Bangla Syntax Analysis: A Comprehensive Approach

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Abstract: *A few researches have been carried out to efficiently recognize natural Bangla sentences. This paper proposes a technique to parse Bangla sentences in a new approach using context-free grammar rules that accepts all types of Bangla sentences including complex, compound, exclamatory and optative sentences. The proposed grammar also allows parsing all five categories of sentences according to Bangla intonation. As the inflection of verb plays a very important role in Bangla parsing, special attention has been paid in decomposing the verb and then extracting the information from the inflection.*

1. Introduction

Natural language processing is a very challenging field of modern computer science because of the versatile characteristics of the concerned language, apart from the perspective of the machine translator itself. In particular, MT [3][4][6] is one of the most promising applications of NLP [6][7]. NLP allows people to interact with computers in a natural human language such as Bangla.

Though the computerization of Bangla is an inevitable need, only a few researches [2][5][8] have been made to efficiently recognize natural Bangla sentences. This paper proposes a technique to parse Bangla sentences in a new approach using context-free grammar rules that accept all types of Bangla sentences.

Section 2 describes the previous works in this field and section 3 gives a diagrammatic model of our proposed parser. Section 4 contains a brief review of the basic Bangla grammar [10]. Section 5 lists the first set of grammar rules for the parser, followed by examples of sentence parsing according to the structure. Section 6 lists the second set of rules, followed by examples of parsing according to the intonation of verb. Some particular areas have been pointed out in section 7 for future research.

2. Past Advancements

Murshed [5] proposed a set of grammar rules which starts parsing by breaking a sentence into noun phrase and verb phrase. Sharaf [7] depicted the relation between object-oriented concepts and NLP systems that can be introduced for Bangla. Mortuza and Ali [2] suggested a way to develop an MT dictionary, which can be a useful tool in the lexical analysis phase.

Selim and Iqbal [8] described a way of syntax analysis of different types of Bangla sentences with the help of a transformational generative grammar. They also showed ways to parse different types of Bangla sentences and proposed an algorithm for the parser.

3. The Proposed Model

It has been observed that recent propositions to build a Bangla parser do not cover the wide category of ways to form Bangla sentences. For example, the breaking of a sentence into NP and VP may be well suited for simple sentences like " সে নিয়মিত লেখাপড়া করে [*Se niomito lekhapora kore* / He studies regularly]", but sentences that are complex or compound cannot be parsed by this grammar [5][8]. This is why we have proposed the starting rule to parse all types of sentences, including complex, compound, exclamatory and optative sentences, which were not considered before.

Secondly, according to Bangla intonation(স্বরভঙ্গি)[10], sentences can be divided into five broad categories as given in section 4. The proposed grammar allows parsing all these types in a new approach. Examples of parse trees of all these types have also been provided in sections 5 and 6.

Thirdly, the Bangla grammar has an excellent inherent property in forming the verbs, that is, unlike the English grammar, various necessary information of a sentence such as the tense, the person, the mode of verb (ক্রিয়ার ভাব) etc. can be extracted from a finite verb. Previous works did so by decomposing the verb phrase [5][8]. As we noted that the inflection of verb (ক্রিয়া-বিভক্তি) plays a very important role in this regard, the proposed grammar has paid special attention in decomposing the verb and then extracting the information.

The parser should accept all Bangla sentences that are syntactically correct, parse each of them using the rules of the proposed grammar, or report an error otherwise. Figure 1 shows the model.

The analysis is divided into 3 phases:

1. Lexical analysis phase: In this phase the stream of characters are sequentially scanned and grouped into tokens or lexicons.

2. Syntax analysis phase: The parser is the most important tool of this phase. To ensure its validity within the underlying grammar, every sentence must be checked by the parser. The lexicons having a collective meaning are grouped together.

The parser involves grouping of tokens into grammatical phrases that are later used to synthesize the output. Usually, the phrases are represented by a parse tree that depicts the syntactic structure of the input. Some examples are given in section 4 and 5.

3. Semantic analysis phase: This is the last phase of analysis where certain checks are made to ensure that the discrete input components fit together meaningfully. This phase is highly application-dependent and is regulated by the norms and rules of the concerned natural language.

This paper focuses on the formation and use of the grammar rules to be used by the parser in the ***syntax analysis*** phase.

4. Bangla Grammar Review

Structurally, there are three types of Bangla sentences:

a. Simple Sentence (সরল বাক্য),
b. Complex Sentence (জটিল বাক্য),
c. Compound Sentence (যৌগিক বাক্য).

Each of these has been defined using clause. ***Clause*** (খন্ডবাক্য) [10] is the subpart of a Bangla sentence that has a meaning. There are two types of Bangla clause:

a. Principal clause (প্রধান খন্ডবাক্য),
b. Subordinate clause (আশ্রিত খন্ডবাক্য)

A ***simple sentence*** is formed by an independent clause or principal clause. *Example:* শাহেদ স্কুলে যায়

A ***complex sentence*** is formed by one principal clause and one or more subordinate clause(s).
Example: যদি বৃষ্টি হয় তাহলে যেও না

A ***compound sentence*** is formed by two or more principal clauses joined by an indeclinable (অব্যয় পদ). *Example:* সূর্য ওঠে এবং কাজ শুরু হয়

Now, a simple sentence can have two parts:
a. Subject (উদ্দেশ্য), **b.** Predicate (বিধেয়)

Subject: There are two types of subject:

a. Simple Subject (সরল উদ্দেশ্য),
b. Expanded Subject (সম্প্রসাবিত উদ্দেশ্য)

Predicate: There are two types of predicate:

a. Simple Predicate (সরল বিধেয়),
b. Expanded Predicate (সম্প্রসারিত বিধেয়)

From this structural point of view we can develop the following rules to parse any type of sentences. Examples are selected so that they follow the most general syntax of Bangla sentences.

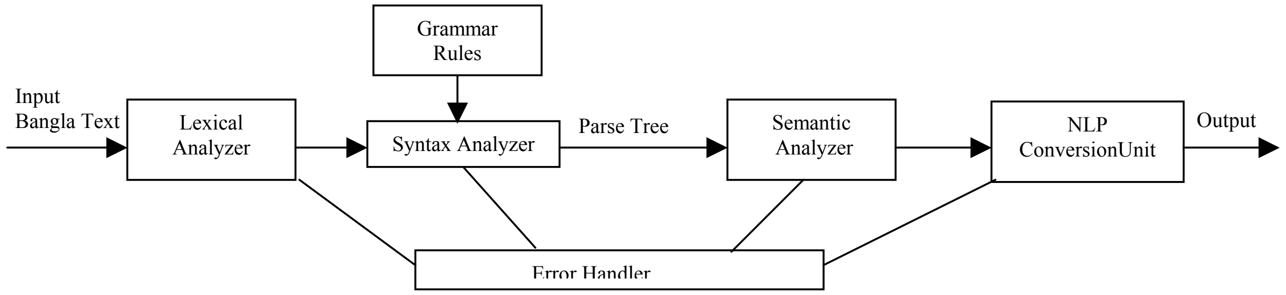


Figure 1: ***Block diagram of the proposed model***

5. ***Set 1: Basic rules to parse a sentence****

1. Sentence -> Simple sentence | Complex sentence | Compound sentence;

2. Simple sentence -> Principle clause;

3. Complex sentence -> Subordinate part + Additive word + Principal clause | Principal clause + Additive word + Subordinate part, **4.** Subordinate part -> Subordinate clause | Subordinate clause + Additive word + Subordinate part,

5. Subordinate clause -> Additive word + Principal clause;

6. Additive word -> Indeclinable | Null; **7.** Compound sentence -> Principal clause + Additive word + Compound part;

8. Compound part -> Principal clause | Compound sentence; **9.** Principal clause -> Subject + Predicate;

10. Subject -> Simple subject | Expanded subject;

11. Predicate -> Simple predicate | Expanded predicate; **12.** Simple Subject -> Actor (কর্তৃপদ);

13. Actor -> Noun + Inflection | Pronoun + Inflection | Implicit (উহ্য) Actor; **14.** Pronoun -> Person ; **15.** Person -> FP | SP | TP;

16. FP -> aami | aamraa; **17.** SP -> SPH | SPNH | SPP; **18.** SPH-> aapni | aapnaara; **19.** SPNH -> tumi | tomraa;

20. SPP -> tui | toraa; **21.** TP -> TPH | TPNH; **22.** TPH -> tini | taaraa; **23.** TPNH -> shey | taaraa; **24.** Implicit Actor -> Null;

25. Expanded Subject -> Sub-expander + Subject;

26. Sub-expander -> Adjective | Adjective + Infinite verb | Adjective clause | Relative part (সম্বন্ধ পদ/পদসমষ্টি) | Relative part + Adjective | Adverbial clause;

27. Relative part -> Noun + এর (er) | Pronoun + এর | Adjective + এর , **28.** Simple predicate -> Verb clause | Implicit verb;

29. Implicit verb -> Null; **30.** Expanded predicate -> Pre-expander + Verb clause;

31. Pre-expander -> Adverb | Adverb + Adverb | Adverb + Object (কর্মপদ) | Adjective + Object | Adjective expander (বিশেষণের বিশেষণ) + Adjective + Object | Object | Adverbial clause;

32. Object -> Noun | Pronoun | Relative part + Noun | Relative part + Pronoun | Null;

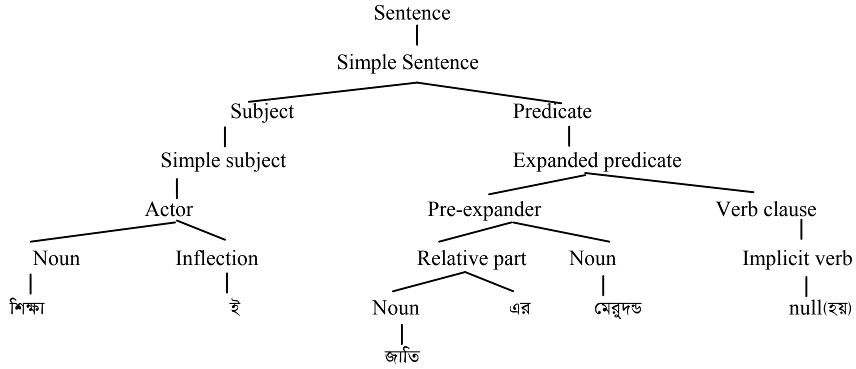
33. Verb clause -> Infinite verb + Finite verb | Finite verb | Implicit verb | Infinite verb + Finite verb + Indeclinable | Finite verb + Indeclinable(অব্যয় পদ);

34. Indeclinable -> না (na) | Other;

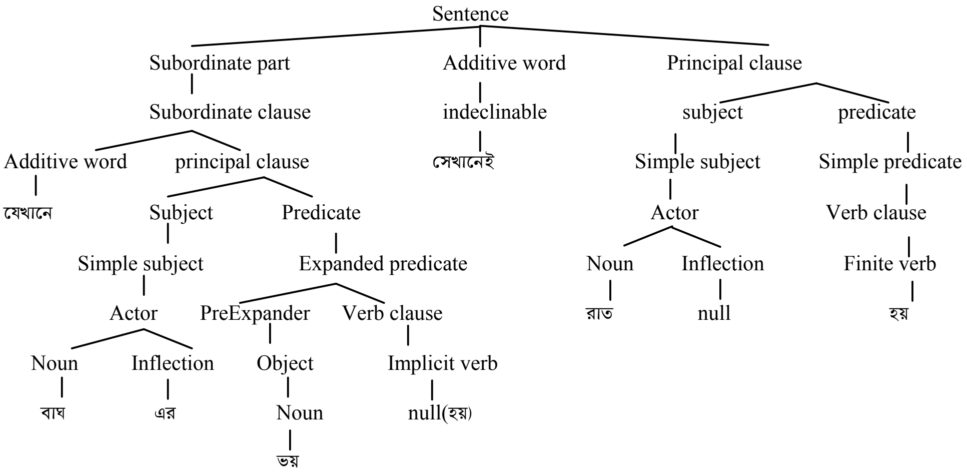
* The '**->**' sign means the phrase "*can have the form of*", the '|' sign indicates *an alternative rule* for the left-side term and the '+' sign means *join* of two terms of a sentence.

5.1 Examples of sentences according to structure:

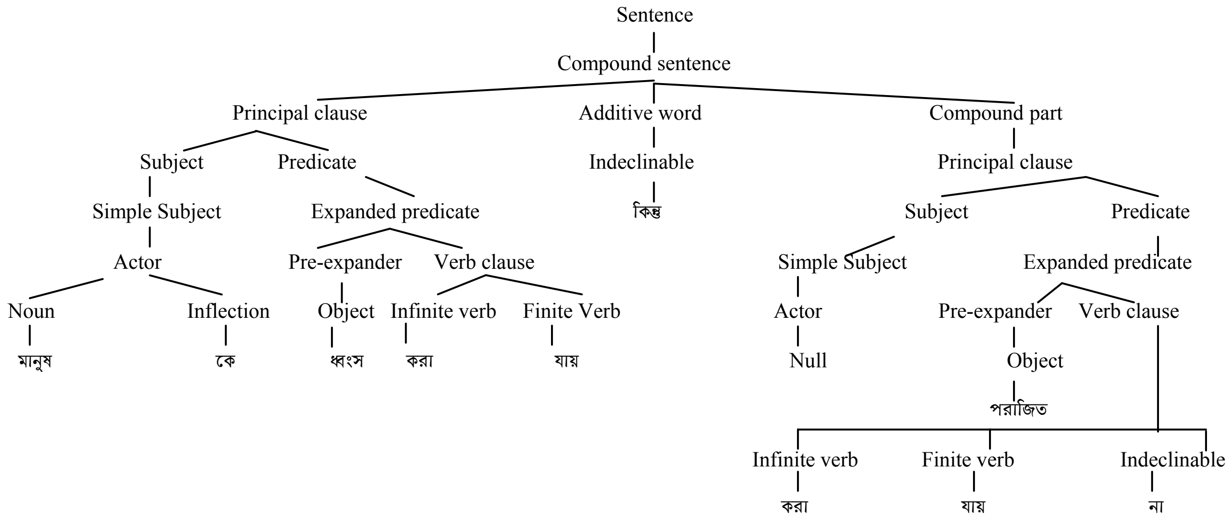
Simple Sentence: শিক্ষাই জাতির মেরুদন্ড



Complex Sentence: যেখানে বাঘের ভয় সেখানেই রাত হয়

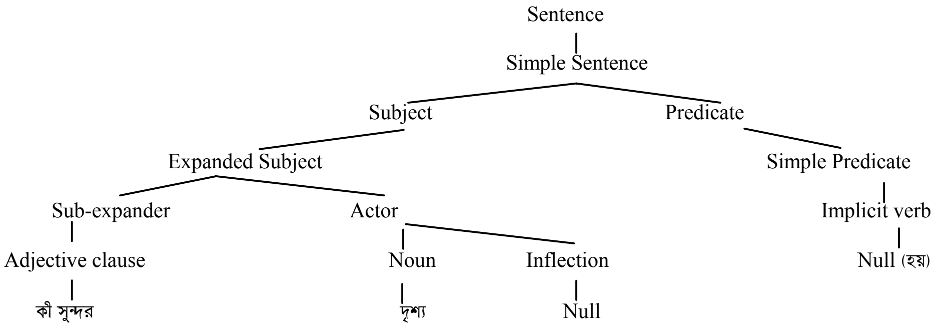


Compound Sentence: মানুষকে ধ্বংস করা যায় কিন্তু পরাজিত করা যায় না

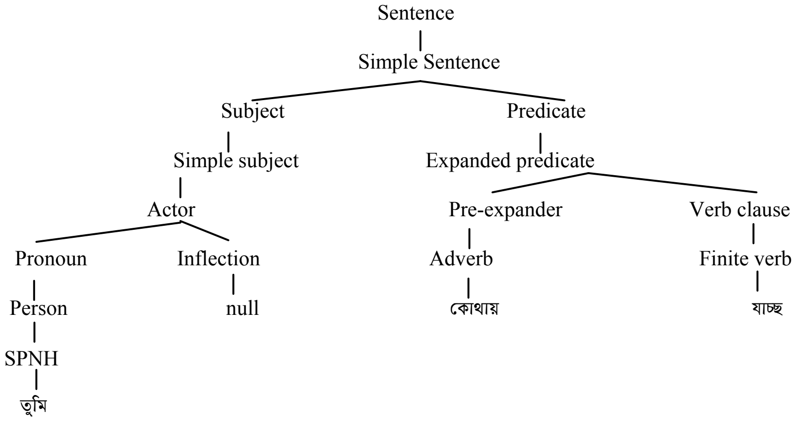


5.2 Examples of sentences according to intonation:

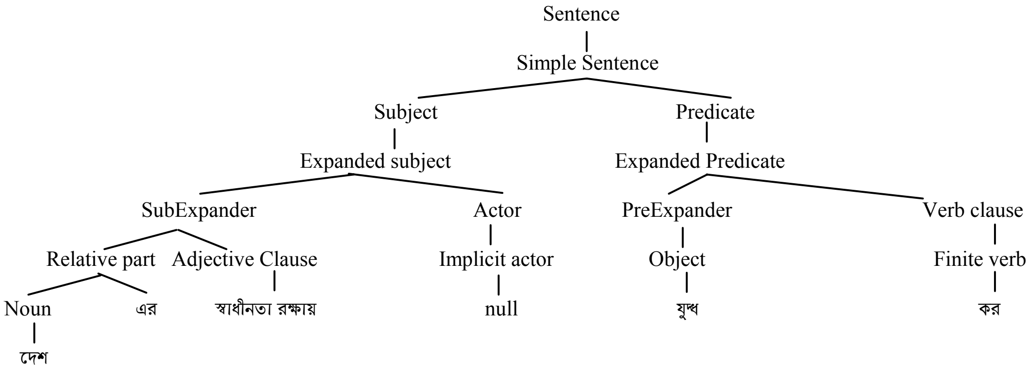
Exclamatory Sentence: কী সুন্দর দৃশ্য



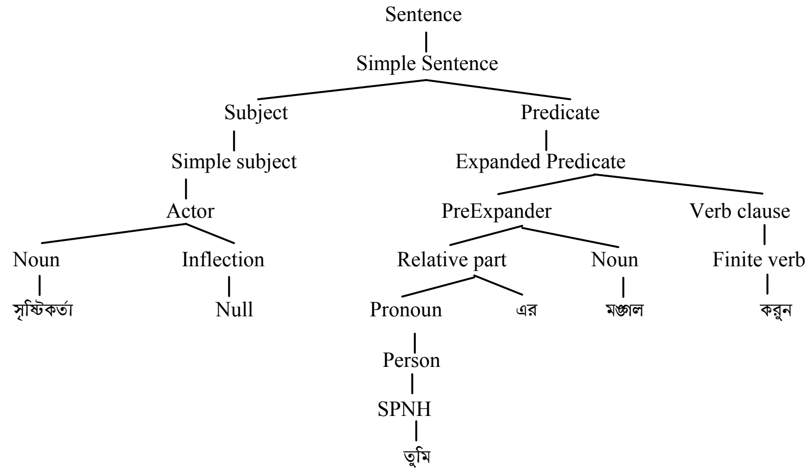
Interrogative Sentence: তুমি কোথায় যাচ্ছ



Imperative Sentence: দেশের স্বাধীনতা রক্ষায় যুম্ধ কর



Optative Sentence: সৃষ্টিকর্তা তোমার মঙ্গাল করুন



As mentioned earlier, depending on intonation (স্বরভঙ্গি), Bangla sentences can be divided into five categories:

a. Assertive Sentence (বিবৃতিমুলক বাক্য),
b. Interrogative Sentenc(প্রশ্নসূচক বাক্য),
c. Exclamatory Sentence (বিস্ময়সুচক বাক্য),
d. Optative Sentence (ইচ্ছাসুচক বাক্য),
e. Imperative Sentence (আদেশ বাচক বাক্য).

By the rules given in set 1, we can parse all of them. Some examples are shown below.

The first example of a simple sentence also serves as an example of an assertive sentence.

6. Parsing of Bangla Finite Verbs

Murshed [4] proposed parsing method for different forms of Bangla present tense. We extend the set by proposing methods for all other types. The types of Bangla tense are shown in figure2.

Murshed [5] used a name 'AUX' for the inflection of Bangla verb (ক্রিয়া-বিভক্তি). In fact, the inflection of Bangla verb can have different forms depending on the tense, the person and the class of subject of the verb. The forms are described in table 1.

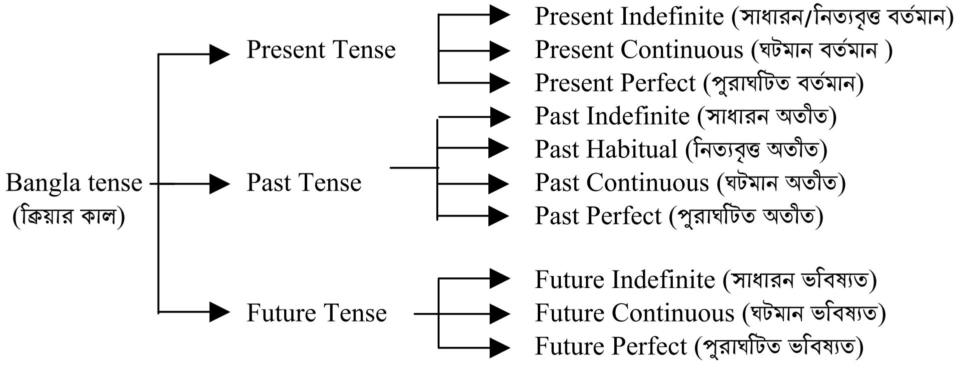

Bangla tense
(ক্রিয়ার কাল)
Present Tense
Past Tense
Future Tense
Present Indefinite (সাধারন/নিত্যবৃত্ত বর্তমান)
Present Continuous (ঘটমান বর্তমান)
Present Perfect (পুরাঘটিত বর্তমান)
Past Indefinite (সাধারন অতীত)
Past Habitual (নিত্যবৃত্ত অতীত)
Past Continuous (ঘটমান অতীত)
Past Perfect (পুরাঘটিত অতীত)
Future Indefinite (সাধারন ভবিষ্যত)
Future Continuous (ঘটমান ভবিষ্যত)
Future Perfect (পুরাঘটিত ভবিষ্যত)

Figure 2: **Types of Bangla tense**

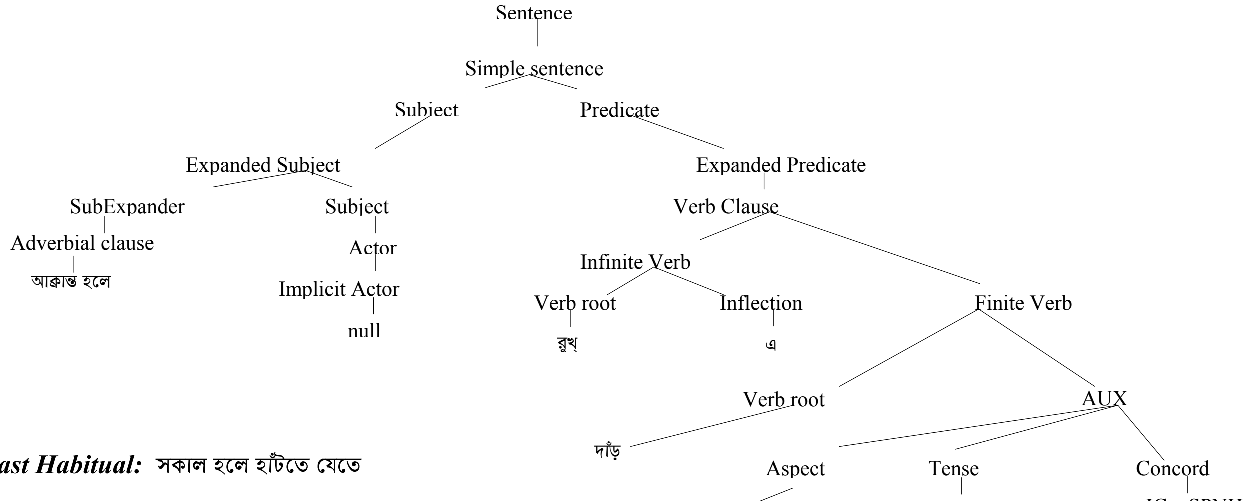
After a thorough observation of table 1, we propose the second set of grammar rules to further decompose and extract information from the finite verb of a sentence. Three examples of parse trees involving less frequently used tenses are also follow to show the decomposition process.

Set 2: Rules to decompose finite verbs

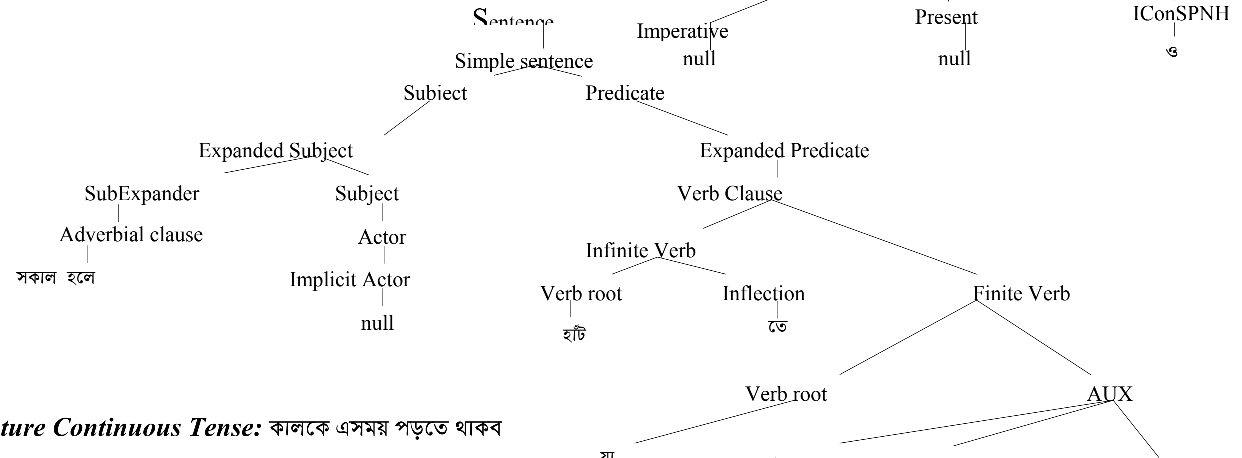
35. Finite verb -> VR + AUX;
36. VR -> কর্ (kor) | যা (ja) | Other verb roots(ক্রিয়ামুল)
37. AUX -> Aspect + Tense + Concord;
38. Tense -> Present | Past | Future

39. Aspect -> Indefinite | Continuous | Perfect | Imperative | Habitual
40. Concord -> NonImperativeCon | ImperativeCon;
41. Present -> null; **42.** Past -> ল (l) | ইল (il)
43. Future -> ব (b) | বো (bo); **44.** Indefinite -> Null;
45. Continuous -> ছ (chh) | চ্ছ (chchh)
46. Perfect -> এছ (echh); **47.** Imperative -> Null;
48. Habitual -> ত (t)
49. NonImperativeCon -> NIConFP | NIConSPH | NIConSPNH | NIConSPP | NIConTPH | NIConTPNH
50. ImperativeCon -> IConSPH | IConSPNH | IConSPP | IConTPH | IConTPNH
51. NIConFP -> ই (i) | আম (am) | Null | ও (o);
52. NIConSPH -> এন (en); **53.** NIConSPNH -> Null | এ (e)
54. NIConSPP -> ইস্ (ish) | ই (i); **55.** NIConTPH -> এন (en); **56.** NIConTPNH-> এ (e) | Null
57. IConSPH -> উন (un) | এন (en); **58.** IConSPNH -> ও (o);
59. IConSPP -> ইস্ (ish) | Null
60. IConTPH -> এন (en) | উন (un); **61.** IConTPNH-> এ (e) | উক (uk); **62.** Infinite Verb -> Verb root + Inflection.

Present Imperative Tense: আক্রান্ত হলে রুখে দাঁড়াও



Past Habitual: সকাল হলে হাঁটতে যেতে



Future Continuous Tense: কালকে এসময় পড়তে থাকব

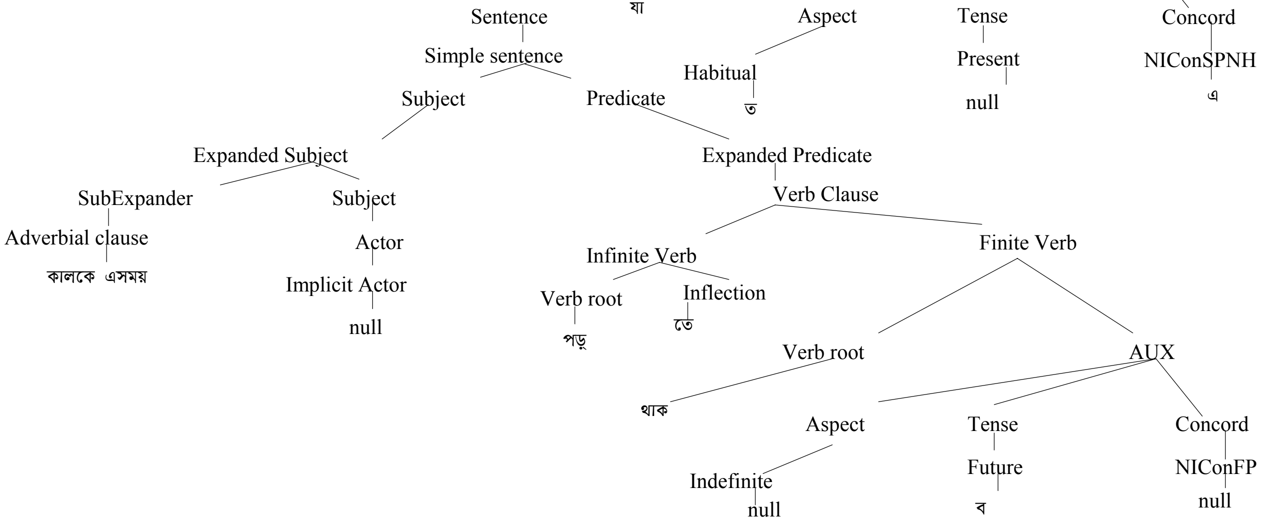


Table 1: Forms of Inflection of Verb

Tense	FP (আমি , আমরা)	SPH (আপনি , আপনারা)	SPNH (তুমি , তোমরা)	SPP (তুই, তোরা)	TPH (তিনি, তাঁরা)	TPNH (সে, তারা)
PrInd	ই (i) কর্ + ই = করি Kor + i = kori	এন (en) কর্ + এন = করেন Kor + en =koren	অ (o) কর্ + অ = কর Kor + o = koro	ইস্ (ish) কর্ + ইস্ = করিস্ Kor + ish= Korish	এন (en) কর্ + এন = করেন Kor + en =koren	এ (e) কর্ + এ = করে Kor + e =kore
PrCon	ছ/চ্ছ + ই = ছি/চ্ছি (chhi/chchhi) কর্ + ছি = করছি Kor + chhi = Korchhi	ছ/চ্ছ + এন = ছেন/চ্ছেন (chhen/chchhen) কর্ + ছেন = কর্ছেন Kor + chhen= Korchhen	ছ/চ্ছ + অ = ছ/চ্ছ (chho/chchho) কর্ + ছ = করছ Kor + chho = Korchho	ছ/চ্ছ + ইস্ = ছিস্/চ্ছিস্ (chhish/chchhish) কর্ + ছিস্ = করছিস্ Kor + chhish = Korchhish	ছ/চ্ছ + এন = ছেন/চ্ছেন (chhen/chchhen) কর্ + ছেন = কর্ছেন Kor + chhen= Korchhen	ছ/চ্ছ + এ = ছেন/চ্ছে (chhe/chchhe) কর্ + ছে = কর্ছে Kor + chhe= Korchhe
PrPer	এছ/এচ্ছ + ই = এছি/এচ্ছি (echhi/echchhi) কর্ + এছি = করেছি Kor + echhi = Korechhi	এছ/এচ্ছ + এন =এছেন/এচ্ছেন (echhen/echchhen) কর্ +এছেন = করে্ছেন Kor + echhen= Korechhen	এছ/এচ্ছ +অ = এছ/এচ্ছ (echho/echchho) কর্ + এছ = করেছ Kor + echho = Korechho	এছ/এচ্ছ + ইস্ = এছিস্/এচ্ছিস্ (echhish/echchhish) কর্ + এছিস্ = করেছিস্ Kor + echhish = Korechhish	এছ/এচ্ছ + এন =এছেন/এচ্ছেন (echhen/echchhen) কর্ +এছেন = করে্ছেন Kor + echhen= Korechhen	এছ/এচ্ছ + এ =এছে/এচ্ছে (echhe/echchhe) কর্ +এছে = করে্ছে Kor + echhe= Korechhe
PrImp	[Not applicable]	উন (un) কর্ +উন = করুন Kor + un =korun	অ (o) কর্ + অ = কর Kor + o = koro	Null কর্ + null = কর্ Kor + null = kor	উন (un) কর্ +উন = করুন Kor + un =korun	উন (uk) কর্ +উক = করুক Kor + uk =koruk
PtInd	ল+আম = লাম (lam) কর্ + লাম= করলাম Kor + lam= Korlam	ল+ এন= লেন(len) কর্ + লেন = করলেন Kor + len = Korlen	ল+ এ= লে(le) কর্ + লে = করলে Kor + le = Korle	ল+ ই= লি(li) কর্ + লি = করলি Kor + li = Korli	ল+ এন= লেন(len) কর্ + লেন = করলেন Kor + len = Korlen	ল+ null= ল(lo) কর্ + ল = করল Kor + lo = Korlo
PtHab	ত+আম = তাম (tam) কর্ + তাম= করতাম Kor + tam= Kortam	ত+ এন= তেন(ten) কর্ + তেন = করতেন Kor + ten = Korten	ত+ এ= তে(te) কর্ + তে = করতে Kor + te = Korte	ত+ ই= তি(ti) কর্ + তি = করতি Kor + ti = Korti	ত+ এন= তেন(ten) কর্ + তেন = করতেন Kor + ten = Korten	ত+ null= ত(to) কর্ + ত = করত Kor + to = Korto
PtCon	ছ + ই ল+আম = ছিলাম (chhilam) কর্ +ছিলাম= করছিলাম Kor +chhilam= Korchhilam	ছ + ই ল+ এন= ছিলেন(chhilen) কর্ + ছিলেন = করছিলেন Kor + chhilen = Korchhilen	ছ + ই ল+ এ= ছিলে(chhile) কর্ + ছিলে = করছিলে Kor + chhile = Korchhile	ছ + ই ল+ ই = ছিলি(chhili) কর্ + ছিলি = করছিলি Kor + chhili = Korchhili	ছ + ই ল+ এন= ছিলেন(chhilen) কর্ + ছিলেন = করছিলেন Kor + chhilen = Korchhilen	ছ + ই ল+ null= ছিল(chhilo) কর্ + ছিল = করছিল Kor + chhilo = Korchhilo
PtPer	এছ + ই ল+আম = এছিলাম (echhilam) কর্ +এছিলাম= করেছিলাম Kor +echhilam= Korechhilam	এছ + ই ল+ এন= এছিলেন(chhilen) কর্ + এছিলেন = করেছিলেন Kor + echhilen = Korechhilen	এছ + ই ল+ এ= এছিলে(chhile) কর্ + এছিলে = করেছিলে Kor + echhile = Korechhile	এছ + ই ল+ ই = এছিলি(chhili) কর্ +এছিলি = করেছিলি Kor + echhili = Korechhili	এছ + ই ল+ এন= এছিলেন(chhilen) কর্ + এছিলেন = করেছিলেন Kor + echhilen = Korechhilen	এছ + ই ল+ null= এছিল(chhilo) কর্ + এছিল = করেছিল Kor + echhilo = Korechhilo
FuInd	ব + null/ ও = ব/বো (bo) কর্ + ব = করব Kor + bo = Korbo	ব + এন =বেন (ben) কর্ + বেন = করবেন Kor + ben = Korben	ব + এ =বে (be) কর্ + বে = করবে Kor + be = Korbe	ব + ই =বি (bi) কর্ + বি = করবি Kor + bi = Korbi	ব + এন =বেন (ben) কর্ + বেন = করবেন Kor + ben = Korben	ব + এ =বে (be) কর্ + বে = করবে Kor + be = Korbe
FuCon	তে থাকব (Te thakbo)	তে থাকবেন (Te thakben)	তে থাকবে (Te thakbe)	তে থাকবি (Te thakbi)	তে থাকবেন (Te thakben)	তে থাকবে (Te thakbe)
FuPer	এ থাকব (e thakbo)	এ থাকবেন (e thakben)	এ থাকবে (e thakbe)	এ থাকবি (e thakbi)	এ থাকবেন (e thakben)	এ থাকবে (e thakbe)
FuImp	Not applicable	ব + এন =বেন (ben) কর্ + বেন = করবেন Kor + ben = Korben	ও (o) কর্ + ও = করো Kor + o = koro	ইস(ish) কর্ + ইস = করিস Kor + ish= Korish	ব + এন =বেন (ben) কর্ + বেন = করবেন Kor + ben = Korben	ব + এ =বে (be) কর্ + বে = করবে Kor + be = Korbe

7. Future Research Areas

The following points should be considered by the future researchers to enhance and improve the proposed model. Due to the constraint in space, we could not include grammar rules to handle various Bangla punctuation symbols. As this paper mainly focuses on the syntax analysis phase, it sets aside the job of extracting additional information about the other parts of speech such as the noun, the pronoun, the adjective, the adverb and the indeclinable which will be of great use in the semantic analysis phase. The concepts of the change of voice, narration and other special concepts of Bangla grammar such as the composition of words (সমাস) and inflection of the noun or pronoun (নাম-বিভক্তি) should be further analyzed As the major emphasis was given to parse the finite verb of the sentence, other types of clauses like the adverbial or adjective clauses were not parsed further.

8. Conclusion

This paper proposes a technique to parse Bangla sentences in a new approach using context-free grammar rules. The principal goal was to design a parser that is capable of accepting all types of Bangla sentences, both from the structural viewpoint and the viewpoint of intonation of verb. Innovative efforts in the areas of future expandability can treat this paper as a starting milestone.

Abbreviations used

MT Machine Translation, **NLP** Natural Language Processing,
NP Noun Phrase, **VP** Verb Phrase, **FP** First Person
SP Second Person, **SPH** Second Person Honorific,
SPNH Second Person Non Honorific, **TP** Third Person
SPP Second Person Pejorative, **TPH** Third Person Honorific,
TPNH Third Person Non Honorific
NonImperativeCon Non Imperative Concord,
NIConFP Non Imperative Concord for FP
NIConSPH Non Imperative Concord for SPH,
NIConSPNH Non Imperative Concord for SPNH
NIConSPP Non Imperative Concord for SPP,
NIConTPH Non Imperative Concord for TPH
NIConTPNH Non Imperative Concord for TPNH,
ImperativeCon Imperative Concord
IConFP Imperative Concord for FP,
IConSPH Imperative Concord for SPH,
IConSPNH Imperative Concord for SPNH,
IConSPP Imperative Concord for SPP
IConTPH Imperative Concord for TPH,
IConTPNH Imperative Concord for TPNH
PrInd Present Indefinite, **PrCon** Present Continuous,
PrPer Present Perfect, **PrImp** Present Imperative
PtInd Past Indefinite, **PtHab** Past Habitual,
PtCon Past Continuous, **PtPer** Past Perfect,
SubExpander Subject Expander
FuInd Future Indefinite, **FuCon** Future Continuous,
FuPer Future Perfect, **FuImp** Future Imperative,
PreExpander Predicate Expander

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