Generating Modular Grammar Exercises with Finite-State Transducers

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Introduction

An ICALL system for learning complex inflection systems, based upon finite state transducers (FST).

- generates a virtually unlimited set of exercises
- processes both input and output according to a wide range of parameters
- anticipates common error types, and gives precise feedback
- makes it easy for a linguist or a teacher to model new language learning tasks
- in active use on the web for two Saami languages
- can be made to work for any inflectional language
Motivation

- Morphology-rich languages offer a challenge for both language learners and NLP – processing of a great number of different forms of the same word.
- In addition to vocabulary acquisition, the learner has to learn the inflection of each word to be able to recognise the word in the context and to use it actively herself.
- A lot of learners of Saami languages have a Germanic language (Norwegian or Swedish) as L1.
- Most of the available ICALL systems deal with English.
- There was no ICALL system usable for Saami languages.
- There existed an important resource – an FST (as the engine of a spell checker).
http://oahpa.no/index.eng.html
Overview of the System

- FST
- Django web application
- MySQL database
  - Lexicon
  - Question-Answer frames
  - Morphological tags
  - Feedback messages
The history

- available on the Internet since 2009
- 2010-13:
  - started improving the structure for porting the system to new languages
  - made the programs for South Saami
  - experiments with other Saami languages
  - integrated the North Saami version into the university’s introductory courses
  - expanded the lexicon, adjusted it for universities in Finland
  - added more task types, e.g. pronouns, derivations and possessive suffices
  - evaluation of the tasks

Generating Modular Grammar Exercises with Finite-State Transducers

Presentation of the system

Finite State-Transducers

bovdna+Loc:bovdnaWG
bovdna+Gen:bovdnaWG
akšuvdna+Loc:akšuvdnaWG
akšuvdna+Gen:akšuvdnaWG

vdnaWG:vnna0

bovdna+Loc:bovnna
bovdna+Gen:bovnna
akšuvdna+Loc:akšuvnna
akšuvdna+Gen:akšuvnna

‘tussock’
‘action’
The FSTs can be manipulated in different ways

- input (for acceptance of the student’s input)
  - normative FST
  - tolerant FST
    - with spellrelax (ex. i = ï)
    - FST enriched with typical L2 errors marked with error tags
- output (for generating model answers)
  - normative FST
  - restricted FSTs
    - one for each dialect, without variants
Advantages of using FST

- generation of an “infinite amount” of exercises
- analysis and automatic evaluation of answers plus suggestions and comments on common error types
- flexibility with regard to language variation (dialects)
  - acceptance of several dialectal forms
  - ... but upon user request, suggest the normative form as a correct answer
Lexicon

Besides the FST, the lexicon is the other central resource for our language learning programs.

- A pedagogical lexicon containing the vocabulary of relevant textbooks
- Created from scratch, complemented in the course of development with data from (both electronic and non-electronic) textbooks and dictionaries
Lexicon – technical details
Lexicon Structure

```xml
<lg>
   <l diphthong="yes" gen_only="N+Sg,N+Ess" gradation="yes"
   pos="n" rime="0" soggi="a" stem="2syll">deadja</l>
</lg>
<dialect class="NOT-KJ"/>
<sources>
   <book name="sam1031_1"/>
</sources>
<mg>
   <semantics>
      <sem class="DRINK"/>
   </semantics>
   <tg xml:lang="nob">
      <t pos="n" stat="pref">te</t>
   </tg>
   <tg xml:lang="fin">
      <t pos="n" stat="pref">tee</t>
   </tg>
</mg>
```
Lexicon Structure

- The meta-information stored in the lexicon is there to select the appropriate words for the exercises.
- In addition, the morphophonological properties of words are used when providing detailed feedback on morphological errors.
Contextual Morphological Exercises

```xml
<question>
  <text>Maid SUBJ MAINV luomus</text>
  <qtype>V-MIX</qtype>
  <element id="SUBJ">
    <grammar pos="Pron"/>
  </element>
  <element id="MAINV">
    <id>bargat</id>
    <grammar tag="V+Cond+Prs+Person-Number"/>
  </element>
</question>

<answer>
  <text>Luomus SUBJ V-COND</text>
  <element game='morfa' id='V-COND' task='yes'>
    <sem class='ACTIVITY'/>
  </element>
  <grammar tag='V+Cond+Prs+Person-Number'/>
  <agreement id='MAINV'/>
</answer>
```

ACTIVITY-set: 87 verbs
pronouns: 9 person-numbers → 783 tasks
Generating exercises

- Morfa S: isolated words
  - 1200 nouns, 750 verbs, 300 adjectives, pronouns, numerals 1-12
  - → appr. 80,000 wordforms, drawn in sets of five at a time
- Morfa C: words in context
  - 330 templates for 34 different types of tasks with nouns, verbs, adjectives, pronouns, numerals and verb derivations
  - → 711,454 different exercises
Feedback

- **Green** if correct
- Metalinguistic help
- Unlimited self-correction
Metalinguistic feedback

Maid soai bivdiba? (guolit)

Soai bivdiba [guoliid] ✗ Veahkki

"guolli" has bisyllabic stem and shall have weak grade. Remember diphthong simplification because of the suffix is -id.
Feedback is modular

1. "guoll" has bisyllabic stem
2. and shall have weak grade
3. Remember diphthong simplification
4. because of the suffix is -id
"3. Remember diphthong simplification"

Stem information in the lexicon:
<l diphthong="yes" gradation="yes" pos="n" finis="0" stemvowel="i" stem="2syll">guolli</l>

Feedback message for this task:
<l stem="2syll" diphthong="yes" stemvowel="i"></l>
<msg case="Acc" number="Pl">diphthongsimp1.</msg>
Evaluating the generated tasks

Three annotators gave scores to 340 randomly selected question-answer-pairs, from 34 different task types, for grammaticality, meaningfulness and appropriateness:

1: wrong or very strange, would not have given it to the students → ‘no’

2: acceptable, but not very good/natural, I wouldn’t have made it myself → ‘perhaps’

3: correct and natural, I could have made it myself for the students → ‘yes’
Evaluating the generated tasks

<table>
<thead>
<tr>
<th></th>
<th>Grammaticality</th>
<th>Meaningfulness</th>
<th>Appropriateness</th>
</tr>
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<tbody>
<tr>
<td>Scores</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>QA-pairs</td>
<td>30</td>
<td>17</td>
<td>308</td>
</tr>
<tr>
<td>Distrib. %</td>
<td>8.5</td>
<td>4.8</td>
<td>86.8</td>
</tr>
<tr>
<td>average</td>
<td>2.9</td>
<td>2.8</td>
<td>2.9</td>
</tr>
</tbody>
</table>

Table: Evaluation of 340 randomly selected QA-pairs, from 34 different task types. The best score is 3 for each evaluation goal.
The bad ones

- not correct agreement between question and answer → fix the template
- noun requires modifier, e.g. ‘her boyfriend’ → make a new set with such nouns and make new tasks for them
- the subject doesn’t match the verb for a natural meaning → delete the noun or the verb from the set
- some nouns would be more natural in plural than in singular, and vice versa → move them to other sets/make new sets
Logging User Activity

- Morphology: 40.0%
- Vocabulary: 50.0%
- QA-drills: 10.0%

N=116,069
User data as basis for research

Present tense of different even-syllabic verbs

- at/ut verbs
- -it-verbs
Logging User Activity – Google Analytics

During the time period from Oct. 22, 2012 to May 21 2013

- 7,017 visits
- 70,474 page views
- 10.04 pages per visit
- Power users: 883 of the visits (12.5% of total visits) resulted in 48,636 page views (69.0% of total page views)
Logging User Activity – Google Analytics
Conclusion

- FST + lexicon and question templates in XML → abundance of exercises for morphology-rich languages
- Inflection of both isolated words and words in context
- The context-free inflection drill was the most popular program
- With FSTs, one may manipulate both input and output according to a wide range of criteria
- Oahpa is highly efficient for under-resourced languages

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