Interactive Pedagogical Programs Based on Constraint Grammar

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OAHPA!

http://oahpa.uit.no

Abstract

OAHPA! is a set of interactive parser-based CALL programs for North Sámi, based on a finite state morphological analyser and a constraint grammar parser which is used for syntactic analysis and navigating in the dialogues. The CG parser provides effective and reliable handling of a wide variety of user input. Relaxation of the grammatical analysis of the user input enables grammatical error detection and reaction to the errors with appropriate feedback messages.

The OAHPA! programs are freely available at *http://oahpa.uit.no*. The programs include basic morphological exercise (*Morfa-S*), question-answer drill (*Vasta*), word quiz (*Leksa*), morphological exercises in a sentential frame (*Morfa-C*), dialogue program (*Sahka*) and a numeral quiz (*Numra*).

Pedagogical lexicon

The OAHPA! programs share a set of common resources: a pedagogical lexicon and a morphological generator that is used for generating the different word forms that appear in the programs. The dialectal variation is taken into account in the lexicon as well as in the morphology. The semantic class is used in the sentence generator for Vasta and Morfa-C. The lexical entry for *monni* "egg" is given to the right.

```
<entry>
  <lemma>monni</lemma>
  <pos class="N"/>
  <translations>
    <tr xml:lang="nob">egg</tr>
    <tr xml:lang="fin">muna</tr>
  </translations>
  <semantics>
    <sem class="FOOD-GROCERY"/>
  </semantics>
  <stem class="bisyllabic" diphthong="no"
      gradation="yes" soggi="i" rime="0"/>
  <dialect class="NOT-KJ"/>
  <sources>
    <book name="d1"/>
    <book name="sara"/>
    <book name="algu"/>
  </sources>
</entry>
```

Morphological feedback

If the user does not inflect the lemma correctly in the morphological exercises, she can ask for hints about the inflection, and try once more, instead of getting the correct answer straight away.

The detailed feedback messages are determined by the combination of morphological features in the lexicon and the inflection task at hand. The morphological specification below gives a rule stating that there is a vowel change in illative singular for bisyllabic nouns that end with the vowel *i*. The corresponding feedback message instructs the user to remember the vowel change.

```
<stem class="bisyllabic" soggi="i">
  <msg case="Ill" number="Sg">i_á</msg>
</stem>

<message id="i_á">Vowel change i > á.
</message>
```

monni
monnii ✗ help
"monni" has even-syllabic stem and shall have strong grade. Vowel change i > á. the suffix –i.
monni
monnái

The system-internal representation of *monni* states that it is a bisyllabic i-stem, which triggers i > á change in illative.

The user types the erroneous *monnii*, and gets feedback from the machine. A correct answer gets green colour as feedback.

Background and motivation

The pedagogical programs in OAHPA! are based upon three pre-existing language technology resources developed at the University of Tromsø: a morphological analyser/generator, a CG parser for North Sámi and a number word generator compiled with the Xerox compiler xfst.

The main goal of the development of OAHPA! is to make a language tutoring system going beyond simple multiple-choice questions or string matching algorithms, with free-form dialogues and sophisticated error analysis. Immediate error feedback and advice about morphology and grammar are seen as important requirements for the program.

Due to its complex morphology, Sámi demands a lot of practising before the student reaches a level of fluency required for everyday conversation. Our programs give a practical supplement to the instruction given at school or university. In addition, the dialogue program consists of everyday topics, with underlying pedagogical goals such as practicing verb inflection, choice of correct case form or vocabulary learning.

The sentence generator in Morfa-C and Vasta is able to generate a virtually unlimited number of different tasks, and allows the student to use the programs over and over again.

Constraint Grammar (CG)

Constraint grammar is a syntactic framework for choosing correct grammatical analysis of a given wordform, based upon the context it occurs within. Each rule removes or selects readings, and adds or removes a syntactic tag. Inappropriate analyses are removed, but the last analysis is never removed. CG thus always gives an analysis, and is therefore a very robust framework, well fit to handle potentially erroneous input.

```
"<Makkár>"
    "makkár" Pron Interr Sg Nom
    "makkár" Pron Interr Attr
"<láibegálvvuid>"
    "láibe#gálvu" N Pl Acc
    "láibe#gálvu" N Pl Gen
"<don>"
    "dot" Pron Dem Sg Gen
    "don" Pron Pers Sg2 Nom
    "dot" Pron Dem Sg Acc
"<hálliidat>"
    "hállidit" V TV Ind Prs Sg2
    "hállidit" V TV Ind Prs Pl1
"<?>"
    "?" CLB
```

The morphological analyser gives the words in *Makkár láibegálvvuid don háliidat?* "What kind of bakery do you want?" all possible morphological analyses.

```
"<Makkár>"
    "makkár" Pron Interr Attr @>N #1->2
"<láibegálvvuid>"
    "láibe#gálvu" N Pl Acc @OBJ> #2->4
"<don>"
    "don" Pron Pers Sg2 Nom @SUBJ> #3->4
"<hálliidat>"
    "hállidit" <mv> V TV Ind Prs Sg2 @FS-STA #4->0
"<?>"
    "?" CLB #5->5
```

The CG grammar then picks the correct analysis, and adds grammatical function and dependency structure.

Evaluation

OAHPA! has been in use for 3 months, and recieves appr. 500 queries every weekday, 53% of the queries were correct. By far the most popular program is the basic morphological drill, cf. usage statistics:

Morfa-S	Leksa	Sahka	Numra	Morfa-C	Vasta
41%	27%	13%	12%	5%	2%

For Sahka and Vasta we measured *precision* (correctly identified errors/ all diagnostised errors), *recall* (correctly identified errors/all errors), and *accuracy* (correct judgements/cases). For the error types we target, precision = 0.85, recall = 0.93, and accuracy = 0.89 (N=277). Better recall than precision indicates that very few errors slip through, at the price of erroneously identifying some correct forms as errors. In this pedagogical setting, a goal for future work is improving precision (avoiding erroneous error flagging).

Breaking down the precision numbers on type of feedback, we get the picture below. Of 27 errouneous judgements, 16 were due to technical malfunction, 9 to wrong syntactical and 2 to wrong lexical analysis.

Rule type	corr.	wr.	corr%	Rule type	corr.	wr.	corr%
wrong tense	7	0	100,0	no finite verb	19	4	82,6
wrong V after neg	3	0	100,0	wrong S-V agr	17	8	68,0
no infinite V	1	0	100,0	wrong V choice	7	4	63,6
orth. error	44	2	95,7	wrong word	4	4	50,0
wr. case for V-arg	26	4	86,7	wr. case after Num	1	1	50,0

Conclusion

By using the syntactical analyser for North Sámi, combined with a set of error-detection rules, we have been able to build a flexible CALL resource. The programs are modular, and the modules may be improved by adding more materials as words, tasks, dialogues, levels, words from textbooks. The CG parser framework was originally chosen as parser framework for Sámi due to its extraordinary results for free-text parsing. The present project has shown that CG is well fit for making pedagogical dialogue systems as well.

Acknowledgements

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Article version of this poster:

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CG-parsing in the interactive free-text analysis programs Vasta and Sahka

The programs are based upon free-form interaction: Within certain limits, the student may formulate her own answer.

We use constraint grammar to disambiguate the student's input only to a certain extent, because there will probably be grammatical and orthographic errors. The manually written, context dependent rules are mainly used for selecting the correct analysis in case of homonymy. The last part of our grammar consists of rules for giving feedback to the student's grammatical errors, and rules for navigating to the correct next question of in the dialogue, depending upon the student's answer.

The system question and student answer are merged and analysed together, delimited by the boundary marker *^qst QDL*. They are first analysed morphologically, and are then disambiguated. If possible, they are assigned an error tag or a navigation tag.

Answer to the questions with full sentences. Remember big initial letter in placenames.

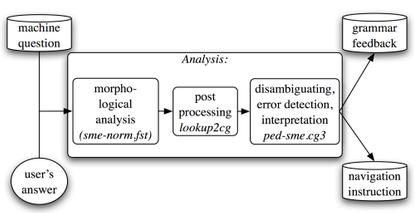
Buorre beaivi! Bures boahtin mu geahčái!

Mun lean aiddo fárren sisa iežan oađa orrunsadjái. Mus leat lossa viessogálvvut dáppe feaskáris. Gillešit go veahkehit mu?
De gillen.
Mus lea TV dás. Guđe lanjas TV lea du orrunsajis?
Dat lea stobus.
Guđe latnjii moai bidje mu TV?
Moai bidje TV hivssegis. ✗ The answer should contain an illative.
Answer

Above is a part of a dialogue in Sahka on furnishing a flat. Below is the analysis of the third question-answer pair from the dialogue. The morphological analysis is disambiguated and a grammar-error-tag (*&grm-missing-Ill*) and a navigation-tag (*&dia-hivsset*) are assigned to the analysis:

```
"<Guđe>"
   "guhte" Pron Interr Sg Gen &grm-missing-Ill
"<latnjii>"
   "latnja" N Sg Ill
"<moai>"
   "mun" Pron Pers Du1 Nom
"<bidje>"
   "bidjat" V TV Ind Prs Du1
"<mu>"
   "mun" Pron Pers Sg1 Gen
"<TV>"
   "TV" N ACR Sg Acc
"<^qst>"
   "^sahka" QDL gosa_bidjat_TV &dia-hivsset
"<Moai>"
   "mun" Pron Pers Du1 Nom
"<bidje>"
   "bidjat" V TV Ind Prs Du1
"<TV>"
   "TV" N ACR Sg Gen
"<hivssegis>"
   "hivsset" N Sg Loc
"<.>"
   "." CLB
```

Schematical view of the process



Grammar feedback

The system may give feedback to grammatical errors. In the third question in the dialogue above, the systems asks "In which room should we place the TV?" The student answers *Moai bidje TV hivssegis* ("We should place the TV in the toilet"), with locative *hivssegis* rather than the correct illative *hivssegii*.

The CG parser disambiguates the input, and the general CG rule below adds a grammar-error-tag (*&grm-missing-Ill*) to the sentence analysis triggered by the interrogative pronoun, which demands an illative in the answer.

```
MAP (&grm-missing-Ill) TARGET ("guhte") IF
(1 (N Ill) LINK *1 QDL LINK NOT *1 Ill OR
DOHKO OR Neg BARRIER S-BOUNDARY);

<message id="grm-missing-Ill">The answer
should contain an illative.</message>
```

In the grammar feedback library, the tag in question looks up a message in the appropriate interface language (in this example, English), and the user is presented with the feedback *The answer should contain an illative*, as shown in the picture above.

Navigation

Navigating inside the dialogue is implemented by using CG rules. The user input is tagged during analysis with information on whether the answer is interpreted as affirmative or negative. In addition, a special tag indicates whether the sentence contains some information that should be stored. The program is thus able to store simple information such as the student's name, place where she lives and for example the type of her car, and use this information in tailored questions or utterances.

In the example to the left the question is "In which room should we place the TV?" One of the alternatives for the navigation is due to the target tag being assigned because of the lemma *hivsset* ("toilet"). The answer will be "That is not a good idea. Make a new try." The CG rule is made for this question-answer pair and assigns the navigation tag (*&dia-hivsset*) to the analysis:

```
MAP (&dia-hivsset) TARGET QDL IF (0 (gosa_bidjat_TV))
(*1 ("hivsset") BARRIER ROOMS OR Neg) ;
```

There are several links in the dialogue, one of them is connected to the *&dia-hivsset* tag:

```
<utt type="question" name="gosa_bidjat_TV">
  <text>Guđe latnjii moai bidje mu TV?</text>
  <alt target="hivsset" link="gosa_bidjat_TV">
  <text>Dat gal ii heive! Geahččal oddasit.</text>
        </alt>
  <alt target="default" link="gosa_bidjat_beavddi">
<text>Moai gudde dan ovttas dohko.</text>
</alt>
</utt>
```

Every question has its own unique id, which is used for navigating between questions. There are both general navigation rules and rules for specific questions, like the one above.

Age-tags are assigned with help of regex-rules to the answer to the question "How old are you?". With help of these tags the system chooses a dialogue branch containing questions relevant to the student's age.