Ontology-based automatic generation of computerized cognitive exercises

Giorgio Leonardi $^{a,c}$, Silvia Panzarasa $^b$ and Silvana Quaglini $^a$

$^a$ Dept. Computer Eng. & Systems Science, University of Pavia, $^b$ CBIM, Pavia, $^c$ Dept. Computer Science, University Piemonte Orientale, Italy

Oslo, 27-31 August 2011
Cognitive rehabilitation exercises: examples

Choose the correct category

SPORT
ANIMALS
FOODS
... examples

Spaghetti : PASTA

= 

Hamburger : ?

Complete the logical similarity

MEAT  VEGETABLE  CEREAL
...examples

Ordering of scenes

grandma, what's a lover?

grandma, what's a lover?
Background

Several (research/commercial) systems exist for moving cognitive rehabilitation from paper to computer from face-to-face encounters to homecare. Not to replace the therapist but to enforce and intensify the rehabilitation.

Among open problems:
- Automatic patient-tailoring
  - According to patient’s skill/performances
  - According to patient’s preferences
- Generating ever new exercises

COGREHAB
Life Science Associates

REHACOM
SCHUHFRIED
ANASTASIS

Serious games

Mie2011, Quaglini
Aim of the work

- To build an architecture allowing easy maintainance and updating of a repository of stimuli (images, words, sounds, etc.) to be used for the exercise generation, with

  • Hierarchical classification of stimuli
  • Full description of every stimulus
  • Relationships among stimuli
  • Relationships between stimuli and specific patients

- Using the repository to generate personalised exercises within the *E-prime* tool
- Maintaining the separation between the stimuli repository and the exercise-generator software, for sake of re-usability
Methods: Protégé for the stimuli ontology

An ontology is composed by a hierarchy of classes (containing the domain concepts), attributes (defining the intrinsic properties of a class) and relationships (defining semantic links between different classes).
Export from Protégé

```xml
<name> lyon </name>
<type>:STANDARD-CLASS</type>
- <own_slot_value>
  <slot_reference>:ROLE</slot_reference>
  <value value_type="string">Concrete</value>
</own_slot_value>
<superclass> mammal </superclass>
- <template_facet_value>
  <slot_reference> lives </slot_reference>
  <facet_reference>:VALUE-TYPE</facet_reference>
  <value value_type="string">Class</value>
  <value value_type="class">den</value>
</template_facet_value>
- <template_facet_value>
  <slot_reference> difficulty_m </slot_reference>
  <facet_reference>:VALUES</facet_reference>
  <value value_type="integer">1</value>
</template_facet_value>
```
From Protégé to a Relational DB

Translator tool
Adding patient’s data at local level
Exploiting ontological relationships
To create ever new exercises

Select the main ingredient of:

among these:

These exercises exploit the relationships between a course and its ingredients and between an animal and its habitations.
To make exercise more/less difficult

Spaghetti : PASTA

Hamburger : ?

MEAT  VEGETABLE  CEREAL  FISH  CHEESE
To tailor exercise according to a patient’s profile

- Showing the patient’s dog instead of a generic dog
- Using classes corresponding to the patient’s hobbies and interests
- Using easy or difficult stimuli according to the patient’s scholarship
- ...

Showing the patient’s dog instead of a generic dog

Using classes corresponding to the patient’s hobbies and interests

Using easy or difficult stimuli according to the patient’s scholarship

...
... less difficult

Using the same relationship "OPPOSITE"

<table>
<thead>
<tr>
<th>Couple the words according to logic</th>
</tr>
</thead>
<tbody>
<tr>
<td>sea</td>
</tr>
<tr>
<td>midnight</td>
</tr>
<tr>
<td>useful</td>
</tr>
<tr>
<td>to find</td>
</tr>
<tr>
<td>useless</td>
</tr>
<tr>
<td>to lose</td>
</tr>
<tr>
<td>mountain</td>
</tr>
<tr>
<td>noon</td>
</tr>
</tbody>
</table>
... More difficult

Couple the words according to logic

- bird
- desk
- paper
- hawk
- secretary
- tree
- newspaper
- squirrel

Using different relationships

Lives in uses

Made of
Different Complexity for the same exercise

Food
First
Second
Dessert
...
Animals
Mammals
Birds
Insects
...
Habitation
For humans
House
Floor
...
For animals
Stable
Nest
...

Find the right category

Food
Animal
Habitation
Increasing complexity by going into subclasses

Food
- First
- Second
- Dessert

Animals
- Mammals
- Birds
- Insects

Habitation
- For humans
  - House
  - Floor
- For animals
  - Stable
  - Nest

Find the right category

- First
- Second
- Dessert
Conclusions

- Every update to the common stimuli repository is made at the ontology level to maintain consistency.

- At the local level
  - The patient’s data are integrated.
  - The concept table may be enriched with patient-specific stimuli.
  - The “interest” relationship between concepts and patient may be valued.

- This keep knowledge level and data level separate, allowing
  - easy personalisation
  - re-using the stimuli ontology in different contexts.
The final architecture
Acknowledgments

The medical staff of
- the Neurological Hospital “C. Mondino”, Pavia (Prof. Sandrini, Dr. Sinforian, Dr. Zucchella)
- the Rehabilitation Hospital “S. Maugeri”, Pavia (Dr. Pistarini, Dr. Cattani)
Thank you

Laboratory of Biomedical Informatics
“Mario Stefanelli”
Department of Computer Science and Systems,
University of Pavia, Italy

www.labmedinfo.org

silvana.quaglini@unipv.it