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Lexical selection rules for Kazakh-to-English machine translation in the free/open-source platform Apertium

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Abstract

Kazakh language has great number of ambiguity words. The most of ambiguous word related to morphological ambiguity. The majority of homonyms pertain to morphological ambiguity. For example, "bas(бас)", "kara(қара)", "zhyz(жүз)", "zher(жер)" and etc. All of these words related to two or more part of speech. The word "bas" can be as noun, verb, also word "zhyz" can be noun, numerical and verb. The word "zher" related to same part of speech like a word "bas". Compared with other words this word has a lot of translation. This word has translation like this: "place", "Earth", "land", "ground", which are noun and "eat" as a verb in future time.

This paper describes process of building lexical selection rules for Kazakh-to-English machine translation system on free/open-source Apertium platform. Lexical selection rules are used for solving problems of ambiguity when ambiguity word has same part of speech. We will consider lexical selection rules for translating from Kazakh to English. Disambiguation is used to improve the quality of machine translation. This paper shows how to create lexical selection rules, what types of phrases and context are used to rules. Solving the task of ambiguity is a difficult task. Today, there are many tools of resolving it. One way of solving disambiguation is writing hand-written lexical selection rules, which we will consider at the paper.

In rule-based free/open-source platform Apertium disambiguation is solved by module of lexical selection. At module of lexical selection rules is written in XML-format. Lexical selection is used to determine the correct translation not the adequate sense. This difference differ it from word-sense disambiguation.

Keywords: ambiguity, rule-based, source language, target language, disambiguation, Apertium, lexical selection

1 Introduction

Today ambiguity is a main problem of computer processing of language. So, each machine translation system must be solved this kind of tasks. Ambiguity appears when word of source language has a two or more translations in target language. In this paper we consider Kazakh language as source language and English as a target language. These languages differ in syntax, morphology and they pertain to different type of language. Also, Kazakh as all Turkic language is agglutinative, whereas English is analytic.

Ambiguity can be lexical; morphological. Lexical ambiguity it means when ambiguity words have same part of speech, but by context it translated differently. Meanwhile, morphological ambiguity opposite to lexical. It means that in morphological ambiguity ambiguous word relate to different part of speech. In some case ambiguity calls polycemy. To solving problems of lexical selection is important to understand context which is translated to English.

Kazakh language has a great number of ambiguity words. We will consider Kazakh's words

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"bauyr (бауыр)" which is ambiguous word. By the nearby words we can distinguish meaning of this word. Firstly, it has a meaning like "brother", the second meaning is "liver". For example, "Менің бауырымның аты Дулат" and "Бауырым ауырып тұр". The first sentence is translated as "My brother's name is Dulat", the second sentence's translation is "Liver is hurts".

Not only noun has ambiguity, pronoun also can be ambiguous. The pronoun "Ол" has tree translations. It can be "he", "she" and "it". When this word appears in context which is meant female, this translated as "she". In Kazakh this word ambiguous, but in English it is unambiguous. By considering features of translation by context, we are developing rules which are solving the task of ambiguity from Kazakh to English based on the Apertium free/open-source machine translation platform (Forcada et. al., 2011)0. For solving polycemy of Kazakh–English language pair we need to build bilingual dictionary and write couple of lexical selection rules.

This paper contains 4 sections: Section 2 describes Apertium platform and its structure, Section 3 describes Kazakh–English lexical selection and Section 4 gives results of system.

2 Apertium platform and its modules

Apertium is a free/open source machine translation system. Apertium is free software which is published by developers according to GNU GPL conditions 0.

At the first time Apertium was developed for translation between similar languages. However this system has been expanded to translate texts between dissimilar language pairs, such as English – Kazakh (vice versa) language pairs. For developing we need to create the linguistic data (dictionaries, rules), which are written in XML formats. By using dictionaries we find words which have two or more translations. So, this machine translation system uses finite state transducers for all of its lexical transformations, and hidden Markov models for part-of-speech tagging or word category disambiguation.

This machine translation system has own modules for implementation of transfer.

Apertium platform consists following modules (Sundetova et.al., 2014):

- Deformatter
- Morphological analyser
- Part of speech tagger
- Lexical transfer
- Lexical selection
- Structural transfer
- Morphological generator
- Post-generator
- Re-formater

So, we consider how to work these modules. First module is **deformater**. This module divides the source text to formatting tags. These tags called as "superblanks" which insert the place between words.

Second module is **morphological analyser**. Morphological analyser constitute to each lexical unit one or more lexical forms. These form consist of lemma, lexical category or part of speech. Morphological analysis is generated by compiling a morphological dictionary of source language. Lexical units containing more than one word (multiword lexical units) are analyzed as a single lexical unit. Morphological analyser uses a finite state transducer based on two-level rules (in the case of Kazakh, apertium-kaz.kaz.lexc, apertium-kaz.kaz.twol). This module therefore separates lexemes and processes morphological analysis, and then returns possible lexical forms. Below we show the morphological analysis of ambiguous word.

```
     ^жүз/жүз<num>/жүз<n><nom>/жүз<n><attr>/жүз<num><subst><nom>/ж
үз<v><iv><imp><p2><sg>/жүз<n><nom>+e<cop><aor><p3><pl>/жүз<n><nom>
+e<cop><aor><p3><sg>/жүз<num><subst><nom>+e<cop><aor><p3><pl>/жүз<
num><subst><nom>+e<cop><aor><p3><sg>$^./.<sent>$
```

As you see this word has 9 morphological interpretations. The frequent interpretation is as a numerical. There four analysis with numerical: `жүз<num>`, `жүз<num><subst><nom>/`, `жүз<num><subst><nom>+e<cop><aor><p3><pl>/`,`жүз<num><subst><nom>+e<cop><aor><p3><sg>`. Here <num> - numerical, <attr>- attributive, <nom>- nominative, <cop>- copula, <p3>- third person and etc (List of symbols: wiki.apertium.org/wiki/List_of_symbols). We receive three analysis with noun, in addition the noun can be nominative, attributive and nominative with copula. Although, we have only one analysis with verb. This analysis like this: `жүз<v><iv><imp><p2><sg>`, where "zhyz" is verb, intransitive, imperative, second peson and singular. By context we distinguish the corresponding analysis using the part of speech tagger, which we consider below.

Third module is **part of speech tagger** which is based on hidden Markov model(HMM).

Final result of part of speech we receive after applying constraint grammar rules. In Kazakh directory this file of rules called "apertium.kaz.kaz.rlx". Here we solve the morphological ambiguity. This type of polysemy appear when the word of source language can be relate two or more part of speech. For example, word "zhyz(жүз)" can be relate to tree part of speech, namely it can be translated as a noun, numeral and verb. If we consider the sentence or phrase "zhyz tenge" it translated as "hundred tenge". So, in this context this word's part of speech is numeral. After applying these rules we receive just one morphological analysis. Here we show the rule for this construction:

```
SELECT Num IF
  ((0 Num) OR (-1))
  (1 N)
```

This rule shows that we choose "zhuz" as a numeral if this word come with numeral or noun before of source word.

Forth module is **lexical transfer**. This module works with bilingual dictionary (apertium-eng-kaz.eng-kaz.dix) 0, from this dictionary lexical transfer module reads lexical form of source language and retrieve corresponding lexical form of source language. The lexical forms of target language can be one or more than two.

Fifth module is lexical selection which we consider in this paper. This module uses the lexical selection rules. The rules is written by hand in file apertium-eng-kaz.kaz-eng.lrx by determining nearest word or context. So, lexical ambiguity is solved here. Lexical selection is the focus of this paper, so we described in detail in the next section.

Sixth module is **structural transfer.** This module uses to transform source language sentence or phrase to target language by using transfer rules. This module covers syntactic processing. To processing it uses transfer rules, which transform lexical forms sequences to another sequence of target language. Structural transfer works in tree step. First of all is "chunker" level, which divide source sentence to chunks. At the second level, namely in "interchunk" it did rearrangement of phrases. For example: "Мен/SN бақшада/SN-LOC ойнаймын/SV" translated to English as "I/SN play/SV in garden/SN-LOC". Here "SN" means noun phrase, "SV" is verb phrase. As you see Kazakh language has "SOV" type, whereas English is "SVO". So, "interchunk" level did arrangement from "SOV" to "SVO". At final level it does some clean-up by deleting unnecessary tags.

Seventh module is **morphological generator.** It generates a corresponding sequence of target language surface forms. The morphological generator executes a finite-state transducer generated by compiling a morphological dictionary for the target language.

The penultimate module is **post-generator**. It takes care of some minor orthographical operations in the target language.

Last module is **reformatter.** It places format tags back into the text so that its format is preserved.

3 Lexical selection from Kazakh into English languages

The lexical selection module is the one of main module in receiving correct translation. The lexical selection module in Apertium does disambiguation, namely solving task of lexical ambiguity.

The operations, which is used in writing rule show below in the Table1.

Table 1. Operations of lexical selection rules

Operations	Meaning
`<rule>`	Start of rule
`<SELECT>`	Operation of choosing
`<tags>`	Determine corresponding tag to word
`<match>`	choose
`<lemma>`	Lexical form
`</rule>`	End of rule

English-Kazakh and Kazakh-English language pairs use same linguistic data of dictionaries. These dictionaries are monolingual dictionary of English, lexical dictionary of Kazakh and bilingual dictionary of both languages. They differ by number of words there. The monolingual Kazakh dictionary consist about 20000 words, the monolingual dictionary of English 36876 and bilingual consist 13751 words (current version: 50582)

By adding words to dictionary, it increased number of ambiguity. Kazakh language is a rich language with ambiguity. We present some words which have several translations from bilingual dictionary. There are some ambiguous words with its translation (Table 2):

Table 2. Example of ambiguous words with its translation

Kazakh words	Translations	POS of translation	Example with context	Translation by using context
бет	page, face, surface	noun	адамның беті кітаптың беті судың беті	face of people book page water surface
ол	he,she	pronoun	Ол қыз Ол бала	She is girl He is boy
үй	home, house	noun	үйге бару үйде тұру	go to home live in house
оқу	read, study	verb	университетте оқу кітапты оқу	study at university read a book
жастық	pillow, adolescence, youth	noun	жастыққа жату жастықтықты еске алу	lie on the pillow remember the adolescence
ара	bee, saw	noun	арамен кесу ара шағып алды	To pick the tree by saw bee bite

3.1 The Kazakh-English lexical selection rules

Kazakh language has no gender. In sentence, which has personal pronoun "ol" we must do lexical selection. So, we solve this by writing the rules in lexical selection file of Kazakh into English machine translation system. So, this rule will be like this:

```
<rule>
  <match lemma="Ол" tags="prn.pers.p3.sg.nom"><select lemma="she"
tags="prn.subj.p3.f.*"/></match>
  <match lemma="қыз" tags="n.*"/>
 </rule>
```

This rule starts with matching the lemma and its tags. The tags illustrate morphological analysis. "prn" is pronoun, "pers" is personal, "p3" is third person, "sg" is singular and "nom" is nominative. After determining tags, we choose lemma, which must be corresponded and write its tags. If we don't write rule for this case, the system translated all sentence with "ol" as he. So, we generate "he" by default.

The next example of rule illustrated the translation with verb. The word "oku(оқу)" has two corresponding translation. It translated as "read" and "study". When this word come with "university" or "institute", it translated as "study". Meanwhile, by default it has a translation "read". Below we illustrate the rule for the first case, which we discuss:

```
<rule>
  <or>
   <match lemma="институт" tags="n.loc"/>
   <match lemma="университет" tags="n.loc"/>
  </or>
   <match     lemma="оқы"     tags="v.*"><select     lemma="study"
tags="vblex.*"/></match>
 </rule>
```

In the case when context or nearest word connected with university or institute, it translated as a "study".

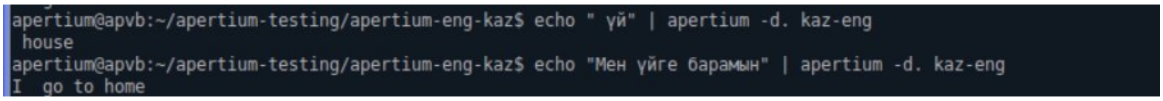
Rules for this phrase are assigned to verb case. After analyzing lexical selection we see that context has a great importance in generating rules. In this level of lexical selection rules are written 15 rules. There are some rules from lexical selection file:

```
<rule>
  <match lemma="Ол" tags="prn.pers.p3.sg.nom"><select lemma="she"
tags="prn.subj.p3.f.*"/></match>
  <match lemma="қыз" tags="n.*"/>
```

```
 </rule>

 <rule>
  <match lemma="Ол" tags="prn.pers.p3.sg.nom"><select lemma="she"
tags="prn.subj.p3.f.*"/></match>
  <match lemma="әдемі" tags="adj"><select lemma="beautiful"
tags="adj"/></match>
  <match lemma="қыз" tags="n.*"/>
 </rule>

 <rule>
  <match lemma="кітап" tags="n.*"/>
  <match lemma="бет" tags="n.*.*"><select lemma="page"
tags="n.*"/></match>
 </rule>


 <rule>
  <match lemma="әдемі" tags="adj"><select lemma="beautiful"
tags="adj"/></match>
 </rule>

 <rule>
  <match lemma="оның" tags="prn.pers.p3.sg.gen"><select
lemma="his" tags="det.pos.sp"/></match>
 </rule>

 <rule>
  <match lemma="үй" tags="n.*"><select lemma="home"
tags="n.*"/></match>
  <match lemma="*" tags="v.*"/>
 </rule>

 <rule>
  <match lemma="үй" tags="n.*"><select lemma="house"
tags="n.*"/></match>
 </rule>

 <rule>
  <match lemma="арқылы" tags="post"><select lemma="through"
tags="pr"/></match>
 </rule>

 <rule>
  <or>
   <match lemma="институт" tags="n.loc"/>
   <match lemma="университет" tags="n.loc"/>
  </or>
   <match lemma="оқы" tags="v.*"><select lemma="study"
tags="vblex.*"/></match>
 </rule>
```

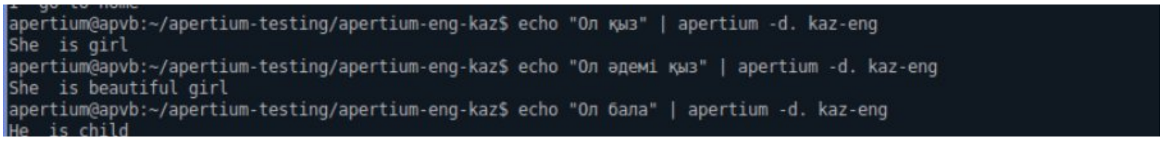
4 Results

The current version of the system (revision №60582) by hand-rules can decide ambiguity noun, pronoun and verb - phrases. We plan to extend the number of rules to improve translation quality. Here we show some results of translation, see Fig. 1,Fig. 2,and Fig. 3.



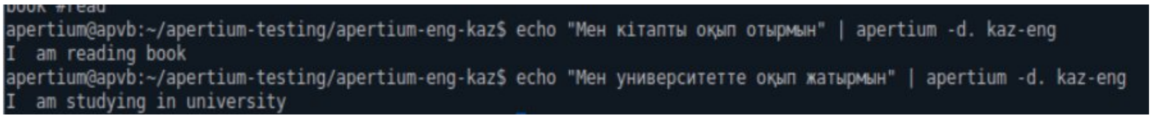
```
apertium@apvb:~/apertium-testing/apertium-eng-kaz$ echo " үй" | apertium -d. kaz-eng
 house
apertium@apvb:~/apertium-testing/apertium-eng-kaz$ echo "Мен үйге барамын" | apertium -d. kaz-eng
I  go to home
```

Fig. 1. Result of translating ambiguous noun.



```
I  go to home
apertium@apvb:~/apertium-testing/apertium-eng-kaz$ echo "Ол қыз" | apertium -d. kaz-eng
She  is girl
apertium@apvb:~/apertium-testing/apertium-eng-kaz$ echo "Ол әдемі қыз" | apertium -d. kaz-eng
She  is beautiful girl
apertium@apvb:~/apertium-testing/apertium-eng-kaz$ echo "Ол бала" | apertium -d. kaz-eng
He  is child
```

Fig. 2. Result of translating ambiguous pronoun.



```
book #read
apertium@apvb:~/apertium-testing/apertium-eng-kaz$ echo "Мен кітапты оқып отырмын" | apertium -d. kaz-eng
I  am reading book
apertium@apvb:~/apertium-testing/apertium-eng-kaz$ echo "Мен университетте оқып жатырмын" | apertium -d. kaz-eng
I  am studying in university
```

Fig. 3. Result of translating ambiguous verb

5 Conclusion

We have described Kazakh—English machine translation system on Apertium platform and process of solving disambiguation. Many features in translating from Kazakh to English as selection cases of noun, verb, pronoun and etc. were solved. However, hand-written lexical selection rules do not cover all situations with ambiguity, because before writing the rules, we must find ambiguity words in context, which require few times. So, we must create a new tool, which generate this kind of rules automatically. In the future this system will be considered automatically generation of lexical selection rules.

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