

An Empirical Machine Translation Framework for Translating Bangla Imperative, Optative and Exclamatory Sentences into English

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Abstract—A set of Context Sensitive Grammar (CSG) rules to translate Bangla imperative, optative and exclamatory sentences into English are introduced in this paper. In this paper, sentences are considered according to the function and purpose of the user rather than structure of the sentence. Three algorithms are implemented to complete major three steps of machine translation system (i.e., parsing, transfer and generation). The experimental results shows that the performance of the proposed machine translation framework is quite appeasement and efficiency is compared with Google Translator for some selected sentences which are quite satisfactory.

Keywords—Machine Translation; context sensitive grammar; parsing; transfer; generation.

I. INTRODUCTION

Machine Translation (MT) is the translation of text by a computer with no human involvement. More simply we can say that machine translation is the application of computers to the task of translating texts from one natural language to another. Due to the many factors such as words with multiple meanings, sentences with multiple grammatical structures and so on makes the machine translation one of the most challenging tasks of natural language processing.

Now a days, most of the computer based resources and technical journals are in English. Due to the language barrier, the common masses face big obstacle to enjoy the optimum benefits of modern Information and Communication Technology (ICT) as well as huge enriched English knowledge database around the globe. There are immense knowledge out there in the internet but most of the people in Bangladesh cannot take advantage of it because of language barrier. Today, we have many Bangla websites and blogs but those are not enough to satisfy our need for knowledge. Language processing in Bangla is one of the key technique that can be used to remove this barrier. So, a Bangla to English translator will be very helpful to make all information meaningful to the people of Bangladesh. Saving time is one of the most attractive characteristics of automated machine translator. Translating a sentence word by word will take lots of time as well as money. An automated machine can do the task easily in short time.

MT system generally follows major three stages namely

parsing, transfer and generation stages. Syntactic information about the sentence can be gathered from parsing stage. In most of the cases, CFG is used for translating Bangla sentences to English sentences. But CFG can't parse all types of Bangla sentences. CFG fails to indicate discontinuous constituent, structural similarity and unable to solve the problem of ambiguity [4]. In order to generate different kinds of Bangla sentences, we have to use CSG's due to its capabilities to handle agreement between subject-verb and person class [1,2,3]. Transfer stage transfers the source structure into target language structure using transfer rules. The complete translated sentence can be generated after implementation of generation algorithm

According to structure, there are three kinds of Bangla sentences including simple, compound and complex sentences. Depending on the mood or intonation, Bangla sentences can also divided into five categories namely assertive, interrogative, imperative, optative and exclamatory sentences. The main contribution of this paper is to implement a MT framework that can translate the three types of Bangla sentences such as, imperative, optative and exclamatory into English by using a set of CSG rules.

II. RELATED WORK

MT from Bangla to English or vice-versa is in unsound stage now. A technique to translate Bangla sentence into corresponding English sentence using context sensitive grammar rules is introduced in [1]. A set of context sensitive grammar rules is proposed to translate all kinds of Bangla natural language sentences including assertive, interrogative and imperative sentences. A set of context-sensitive grammars (CSG's) to parse the Bangla sentences including assertive, interrogative and imperative is implemented in [2]. Again, a method to analyze syntactically Bangla sentence using context-sensitive grammar rules which accept almost all types of Bangla sentences including simple, complex and compound sentences is implemented in [5]. A machine translation (MT) system which translates an English sentence into a Bangla sentence of equivalent meaning is implemented in [6]. They have defined context-free grammars (CFGs) for English simple assertive sentences to discover the syntactic structures

of both English and Bangla correct and complete sentences. Some research work has been done in English to Bangla MT in [7]. They proposed a way that represents a new solution for building a MT system for English to Bangla translation by modifying the rule based transfer approach of MT system. A Bangla to English machine translation system using parts of speech tagging is developed in [8]. A set of transformational generative grammar is designed which in conjunction with phrase structure grammar in [9]. It is used to generate or recognize all types of Bengali sentences. Verb based machine translation (VBMT) is a new approach of machine translation (MT) from English to Bangla is presented in [10]. A new approach of MT based on phrase is implemented in [10]. They presented a phrase-based Statistical Machine Translation (SMT) system that translates English sentence to Bangla sentences. After analyzing the related work, we have found that most of the previous MT systems translates the Bangla sentences into English structurally rather than depending on mood or intonation.

III. PROPOSED MT FRAMEWORK

The schematic representation of proposed rule based MT from Bangla to English sentence is illustrated in Fig. 1. Let us consider a Bangla sentence “কি সুন্দর পাখিটি!”. Details processing of this sentence by using this module is given in the following subsections.

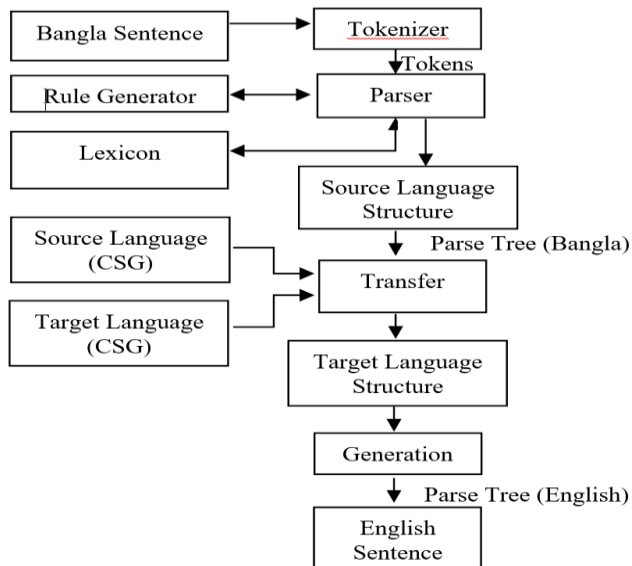


Fig. 1. Proposed MT system

A. Tokenizer

The system starts with the Tokenizer and the input sentence enters into the Tokenizer where a sentence will be parsed. Then the sentence breaks into individual words which are called Tokens. For the further access the tokens are stored. Input sentence: “কি সুন্দর পাখিটি !”

Output of tokenizer: (“কি”, “সুন্দর”, “পাখি”, “টি”, “!”)

Then the result goes to the parser to get the source language structure. Tokens are also taken for checking validity in the bilingual dictionaries.

B. Lexicon

A bilingual dictionary is used as lexicon to store the Bangla words with the English meaning as well as contains features. For example: if we consider a word “বই” then the corresponding English meaning is “book” and feature is “noun” will be found from the lexicon. The typical entries in the lexicon which we have used in our system is shown in the Table 1.

TABLE I. TYPICAL ENTRIES IN LEXICON

Bangla	English	Feature
বই	Book	[N]
রহিম	Rohim	[N, Per 3]
পড়	read	[V]
সাবাস	Bravo	[E.W]
মঙ্গল	bless	[V]
টি	the	[Det]
আল্লাহ	Allah	[N.C]
আস	come	[V]
!	!	[E. M]
আমার	My	[PN]
সুন্দর	beautiful	[Adj]

[Abbreviations: PN: Pronoun, N: Noun, E.W: Exclamatory word, E.M: Exclamatory Marker, N.C: Noun.creator, ind: Indeclinable, V: Verb, Adj: Adjective]

C. Rule Generator

In Bangla Exclamatory sentences, we always find an exclamatory word (EW->কি মজা, হায়, আহা,...) at the starting of the sentence and an exclamatory marker (EM->!) after the exclamatory word (e.g., “হায়! আমার মা আর বেঁচে নেই”). In English Exclamatory sentence, we always find an exclamatory word (EW->Hurrah, Alas, oh,...) at the starting of the sentence and an exclamatory marker (EM->!) after the exclamatory word (e.g., “Alas! My mother is no more”). In the case of request type for Bangla imperative sentences we always find an imperative word (IW->দাও) at the ending of the sentence (e.g., “আমাকে বইটি পড়তে দাও”). In English imperative sentences, we always find an imperative word (IW->Let) at the starting of the sentence (e.g., “Let me read the book”). Again in the case of Bangla optative sentences, we always find an optative word (OW->করুন, ইউক,...) at the ending of the sentence (e.g., “আল্লাহ রহিমকে সাহায্য করুন”). In English optative sentences, we always find an optative word (OW->May) at the starting of the sentence(e.g., “May Allah help Rahim”). Based on the above discussion we have proposed a set of CSG’s rules for Bangla sentences in Table 2.

TABLE II. CSG Rules of Bangla Sentences

Rule No	Bangla CSG’s Rule
1	S->OS IS ES
2	OS->NP VP
3	IS->NP VP
4	ES->AP NP NP VP
5	NP->(N.creator)N PN(BIV)
6	NP->N PN(BIV)
7	NP->N(Det)E.M
8	NP->Null

9	NP→E.W E.M N PN
10	VP→(Adj)V OW
11	VP→(N)(Det)V(Con)IW
12	VP→E.W E.M V(Con)V
13	VP→(Adv)(N)(BIV)V(NEG)
14	AP→WH Adj(Qtfr)
15	WH→ কি
16	V→ মঙ্গল সহায় সাহায্য
17	PN→ তোমার আমার তারা আমাকে আমরা
18	Adj→ দীর্ঘজীবী সুন্দর মজার বাজে সুখী
19	Det→ টি
20	V→ হ কর পড় যে দেখ খেল গাই নাচ জিত
21	BIV→ এর কে য়
22	E.W→ কি সাবাস কি মজা হায়
23	N.creator → আল্লাহ
24	Adv→ আর
25	NEG→ নেই
26	E.W→!
27	Con→ তে
28	Qtfr→ একটি
29	N→ কাজ বই রহিম মা ছবি বাড়ি
30	OW→ করুন হউক.
31	IW→ দাও

[Abbreviations: S: Sentence, OS: Optative sentence, ES: Exclamatory sentence, IS: Imperative sentence, NP: Noun phrase, N: Noun, PN: Pronoun, VP: Verb phrase, VF: Verb form, V: Verb, Qtfr: Quantifier, Biv: Bivokti (inflection), Adj: Adjective, Con: Concord, NEG: Negation, EW: Exclamatory word, EM: Exclamatory marker, OW: Optative word, N.creator: Noun creator, Det: Determiner, IW: Imperative word]

D. Parser

Parser takes tokens as input and with the help of CSG of source language it produces parse tree as output. Parse tree is represented in a list form in our system. The standard representation of structural representation (SR) can be considered as list that is one of the data structures that can be implemented and manipulated very easily with a computer [11].

1) Parsing Algorithm

The input sentence is parsed through the following steps:

Step 1: The output of the tokenizer goes to the parser as input. For example, if the input sentence is “আল্লাহ তোমার মঙ্গল করুন” then the tokens will be (“আল্লাহ”, “তোমার”, “মঙ্গল”, “করুন”). For further access these tokens will store in a stack.

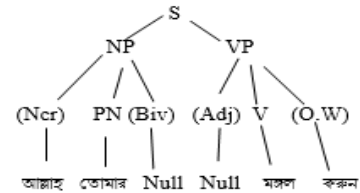
Step 2: In the next step, the tokens will enter into the lexicon for testing its validity. For example, the tokens (“আল্লাহ”, “তোমার”, “মঙ্গল”, “করুন”) will be gone to the lexicon to find its validity.

Step 3: Appropriate parts of speech will be assigned in this step by matching the tokens grammar rules of Bangla. Here, a token must be matched with a rule's right hand side. For example: N.creator→আল্লাহ, PN→ তোমার, V→মঙ্গল, OW→করুন will produce a partial structure.

Step 4: Beginning from the left to right hand side of token list check every rule whose right hand side will match one or more parts of speech. If a right hand side of a rule matches with appropriate parts of speech, then we have to choose that rule [1].

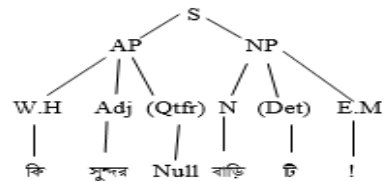
Step 5: Repeat step 4, until no more words remains to generate.

Step 6: When all words have finished the processing generate SR of the sentence in a list. For example: the parser output of the sentence “আল্লাহ তোমার মঙ্গল করুন” is given below-
S[NP[Ncr আল্লাহ][PN তোমার][VP[V মঙ্গল][OW করুন]]
SR of this optative sentence is

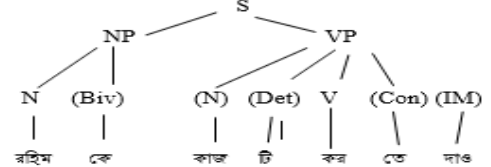


(a) Structural representation of “আল্লাহ তোমার মঙ্গল করুন”

Similarly, by using the steps of the parsing algorithm and rules from table 2, we can generate the parse tree for the exclamatory and imperative Bangla sentences. SR of these sentences are shown in Fig. 2 (b)-(c).



(b) Structural representation of “কি সুন্দর বাড়িটি!”



(c) Structural representation of “রহিমকে কাজটি করতে দাও”

Fig. 2. Structural representation of “আল্লাহ তোমার মঙ্গল করুন”, “কি সুন্দর বাড়িটি!” and “রহিমকে কাজটি করতে দাও”

E. Transfer

In transfer stage, the source language is analyzed into source language dependent representation which is transferred into a target language dependent representation. In order to get the target language structure, we have proposed the CSG rules of English sentences in Table 3. Using Bangla and English CSG rules and tree to tree transformations we can get the target language structure. We have introduced the following algorithm in our system for the transfer stage.

TABLE III. CSG RULES OF ENGLISH SENTENCES

1	S→OS IS ES
2	OS→NP VP
3	IS→NP VP
4	ES→AP NP NP VP
5	NP→O.W N.creator N PN

6	NP→I.W N PN
7	NP→(Det)N(V)E.M
8	NP→Null
9	NP→E.W E.M N PN
10	VP→V(PN)(Adv)(Adj)
11	VP→V(Det)(N)
12	VP→E.W E.M V(Pre)V(Grnd)
13	VP→(Aux)V(Ind)(Adv)(Det)(N)
14	AP->WH(Det)Adj
15	N.creator →Allah
18	Adj→happy beautiful bad nice
19	Adv→long more
20	V→bless help live do go read play sing dance won is
21	OW→May
22	IW→Let
23	E.W→ Bravo Hurrah Alas
24	Det→The a
25	Grnd->ing
26	Pre→on
27	Aux→have
28	NEG->no
29	E.M->!
30	WH-> What How
31	Det->Determiner

[Abbreviations: S: Sentence, OS: Optative sentence, ES: Exclamatory sentence, IS: Imperative sentence, NP: Noun phrase, N: Noun, PN: Pronoun, VP: Verb phrase, VF: Verb form, V: Verb, Qtfr: Quantifier, Biv: Bivokti (inflection), Adj: Adjective, Con: Concord, NEG: Negation, EW: Exclamatory word, EM: Exclamatory marker, OW: Optative word, N.creator: Noun creator, Det: Determiner, IW: Imperative word ,Gr: Gerund, PP: Preposition, WH: Exclamatory Marker]

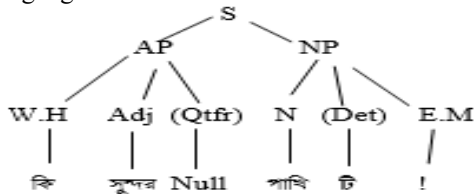
1) *Bangla to English Transfer Algorithm:* The Bangla to English Transfer algorithms can be introduced as following:

Step 1: By searching the grammar rule generator, terminals of the Bangla parse tree can be found. In this stage, the lowest level sub tree of Bangla parse tree is processed.

Step 2: The Bangla- English transfer rules are used for converting an upper level Bangla sub tree to a corresponding English sub-tree. The top node of the upper sub-tree determines which set of Bangla- English transfer rules is to be used [1].

Step 3: The source language structure check the grammar rule generator according to the sub-tree in order to get the target language sub tree by using CSG rules of both types of sentences [1]. For example, we consider the sentence “কি সুন্দর পাখিটি!” as the source language sentence

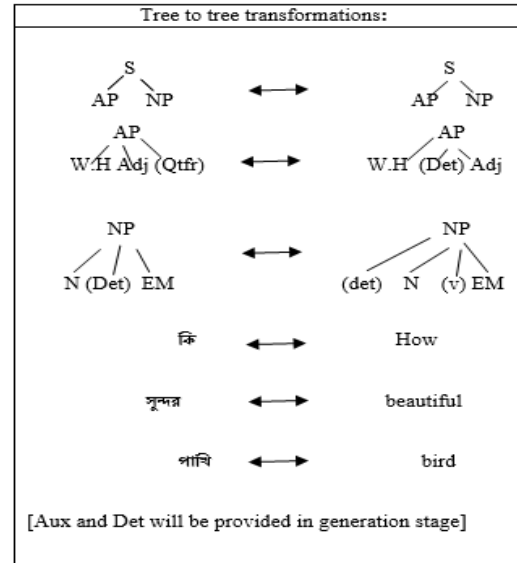
Source Language Tree:



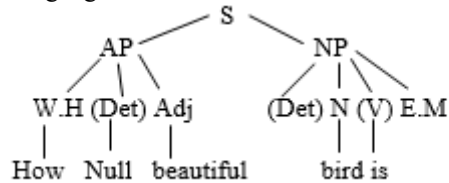
Step 4: Repeat step 3, until no remaining sub trees to process.

Step 5: After completing tree to tree transformation, all the sub trees are transferred into a complete target language tree by using target language CSG rules. For example, the sub trees which we found in the third step can be transferred into the complete parse by using the rules given in table 3.

Tree to Tree Transformations:



Target Language Tree:



Step 6: In the next stage, english auxiliary verb, determiner, negation etc. will be provided.

F. Generation

Determining appropriate English equivalent of adverbs, negation, determiners, generating auxiliary verb and conjunctions including subordinate clauses etc. are the main tasks of generation stage. For example, after the transfer stage we get the target sentence structure of input sentence “কি সুন্দর বাড়িটি!”. As it is an exclamatory sentence we have translated “কি” as “How” instead of “What”. It cannot but help to express the exact expression of the exclamatory sentence. Now, the determiner and exclamatory marker will be provided by the generation stage. Finally, we get our desired translated sentence “How beautiful the bird is!”

1) *Bangla to English Generation Algorithm:* Bangla to English generation algorithm for can be represented as following:

Step 1: Detect sentence type.

Step 1.1: For the Exclamatory sentence, if the first token is a exclamatory word then put the sentence type exclamatory, provide the exclamatory marker (“!”) after the exclamatory word. .

Step 1.2: For the optative sentence, if the last token is optative word in the Bangla sentence then put the sentence type optative and provide optative word (“may”) in the corresponding english sentence.

Step 1.3: For the imperative sentence, it puts the sentence type imperative if there is no noun or pronoun in the first noun phrase [1].

Step 2: Generation stage provides english auxiliary verbs, adverbs, determiners and conjunctions including subordinate clauses etc. to get complete translated sentence with complete target language tree. SR of “ How beautiful the bird is” is represented below:

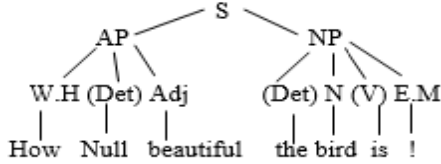


Fig. 3. Structural representation of “How beautiful the bird is!”

IV. IMPLEMENTATION

The implementation snapshots of our proposed MT system for exclamatory, optative and imperative sentences are shown in Figs. 4, 5, and 6 respectively.

Bangla Sentence: হায়! আমার মা আর বেঁচে নেই

Bangla Tree: S[NP[EW হায়][EM !][PN আমার][VP[N মা][ADV আর][V বেঁচে][NEG নেই]]

Sentence Type: Exclamatory

Translated Sentence: Alas! my mother is no more

English Tree: S[NP[EW Alas][EM !][VP[PN my][N mother][V is][NEG no][ADV more]]

Translate

Fig. 4. Translation of the exclamatory sentence of “হায়! আমার মা আর বেঁচে নেই”

Input: হায়! আমার মা আর বেঁচে নেই

Sentence Type: Exclamatory sentence

Bangla parse tree: S[NP[EW হায়][EM !][PN আমার][VP[N মা][ADV আর][V বেঁচে][NEG নেই]]

Translated Sentence: Alas! My mother is no more

English Parse Tree: S[NP[EW Alas][EM !][VP[PN me][N mother][V is][NEG no][ADV more]]

Bangla Sentence: আল্লাহ রহিমকে সাহায্য করুন

Bangla Tree: S[NP[Ncr আল্লাহ][NN রহিম][VP[BIV কে][V সাহায্য][OW করুন]]

Sentence Type: Optative

Translated Sentence: May Allah help Rahim

English Tree: S[NP[OW May][Ncr Allah][VP[V help][NN Rahim]]

Translate

Fig. 5. Translation of optative sentence of “আল্লাহ রহিমকে সাহায্য করুন”

Input: আল্লাহ রহিমকে সাহায্য করুন

Sentence Type: optative sentence

Bangla parse tree: S[NP[Ncr আল্লাহ][NN রহিম][VP[BIV কে][V সাহায্য][OW করুন]]

Translated Sentence: May Allah help Rahim

English Parse Tree: S[NP[OW May][Ncr Allah][VP[V help][NN Rahim]]

Bangla Sentence: আমাকে বইটি পড়তে দাও

Bangla Tree: S[NP[PN আমা][BIV কে][VP[N বই][DET টি][V পড়া][CON তে][IW দাও]]

Sentence Type: Imperative

Translated Sentence: let me read the book

English Tree: S[NP[IW let][PN me][VP[V read][DET the][N book]]

Translate

Fig. 6. Translation of the imperative sentence of “আমাকে বইটি পড়তে দাও”

Input: আমাকে বইটি পড়তে দাও

Sentence Type: imperative sentence

Bangla parse tree: S[NP[PN আমা][BIV কে][VP[N বই][DET টি][V পড়া][CON তে][IW দাও]]

Translated Sentence: let me read the book

English Parse Tree: S[NP[IW let][PN me][VP[V read][DET the][N book]]

V. IMPLEMENTATION

We have tested the system for about 400 different kinds of sentences with various sentence lengths in order to evaluate the effectiveness of our proposed system. These sentences were collected from different Bangla grammar books [12], story books [13], and Bangla text books [14].

A. Success Rate

We have found that total 326 of generated outputs are correct among them about 155 sentences are imperative, 150 sentences are exclamatory and 21 sentences are optative. Success rate denotes the ratio between total no. of correctly translated sentences and total no of input sentences [1]. Overall success rate of proposed system is 81.5%. The success rate of different types of sentence is provided in the table 4. A graph of success rate versus sentence length of the system represents in the Fig. 7. By analyzing the graph, we can say that when sentence length increases then the success rate decreases.

TABLE IV. SUCCESS RATE FOR DIFFERENT TYPES OF SENTENCES

Sentence types	Sentence length	No. of input sentences	No. of correctly translated sentences	Overall success rate (%)
Imperative	3	70	59	80.00
	4	54	44	
	5	70	52	
Exclamatory	2	55	48	80.0
	3	30	25	
	4	55	45	
	5	40	32	
Optative	3	11	9	80.7
	4	15	12	
Total	-	400	326	81.5

VI. CONCLUSION

Designing a MT system that is capable of translating Bangla sentences into English according to the mood or intonation of sentences is the main motive of our work. We have introduced a MT framework that can translate Bangla imperative, optative and exclamatory sentences into its equivalent English sentences. Sentence type can be detected by a parsing algorithm and generate the corresponding parse tree efficiently with the help of CSG's. For Bangla to English translation, transfer and generation algorithm are proposed. Experimental result shows that it is functioning well with 82% accuracy though the proposed MT system is evaluated for limited sentences. Semantic features can be implemented on the system in future.

REFERENCES

- [1] M. S. Arefin, M. M. Hoque, M. O. Rahman and M. S. Arefin, "Machine Translation Framework for Translating Bangla Assertive, Interrogative and Imperative Sentences into English ", In Proc. 2nd International Conference on Electrical Engineering and Information Communication Technology, ICEEICT'15, Jahangirnagar University, Dhaka, Bangladesh, 2015.
- [2] M.S . Arefin, L. Alam, S. Sharmin and M. M. Hoque, "An Empirical Framework for Parsing Bangla Assertive, Interrogative and Imperative Sentences" In Proc. 1st International Conference on Computer and Information Engineering, ICCIE'15, RUET, Bangladesh, 2015.
- [3] M. M. Hoque and M. M. Ali, "Context-sensitive phrase structure rules for structural representation of Bangla natural language sentences ", In Proc. ICCIT'04, Bangladesh, pp. 615-620, 2004.
- [4] Md. M. Anwar, M. Z. Anwar and Md. A. Bhuiyan, "Syntax Analysis and Machine Translation of Bangla Sentences", IJCSNS International Journal of Computer Science and Network Security, VOL.9 No.8, August 2009.
- [5] Md. M. Anwar, M. Z. Anwar and Md. A. Bhuiyan, "Syntax Analysis and Machine Translation of Bangla Sentences", IJCSNS International Journal of Computer Science and Network Security, VOL.9 No.8, August 2009.
- [6] S. S. Ashrafi, Md. H. Kabir, Md. M. Anwar and A. K. M. Noman, "English to Bangla machine translation system using Context-Free Grammar ", IJCSI International Journal of Computer Science Issues, Vol. 10, Issue 3, No 2, pp. 287-293, May 2013.
- [7] M. G. R. Alam, M. M. Islam, N. Islam, "A New Approach To Develop An English To Bangla Machine Translation System ", Journal of Modern Science and Technology, Vol 6, No 1, 2011.
- [8] M. S. A. Chowdhury, "Developing a Bangla to English Machine Translation System Using Parts Of Speech Tagging", Journal of Modern Science and Technology.
- [9] M. R. Selim and M. Z. Iqbal, "Transformational Generative Grammar for Various Types of Bengali Sentences", SUST Studies, Vol. 12, No.1, pp. 276-280, 2010.
- [10] M. Rabbani, K.M.R. Alam, M. Islam, "A new verb based approach for English to Bangla machine translation," ICIEV'14, pp.1-6, 2014.
- [11] H. Azad, Bakyatattya(বাক্যতত্ত), The University of Dhaka, Dhaka, 1994.
- [12] H. Mamud, Vasha-shikha (ভাষা-শিক্ষা), 2006.
- [13] M. Z. Iqbal, Dipu Number two (দিপু নাম্বার টু), 1996.
- [14] Bangla Bakoron(বাংলা ব্যাকরণ), Class six(ষষ্ঠ শ্রেণী), 2014.
- [15] S.M Zakir Hossain, "A Passage to the English Language", 2005.
- [16] D. Arnold, et. al., "Machine translation an introductory guide", Ncc, Blackwell Ltd., London, 1994.

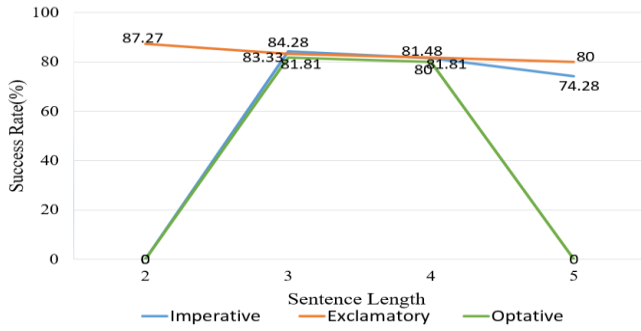


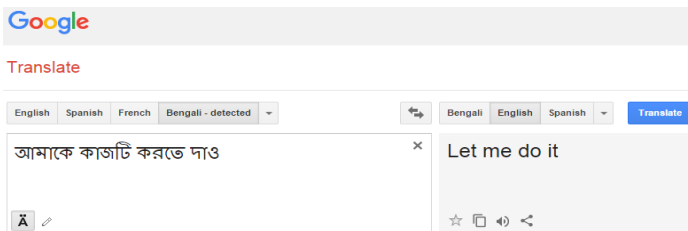
Fig. 7. Success rate vs. sentence length for different types of sentences

A. Comparison with Google Translator

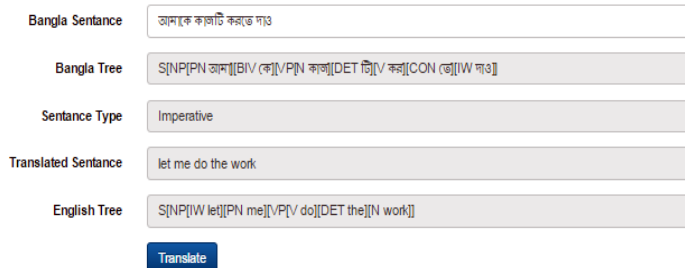
Google Translate is a free multilingual machine translation service provided by Google which uses statistical translation method to translate text, speech, images, or real-time video from one language into another. In order to compare our proposed translator with Google translator we have considered selective 50 sentences for both translator. Although we have tested some selected sentences, results show that the proposed system is working better than the Google translator. This data was taken at 2pm on 10 October 2015 from Google Translator. Table 5 summarizes results of both translators. We have provided the snap shots for a sentence ("আমাকে কাজটি করতে দাও") in proposed translator [Fig. 8 (a)] and Google translator [Fig. 8 (b)].

TABLE V. COMPARISON OF GOOGLE TRANSLATOR VS. PROPOSED TRANSLATOR

Translator	Sentence Length	Sentences	Total no. of sentences	Correctly translated	Success rate (%)
Proposed	3	20	50	41	82
	4	30			
Google	3	20	50	32	64
	4	30			



(a) Snapshot of "আমাকে কাজটি করতে দাও" for Google translator.



(b) Snapshot of "আমাকে কাজটি করতে দাও" for proposed translator.

Fig. 8. Google translator output vs. proposed translator output