presented our work on building a bidirectional English-Vietnamese statistical machine translation system using open-source toolkit MOSES. The proposed system outperforms the Google and Microsoft Bing translation systems in both English to Vietnamese and Vietnamese to English translation when applying BLEU to evaluate the translation of the test set with 2,090 random sentences. We also show the effort to collect the English-Vietnamese parallel corpus with 882,000 sentence pairs and Vietnamese monolingual corpus with 11,758,352 sentences from diversified resources.

In the future, in order to improve the translation accuracy, we plan to collect more data for parallel corpus then applying POS tagger as well as word-sense disambiguation processing methods for Vietnamese data. We also consider attempting to apply some accurate methods, neuron networks and deep learning for training process.

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