An Intelligent Engine for the Generation of Adaptive Tutorials

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Abstract

The goal of this work is the design and construction of adaptive tutorials based on the application of algorithms for the automatic resolution of problems which can be used to automatically generate texts of a formative character, practical exercises or tests and to evaluate them.

1. Introduction

The use of technology in teaching is a very active field of research. In the last years there have appear a great number of proposals to introduce innovative tools in teaching, especially in connection with the World Wide Web. In particular, the subfield of adaptive tests is also being explored [1, 2, 3] and is expanding in connection with the semantic web [6].

This evolution towards the use of (intelligent) e-learning tools is particularly appropriate and useful for disabled users with limited movability. Due to the generic and modular nature of our inferential engine (see figure 3) the formative strategies could be adapted to the special requirements of a wider spectrum of disabilities.

In this work we describe a supporting tool for the teaching of mathematics courses. The general plan is divided in several parts which converge in the design and development of an intelligent engine for the generation of adaptive tutorials. Moreover, the work here described could be used in other areas different from mathematics. The modules in which this work can be split are:

- Automatic generation of texts.
- Automatic generation of exercises.
- Automatic evaluation of exercises.

These modules are based on a knowledge base specifically designed to store the information related to the knowledge to be created.

In the next sections we explain in some detail how to design and construct these different modules.

2. Ontologies

The knowledge system of the inference engine is based on ontologies, having arrived to this conclusion after studying the fundamentals of the Semantic Web, area with a wide literature. Initially, the RDF (Resource Description Framework) language was not appropriate for the intended work. However, the services supplied by OWL (Ontology Web Language, a language to describe ontologies) provide the base of appreciation of knowledge described in a computational language.

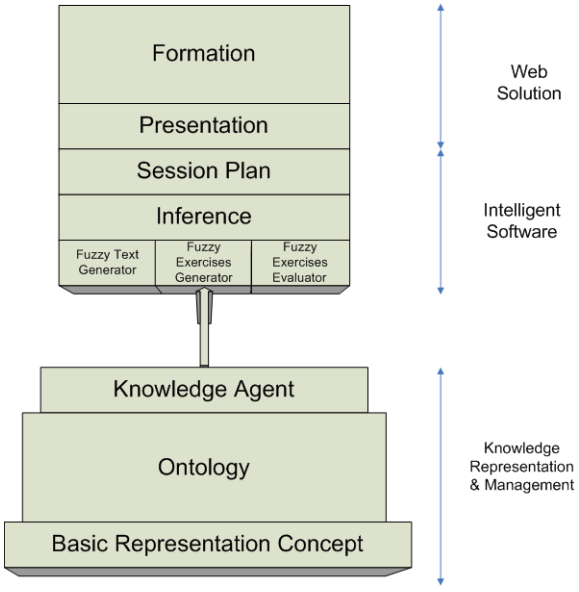

Fig 1. Basic Architecture Scheme

The ontology would contain the information about the subject to learn, related by concepts and chunks,

and marked with meta-information essential for the search agents to select the appropriate information. In the future, an intelligent agent should be able to provide a way to search these structures to extract fragments of information and take them to a higher level of processing, in such a way that the user receives the appropriate theoretical information in relation to his current knowledge.

Therefore, the objectives on the long run would be to obtain a clear and concise ontology generic model that could be used by an agent to make consultations and searches. Moreover, other objectives would be to construct examples for those ontologies in relatively small and manageable fields. The growth of the ontology should be scaled, i.e., the different ontological nets form themselves an ontology.

3. Automatic generation of texts

Several Artificial Intelligence techniques and technologies, in particular those related with the automatic resolution of problems [4], can be used for this task. The main components of this module are:

- Fuzzy control of the speed of the learning plan: The input for the system would be the answers of the student which, properly interpreted in a score/difficulty table would be understood as statistics about the student knowledge on a particular subject. Using this data, the controller would give as a result a calibration of the learning plan the student should follow, as well as a vector of indications to elaborate the work plan (this would be also useful to generate adequate exercises). The better the answers, the faster the plan will be.
- Texts planner: The input for this module would be the advance made by the student on the syllabus and the calibration vector above mentioned. This module would be a hierarchic planner which would look at a knowledge base on the area in order to select appropriate texts, diagrams and tutorials according to the calibration vector. The knowledge base would be based on ontologies (using the technology XML). The output of this tool would be a file about the progress in the syllabus which could be used as input for the same planner in future sessions. Moreover, the use of standard web technologies implies that this tool could interact with other teaching tools.

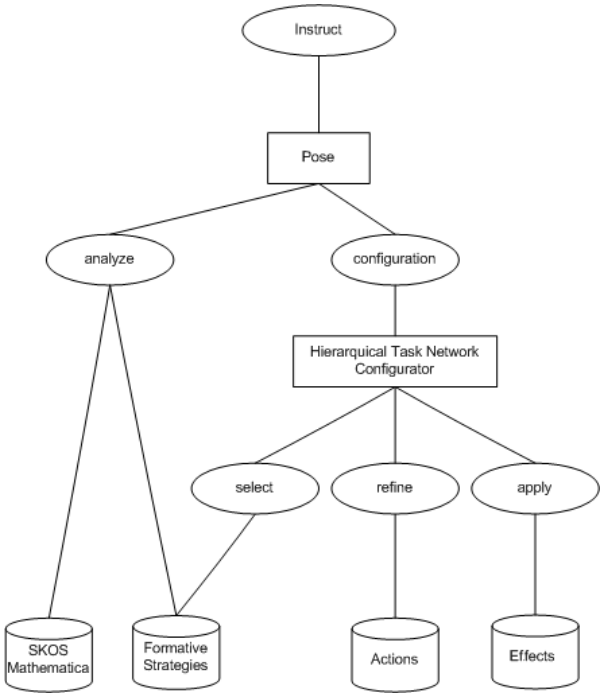

Fig 2. Automatic Generator of Text Solution

The result of this module is a planning for the publication of texts indexed by the ontology described in section 2. This planning would serve as a guide to generate the associated dynamical web.

4. Automatic generation of exercises

The main components of this module are:

- Fuzzy controller of difficulty: The results of the above described fuzzy controller would be used to establish a criterion suitable for the generation of the exercises according to its type, difficulty and usefulness.
- Planner of exercises: For the generation of exercises, a propose-review model is proposed. First, the type of exercise to construct would be chosen (in principle, a Simple Knowledge Organization System - SKOS – is proposed to store the knowledge about the types of exercises) and, later, it would be parameterized. In case that a parameter were not coherent with the problem or with the other parameters, a change would be proposed on it, and the exercise would be revised again.

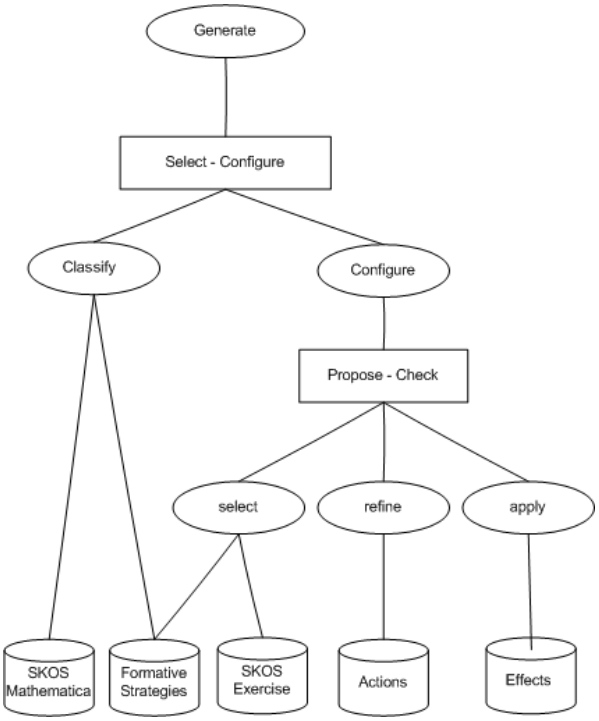

Fig 3. Automatic Exercises Generator Solution

The output of this module is a planning of exercises, complementary to the planning of theory. The exercises model will have its own knowledge base, which would contain the different types of exercises and their functions.

5. Automatic evaluator of exercises

A possible solution to this problem is also proposed. The main components of this module are:

- Planner of exercises: The configuration of the exercise would be detected, as well as a tree of different ways to solve it. The problem would adjust itself according to the answers provided by the student.
- Generation of solutions: Taking advantage of the great amount of mathematical tools available nowadays, a solution (theoretical, as well as practical) could be programmed for the current exercise in order to have a result to which compare the solution obtained by the student. Maple, Matlab and other platforms could be especially useful in this part of the work.
- Evaluator: The generated solution would be compared with the plan of solution obtained by the student. The tool would verify if it agrees with the right answer and the coherence of the proposed solution would be analyzed. Again, the use of web technologies and languages as MathML [5] would be an advantage.

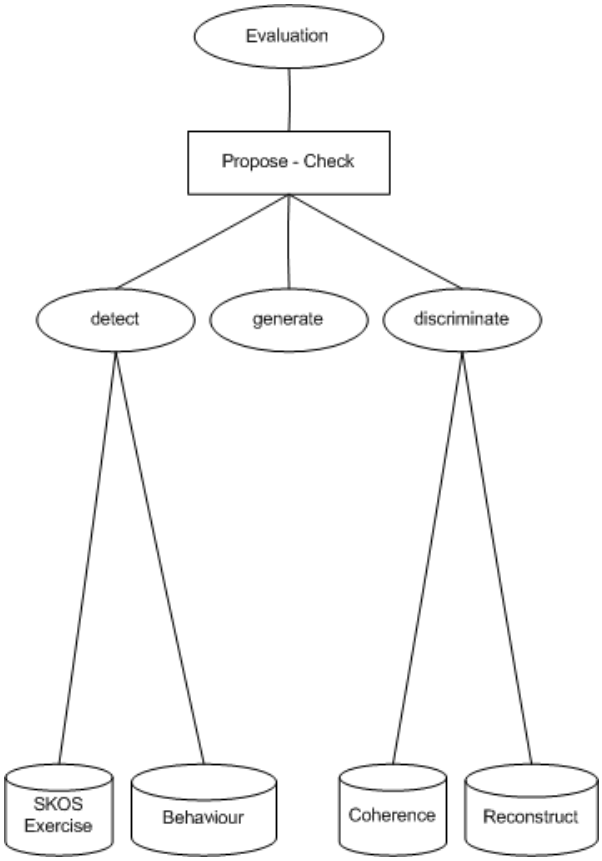

Fig 4. Automatic Evaluator of Exercises Solution

6. Web technologies

Once obtained the execution plan of a tutorial session based on previous results, we have to take a special care in the way the content is presented via web. The use of verbal-iconic systems which take advantage of the multimedia capability of the World Wide Web is essential for the transmission of knowledge. Plug-ins, multimedia files, animations, videos, sounds and other correctly used web-compatible multimedia material will constitute a formation and communication channel plenty of possibilities.

From the point of view of the academic formation (an environment in which we will propose a first approximation of the complete tool) we understand that the complexity of the channel for the communication of the information is itself a problem.

The objective of this paper is not the development of a basic theory on the use of new technologies in education. In fact, there is a lot of information in this area and many research works with concrete and accessible results. However, this topic can not be neglected. Our goal is the development of a technology that could be used independently of the type of education, i.e. we intend to develop the foundations of a more complete tool made in collaboration between professionals of education and of new communication technologies.

7. A framework for the system

One of the advantages of the system that we are developing is its versatility. The same scheme can be used in different fields. On the one hand, it can be modified to be used by people with different disabilities, just changing the strategies module in figure 3. On the other hand, it can be used as a complementary education system in more specialized environments, for example in higher education or in specific enterprise courses.

The implementation of the system will be at the University level, initially for an Infinitesimal Calculus course.

In this framework, the ontologies knowledge would be a network of nodes of knowledge concerning mathematical concepts (not from a mathematical but from a formative point of view) interrelated and tagged according to their complexity, their relevance, etc.

The formative strategies are oriented to higher education and will require as a pre-requisite certain academic level.

The objective is to develop tests for the students in order to establish a median line from which to start instructing the students. In this way the system has some results to reduce the uncertainness upon the user level.

The main objective that we want to acquire, when using this system in education, is to increase the teacher-student communication, not to replace the still necessary classroom sessions with the teacher. However, the student can use the system to self control his progress, while the teacher can monitor the level of the class. In this way, the continuous evaluation pretended in the framework of the European Convergence becomes more tangible.

8. Acknowledgements

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9. References

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