

UNL-Based Machine Translation Scheme for Bangla Locative Case Constructs

Nawab Y. Ali, Golam S., and Ameer A.

Abstract—Case structure plays a vital role in grammatical structure of any language during language translation. This paper presents an in-depth analysis of Bangla locative case constructs based on UNL (Universal Networking Language) machine translation scheme. A set of analysis rules have been defined to convert various Bangla locative case sentences into UNL expressions that can later be converted to any native language using language independent deconversion rules. We have demonstrated five different analysis rules and illustrated how each of them can effectively convert Bangla sentences to UNL expressions

Index Terms—Universal networking language (UNL), universal words (UWs), Bangla-UNL dictionary, morphological analysis, EnConverter (EnCo).

I. INTRODUCTION

UNL is a digital meta-language for describing, summarizing, refining and disseminating information in a machine independent and human language neutral form, which represents information in the form of semantic networks with hypergraph. The hypergraph has formal English text realization as English is known to experts. It consists of *Universal Words (UWs)*, *UNL Relations* and *UNL attributes*. An UW expresses the English equivalent meaning of the word along with some constraints lists and is to be used in creating UNL expression of output. UNL Relations are the building blocks of UNL expressions. The existence of UNL expressions relation is found in between two UWs of sentence. Relation between the words is drawn from a set of predefined relations. The UNL attributes are attached with UWs to provide additional information like tense, numbers etc. to complete the UNL expressions [1]. A set of analysis rules is to be used to generate UNL expressions from Bangla locative case sentences. The EnConverter [1], [2] is a language independent parse that provides synchronously a framework for morphological, syntactic and semantic analyses. EnConverter operates on the nodes of the Node-list through its windows. EnConverter analyses a sentence using the Word Dictionary, and enconversion Rules. It retrieves relevant dictionary entries from the word dictionary, operates on nodes in the Node-list by applying enconversion rules, and generates semantic networks of UNL by consulting the Knowledge Base. It generates UNL expressions from sentences of a native language using enconversion rules by finding the most

suitable rules for the respective sentences. Among the various types of analysis rules described in [2], left & right composition and left & right modification rules play important roles in conversion processes. Composition rules combine the two headwords of the left and right nodes into a composite node to perform the morphological analyses and modification rules create the syntactic trees and the semantic relations of the two nodes on the analysis windows to perform semantic analyses of the sentences. For example, the UNL expression and the UNL graph of the sentence *We live in Bangladesh* is shown in Fig 1.

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{unl}
  aoj(live(icl>be,aoj>person).@entry.@present,we(icl>group).@pl)
  plc(live(icl>be,aoj>person).@entry.@present,bangladesh(iof>asian_country>thing))
{/unl}
```

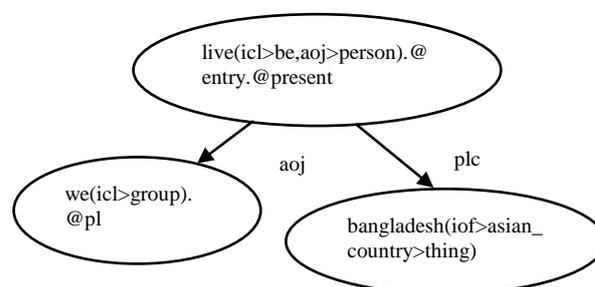


Fig. 1. UNL expressions and UNL graph.

In Fig. 1, aoj is the UNL relation which indicates "thing with attribute"; plc is another UNL relation which indicates "a place where an event occurs"; @entry and @ present are UNL attributes which indicate the main verb and tense information; and attribute @pl indicates number information.

This organization of this paper is determined as following: The literature, which is related to the UNL structure and format of dictionary is illustrated in Section II. Analysis of different Bangla locative case sentences based on UNL structure and development of analysis rules are demonstrated in Section III. In Section IV we have illustrated the step by step conversion procedures of a complete locative case sentence using some analysis rules, and the conclusion of the paper has been drawn along with several concluding remarks in Section V.

II. LITERATURE REVIEW

Generation of Hindi from Universal Networking Language

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has been analyzed by Dwivedi [3]. UNL based MT system for Hindi language and Hindi generation rules for Hindi Enconverter have been analyzed and created by Giri [4], Dave [5]. The analysis of Tamil morphology for the development of Tamil Enconverter has been performed by Dhanabalan [6]. Arabic grammar generator has been proposed for the advancement of Arabic MT system based on UNL by Adly and Alansary [7]. Morphological analyses of Bangla simple and compound words for MT have been discussed in [8], [9]. Similar approaches have also been observed in languages like France, Spanish, Chinese, English, Russian and German [10]. Apparently, numerous research works on morphological analysis of Bangla words for UNL, conversion of Bangla sentence into UNL expressions, algorithms for conversion of Bangla sentence to UNL have been found or in progress for the last few years [11], [12].

III. ANALYSIS OF BANGLA LOCATIVE CATIVE CASE SENTENCES IN CONTEXT OF UNL

In Bangla the locative case is formed differently depending on the ending of the word [12], [13]. For examples, ঢাকা (dhaka) + য় (ye) = ঢাকায় (dhakaye) meaning in English 'in Dhaka', লন্ডন (london) + এ (e) = লন্ডনে (londone) meaning in English 'in London' etc. We have analyzed five categories of locative case sentences and developed analysis rules for those classes of sentences to convert them into UNL expressions.

A. Case in Place

To identify the conditions for case in place we define i) attribute #PLC with verb roots such as 'বস' (bosh), 'থাক' (thak) etc. that can form verbs, ii) attribute #PLC with the name of the places e.g. name of the river, name of the country etc. and finally, iii) case inflexions 'এ' (e) or 'য়' (ye) or 'তে' (te) are included with the nouns/noun phases and an attribute 7TH must be added with nouns or noun phases. Say, consider the following three sentences, 'সে ঢাকায় থাকে', pronounce as, Shey dhakaye thake, meaning, 'He lives in Dhaka', 'আমি সিঙ্গাপুরে থাকি', pronounce as *Aami singapore thaki*, in English, 'I live in Singapore' and 'নদীতে মাছ আছে' pronounce as *Nodite machh ache* meaning 'Fishes are in the river'. In the first sentence, noun 'ঢাকা' (dhaka) is a vowel ended word, where 'ঢাকা' is combined with case inflexion 'য়' (ye) to make 'ঢাকায়' (dhakaye) meaning *in Dhaka* that reflects *case in place* and produces UNL relation *plc* with verb 'থাকে' (thake). And in the second sentence, noun 'সিঙ্গাপুর' (Singapore) is a consonant ended word where 'সিঙ্গাপুর' is combined with case inflexion 'এ' (e) to make 'সিঙ্গাপুরে' meaning *in Singapore* that also reflects *case in place* and produces UNL relation *plc* with verb 'থাকি' (thaki). Whereas in the third sentence, noun 'নদী' (nodi) meaning *river* is a vowel ended word, where 'নদী' is combined with 'তে' (te) to make 'নদীতে' (nodite) meaning *in the river* that also reflects *case in place* and produces UNL relation *plc* with verb 'আছে' (achhe). So, if the place is vowel ended case

inflexions 'য়' (ye) & 'তে' (te) and if the place is consonant ended, the case inflexion 'এ' (e) are used to make *case in place* for *plc* relation. Attributes VEND and CEND are used with all kinds of vowel ended and consonant ended places in all locative cases respectively. Analysis rules for converting the sentences for case in place are as follows:

Rule for morphological analysis:

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+{N,VEND/CEND,#PLC,7TH,^anus,^krok:@::}{INF,KROK,7TH,VEND/CEND,#PLC::}
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Rule for semantic analysis:

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>{N/NP,#PLC,inf,krok,7th::plc:}{V,#PLC::}
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Morphological rule is to be used to complete the morphological analysis between noun and case inflexion and semantic rule is to be used to perform semantic analysis between noun/noun phase and verb by making *plc* relation to convert the sentence into UNL expression where, 'INF' denotes attribute for inflexion, 'KROK' for case inflexion, 'N' for noun, 'NP' for noun phase, and temporary attributes 'inf' and 'krok' are to be used to prevent recursive operations.

B. Case to Place

In case to place we use movement related verb roots such as 'যা' (ja), 'আস' (ash), 'ঘুর' (ghur), 'ফির' (fir), 'দৌড়' (dour) etc. To identify the conditions for case to place we define i) attribute #PLT with verb roots that can form verbs, ii) attribute #PLT with the name of the places and finally iii) case inflexion 0 (zero) is added with nouns/noun phases. For example, consider the following two sentences, 'আমি লন্ডন যাব' pronounce as *Aami london jabo*, meaning "I will go to London" and 'তাহারা বাড়ি যাবে' pronounce as *Tahara bari jabe*, meaning 'They go to home'. In the first sentence, noun 'লন্ডন' london is a consonant ended word where 'লন্ডন' is combined with case inflexion 0 (zero) to make 'লন্ডন' that reflects case to place and produces UNL relation *plt* with verb *jabo*. And in the second sentence, noun 'বাড়ি' (home) is a vowel ended word where 'বাড়ি' is combined with case inflexion '0' (zero) to make 'বাড়ি' that also reflects case to place and produces UNL relation *plt* with verb *jabe*. As inflexion '0' is added in both instances to make noun phases no morphological analysis is needed. Attributes VEND and CEND are used with vowel ended and consonant ended nouns respectively.

Analyses rules for converting the sentences for case in place are as follows:

Rule for morphological analysis:

No analysis rule is required

Rule for semantic analysis:

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>{N/NP,#PLT::plt:}{V,#PLT::}
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This semantic rule performs semantic analysis between noun/noun phase and verb by making *plt* relation to convert the *place to* related locative case sentences into UNL expressions.

C. Case in Time

In order to identify the conditions for case in time we define i) attribute #TIM with verb roots that can form verbs, ii)

attribute #TIM with the nouns related to times e.g. morning, evening, day, night, 6 o clock etc. and finally iii) case inflexions ‘এ’ (e) or ‘য’ (ye) or ‘তে’ (te) must be included with the nouns/noun phases and an attribute 7TH must be added with nouns or noun phases. Consider a sentence, say, ‘আমি প্রত্যহ সকালে রুটি খাই’ pronounce as *aami prottoho shokale ruti khai* meaning ‘I eat bread every morning’. In this sentence, noun সকাল (shokal) meaning *morning* is a consonant ended time where ‘সকাল’ is combined with case inflexion ‘এ’ (e) to make ‘সকালে’ (shokale) meaning *in the morning* that reflects case in time and produces UNL relation *tim* with verb ‘খাই’ (eat).

Analysis rules for converting the sentences for case in time are as follows:

Rule for morphological analysis:

+{N,VEND/CEND,#TIM,7TH,^anus,^krok:@::}{INF,KROK,7TH, VEND/CEND, #TIM::}

Rule for semantic analysis:

>{N/NP,#TIM,VEVD/CEND,inf,krok,7th::tim:}{V,#TIM::}

D. Case to Time

In order to identify the conditions for case to time we define i) attribute #TMT with verb roots that can form verbs, ii) attribute #TMT with the nouns related to times e.g. morning, evening, day, night, 6 o clock etc. and finally iii) case inflexions ‘পর্যন্ত’ (porjonto) or ‘অবধি’ (obodhi) is to be included with the nouns/noun phases. Consider the following two sentences, say, ‘আমি প্রত্যহ বিকাল পর্যন্ত অফিসে থাকি’ pronounce as *Aami prottoho bikal porjonto ofishe thaki* meaning ‘I stay in my office till every afternoon’ and ‘সে আজ রাত ৯টা অবধি বাসায় থাকবে’ pronounce as *Se aaj rat noi ta obodhi bashae thakbe*, in English He will stay at home till 9 pm. In the first sentence, case inflexion ‘পর্যন্ত’ (porjonto) meaning *till* is placed after ‘বিকাল’ (bikal) meaning *afternoon* to make noun phase ‘বিকাল পর্যন্ত’ (bikal porjonto) meaning *till afternoon* and in the second sentence case inflexion ‘অবধি’ (obodhi) meaning *till* is placed after ৯টা (noi-ta) meaning 9 pm to make noun phase ‘৯টা অবধি’ (noi-ta obodhi) meaning *till 9 pm*. Both of them reflect case to time and produce UNL relation *tmf* with verb ‘থাকি’ (thaki) and ‘থাকবে’ (thakbe) respectively.

Analyses rules for converting the sentences for case to time are as follows:

Rule for morphological analysis:

+{N,VEND/CEND,#TMT,^anus,^krok:@::}{INF,KROK,7TH, VEND/CEND, #TMT::}

Rule for semantic analysis:

>{N/NP,#TMT,VEVD/CEND,inf,krok,7th::tim:}{V,#TMT::}

IV. CONVERSION OF A BANGLA LOCATIVE CASE SENTENCE TO UNL EXPRESSIONS

This section describes the conversion procedures and the

experimental results of the following locative case sentence into UNL expressions.

Bangla sentence: ‘আমি জানুয়ারী হইতে জুন পর্যন্ত ঢাকায় থাকবো’

English pronunciation: ‘*Aami january hoite june porjonto dhakaye thakbo*’

Equivalent English Sentence: I will stay in Dhaka from January to June.

The chunks obtained from the input sentence are given below:

(<<)(আমি)() (জানুয়ারী) () (হইতে) () (জুন) () (পর্যন্ত)() (ঢাকা)(য়) () (থাক)(বো)(>>)

There are nine nodes in the given sentence shown in Table I. We have used an EnConverter [14] tool for our experiment. The tool takes as its input a dictionary file (Table I), a set of analysis rules (Table II). These analysis rules are to be applied to the nodes in the node list thorough the windows of the Enconverter. Enconverter inputs the string of sentence and initially the sentence will be placed in the right analysis windows (RAW). Then in scans the string of the sentence from left to right and all matched morphemes with the same string characters are retrieved from the word dictionary and become the candidate morphemes. The rules are applied to these candidate morphemes according to a rule priority to build the syntactic tree and the semantic network of UNL for the sentence [2], [14], [15]. This semantic network for UNL can later be converted into a variety of native languages using Deconverter [16] by language specific generation rules. The nodes of the dictionary are processed by the EnConverter using the dictionary entries and analysis rules.

TABLE I: HEAD WORDS UNIVERSAL WORDS AND THE GRAMMATICAL ATTRIBUTES OF THE NODES IN THE INPUT SENTENCE

Nodes	Head Words	Universal Words	Attributes
Node 1	আমি	I(icl>person)	PRON, HPRN, SUBJ, 1P, SG
Node 2	জানুয়ারী	January(icl>month)	N, VEND, #TIM
Node 3	হইতে	Null	ABY, ANUS, #FRM
Node 4	জুন	June(icl>month)	N, CEND, #TIM
Node 5	পর্যন্ত	Null	ABY, ANUS, #TO
Node 6	ঢাকা	Dhaka(iof>city)	N, VEND, NPRO, #PLC, CAPT
Node 7	য	Null	BIV, KROK, 7TH
Node 8	থাক	Stay(icl>live)	ROOT, CEND, CEG2, #PLC
Node 9	বো	null	INF, VI, 1P

(where, *N* indicates noun, PRON indicates pronoun, HPRN denotes human pronoun, SUBJ for subjective pronoun, SG for singular number, #TIM indicates time related node, VEND for vowel ended, CEND for consonant ended, ABY represents preposition, ANUS also represents preposition, NPRO for proper noun, #PLC for place related node, INF for inflexion, VI for verbal inflexion, 7TH denotes case inflexion

for seventh number and Null represents no universal word). These nodes are processed by the EnConverter using the dictionary entries and analysis rules.

TABLE II: ANALYSIS RULES TO CONVERT THE GIVEN SENTENCE INTO UNL EXPRESSIONS

Rule 1. R{SHEAD:::}{PRON,HPRON,SUBJ:::}{BLK:::}
Rule 2. R{PRON,HPRON,SUBJ:::}{BLK:::}
Rule 3. R{PRON,HPRON,SUBJ:::}{BLK:::}{N,#TIM:::}
Rule 4. DR{N,#TIM,^blk:blk:::}{BLK:::}
Rule 5. +{N,#TIM,blk,^ABY,^ANUS,^#FRM:@::}{ABY,ANUS,#FRM:::}
Rule 6. R{:::}{N,#TIM,blk,ABY,ANUS,#FRM:-N,-ABY,-ANUS,+NP:::}
Rule 7. R{NP,#TIM,#FRM,blk:::}{BLK:::}
Rule 8. R{BLK:::}{N,#TIM:::}
Rule 9. +{N,#TIM,blk,^ABY,^ANUS,^#TO:@::}{ABY,ANUS,#TO:::}
Rule 10. R{:::}{N,#TIM,blk,ABY,ANUS,#TO:-N,-ABY,-ANUS,+NP:::}
Rule 11. R{NP,#TIM,#TO,blk:::}{BLK:::}
Rule 12. R{BLK:::}{N,#PLC:::}
Rule 13. +{N,#PLC,^biv,^krok,^7th:@::}{BIV,KROK,7TH:::}
Rule 14. R{:::}{N,#PLC,BIV,KROK,7TH:-N,-BIV,-KROK,-7TH,+,biv+NP:::}
Rule 15. R{NP,#PLC,biv:::}{BLK:::}
Rule 16. R{BLK:::}{ROOT:::}
Rule 17. +{ROOT,CEND:@::}{BIV,KBIV,1P:::}
Rule 18. DL{BLK:::}{ROOT,CEND,BIV,KBIV,1P:-ROOT,-CEND,-BIV,-KBIV,+V,+biv,+kbiv:::}
Rule 19. >{NP,#PLC:plc:::}{V:::}
Rule 20. DL{BLK:::}{V:::}
Rule 21. >{NP,#TIM,#TO:tmt:::}{V:::}
Rule 22. >{NP,#TIM,#FRM:tmf:::}{V:::}
Rule 23. >{PRON,HUMN,SUBJ:aoj:::}{V:::}
Rule 24. L{SHEAD:::}{V:::}

Before applying rules sentence head (<<) places in the left analysis window (LAW) and pronoun ‘আমি’ (aami) meaning I in the Right Analysis Window (RAW). Now right shift rule 1, 2 and 3 are applied to shift the windows of Enconverter to three steps right. Then right node deletion rule (rule 4) is applied to delete the node between noun ‘জানুয়ারী’ (January) and case maker ‘হইতে’ (hoite) meaning from. Rule 5 is used to perform morphological analysis between ‘জানুয়ারী’ and ‘হইতে’ to make noun phase ‘জানুয়ারীহইতে’ (january hoite) meaning from January. Three right shift rules 6, 7 and 8 are to be applied to shift the windows three steps right. Morphological analysis between noun ‘জুন’ (June) and case maker ‘পর্যন্ত’ (porjonto) is to be performed using analysis rule 9. Again morphological analysis between noun ‘ঢাকা’ and case maker ‘য়’ (ye) will be performed using rule 13 after applying right shift rules 10, 11 and 12. After that three right shift rules 14, 15 and 16 are to be applied followed by an analysis rule (rule 17) to perform morphological analysis between verb root ‘থাক’ (thak) and verbal inflexion ‘বো’ (bo). After completion all morphological analyses a left node deletion rule (rule 18) is to be applied to delete the node between noun ‘ঢাকা’ and verb ‘থাকবো’. Considering the UNL relation *plc* a semantic analysis is to be performed between place ‘ঢাকা’ and verb ‘থাকবো’ using rule 19 and consequently noun ‘ঢাকা’ will be deleted from the node-list. Again another left node deletion rule (rule 20) is to be applied to delete the node between noun phase ‘জুনপর্যন্ত’ and verb ‘থাকবো’. To perform the semantic analysis between noun phase ‘জুনপর্যন্ত’ and verb

‘থাকবো’ rule 21 is to be used for making UNL relation *tmt*. In this step, verb ‘থাকবো’ remains in the RAW and noun phase is deleted from the node-list. Another semantic operation will be resolved by *tmf* relation between noun phase ‘জানুয়ারীহইতে’ and verb ‘থাকবো’ and ‘জানুয়ারীহইতে’ is deleted after applying rule 22 followed by left node deletion rule 20. Finally, *aoj* relation can be resolved between pronoun ‘আমি’ and verb ‘থাকবো’ and pronoun is deleted followed by a left shift rule 24 to place sentence head, which has the attribute SHEAD in the RAW to complete the conversion procedures. Table III shows the UNL expressions of the sentence.

TABLE III: UNL EXPRESSIONS OF THE GIVEN BANGLA SENTENCE

{org:en}
I will stay in London from January to June
{/ogr}
{unl}
aoj(stay(icl>dwel>be,aoj>person,plc>uw).@entry.@future,i(icl>person))
plc(stay(icl>dwel>be,aoj>person,plc>uw).@entry.@future,london(iof>national_capital>thing))
tmf(london(iof>national_capital>thing),january(icl>gregorian_calendar_month>thing))
tmt(london(iof>national_capital>thing),june(icl>gregorian_calendar_month>thing))
{/unl}

V. CONCLUSIONS AND FUTURE WORKS

This paper analyzed various types of Bangla locative case sentences in favor of UNL structure considering the lexicon and UNL relations they create. It also proposed some analysis rules of all kinds of sentences to convert them into UNL expressions. By using the analysis rules we successfully converted locative case sentences into correct UNL expressions. Our future plan is to develop a mechanism which will allow users to translate any kinds of locative case sentences into UNL expressions. These UNL expressions can later be converted to any other native languages using language specific generation rules. Currently, we are experimenting on other case sentences. Our analysis rules have been developed by using standard format provided by the UNL Center of the UNDL Foundation so that analysis rules of other languages can be benefited from our formats. Completion of other rules for all types of Bangla sentences will be a major step towards developing a generic Bangla language translation.

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