Adaptive Learning Systems

• They provide individualized instruction for each learner

• They are able to generate personalized courses taking into account:
  – the learning goals to be achieved
  – the existing knowledge of each learner
  – the learning style of each learner
  – the context where the learning takes place

• In past researches we defined and experimented an adaptive learning system named IWT (Intelligent Web Teacher)
How IWT Works

- Starting from a **formal representation** of a teaching domain through concept graphs
- A teacher selects a **learning goal** for a target student
- The system generates a **personalized sequence** of concepts to be taught
- Concepts already known by the target student are **removed**
- Learning resources are then selected according to student’s **learning style**
- Concepts learnt by a student are maintained in structures named **learner models**
- That are updated after each **testing activity**

Improvements Made So far

- We improved IWT by providing **self-regulated learning** features

- To do that we have added the possibility to generate a course starting from an **explicit request** made by a learner
  - A learner specifies his/her **learning needs** in natural language
  - **Sentence similarity** algorithms are applied to find the best matching concept(s) from available domains
  - A **personalized course** is generated starting from best matching concepts
Aim of This Work

• To improve IWT to let it generate a personalized course starting form an implicit request rather then from an explicit one

• Motivations
  – To anticipate and spread needs, knowledge and learning paths
  – To serve as a pedagogical advance organizer for the learners' community
  – To support the development of self-regulated learning

Methodology

• A methodology to recommend learning goals has been defined

• It consists of the following steps:
  – Concept mapping: for each learner, known concepts plus concepts currently under learning are identified
  – Concept utility estimation: for each learner, the utility of each unknown concept is estimated
  – Learning Goals Suggestion: concepts with the greater utility for each learner are suggested to him
  – Course Building: if the learner selects one or more concepts among those suggested, the system generates a course covering them
Concept Utility Estimation

- For each learner, the utility of unknown concepts is estimated
  - A collaborative component calculates the concept utility basing on what similar learners know
  - Learners with similar learner models are identified
  - Unknown concepts that are known by similar learners are recommended

![Diagram](image1)

Concept Utility Estimation

- For each learner, the utility of unknown concepts is estimated
  - A cognitive component calculates the concept utility basing on the analysis of the learner model of the target learner
  - Known concepts are identified on available concept graphs
  - Concepts that complement current knowledge are recommended

![Diagram](image2)
Hybridization

- **Collaborative approaches**
  - Provide less obvious advice allowing **serendipity**: the chance to discover useful things even if they differ from one’s preferences
  - Inaccurate recommendations when few data is available (**cold start problem**) e.g. in the early days of life of a system

- **Cognitive approaches**
  - First useful recommendations are available **immediately**, with only one assessment made by the user
  - Basing only on the user’s **past history** the recommendations tend to follow his preferences too closely and do not allow serendipity

- **Applied Solution**
  - **Hybridize** the two approaches to sum advantages and mitigate drawbacks

Latent Factor Model

- Utilities of concepts for learners are stored into a huge **data matrix**
- The maintenance of such matrix can decrease **performances**
- A **latent factor model** is applied to factorize the data matrix as a product of two compressed matrices

\[
\text{DATA MATRIX } X \approx \text{COMPRESSED MATRIX } U \text{ BASIS MATRIX } V^T
\]
The Prototype

• Once the learning goal has been selected the corresponding course is generated and delivered
The Prototype

We also introduced **sharing and rating** functions allowing learners to:

- Create own learning goals by selecting concepts from available ontologies
- Share self-created learning goals with other learners
- Rate learning goals created by teachers or other learners

Architecture

IWT e-Learning System

Developed components
Experimentation

- **Participants:**
  - 61 students of an online University course on Software Engineering

- **Groups:**
  - The experimental group was enabled to use the “personal learning need panel” to let the system suggest adequate complementary topics
  - The control group studied the standard course within the IWT environment

- **Purpose:**
  - To estimate perceived validity of the additional functions
  - To estimate system usability
  - To evaluate improvements on knowledge acquisition

Experimentation

- **Perceived Validity:**
  - Many students have found the recommender system useful for their study (M=6.21, SD=2.02, Md=6).
  - Most of them agreed that recommended learning goals correctly complement topics studied within the course (M=6.17, SD=2.37, Md=6).

- **Usability:**
  - SUS score of 53.97 on a range between 0 and 100

- **Quantitative Evaluation:**
  - Two open questions evaluated by a teacher

<table>
<thead>
<tr>
<th>Questions</th>
<th>Experimental group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1</td>
<td>M=6.11, SD=1.87, Md=6</td>
<td>M=5.84, SD=1.31, Md=6</td>
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<tr>
<td>Question 2</td>
<td>M=7.81, SD=1.28, Md=8</td>
<td>M=7.32, SD=1.24, Md=7</td>
</tr>
<tr>
<td>Overall</td>
<td>M=6.96, SD=1.57, Md=7</td>
<td>M=6.58, SD=1.27, Md=6</td>
</tr>
</tbody>
</table>
Conclusions

• We defined a **methodology** to recommend learning goals basing on similarities between users and on models representing teaching domains

• A **prototype** component was developed and integrated within an existing e-learning system

• **Experimentation** results have shown that:
  – the students liked the tool and found it interesting and useful to complement their knowledge about topics under study
  – in line with the prototypical nature of the system, the usability was not a barrier when using it
  – grades obtained by students of the experimental group were slightly higher with respect to those belonging to the control group

• **Future work** will focus mainly on the improvement of the usability

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**Thanks for Your Attention**

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