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Expert System as a Support Tool for Teaching Calculus

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Abstract. Expert systems are tools that can diagnose and correct the development of learning students helping improve their weaknesses determining their cognitive level. This paper aims to develop an expert system as a support tool for teaching Calculus using Bayesian networks as inference engine and records of semiotic representation for the base of probabilistic classifier. There are two stages: the first is to diagnose certain weaknesses in the student; the second allows to emphasize the way in which aspects of learning will be discussed and how the topics to be presented to reinforce the area.

Keywords: Expert systems, Bayesian networks, records of semiotic representation, probabilistic classifier.

1 Introduction

Applications of learning systems are quite extensive, there are several e-learning platforms that allow to structure content based on a variety of multimedia resources, however, have each element statically, do not make decisions or determine that element displayed on a given time; not check which is the most suitable, they not reasonably monitor user progress. This justifies the study of areas such as artificial intelligence applied to learning within the framework of e-learning, because in a number of contexts has been proven efficient operation [1].

The field of expert systems (also associated with knowledge representation systems and knowledge engineering) are an important part of the field of Artificial Intelligence. In particular they represent knowledge in the domain expert (specialist), being employed, including, as a tool by the same expert [2]. In various areas of knowledge, these systems can diagnose and correct the development of learning students helping improve their weaknesses determining their cognitive level. This paper aims to develop a tool for teaching Calculus using Bayesian networks as inference engine and records of semiotic representation as the basis of probabilistic classifier.

2 Expert Systems

An expert system can be defined as a computer system that simulates human experts in a given area of expertise. As such, an expert system should be able to process and store information, learn and reason in deterministic and uncertain situations and communicate with users and / or other expert systems, make appropriate decisions, and explain why they have taken such decisions.

This kind of systems encode a knowledge base and reasoning rules to determine or conclude the solution of a particular problem. Are formed by various interrelated parts: a rule base, a base of facts, an inference engine and an user interface [3]. Figure 1 shows the traditional composition of an expert system.

The knowledge of the expert is represented by the rule base that are generally of the form $R_i : Pr(x) \Rightarrow C(x)$, where $Pr(x)$ its a premise and $C(x)$ a conclusion. The conditions of application of a rule are the premises and new knowledge are conclusions.

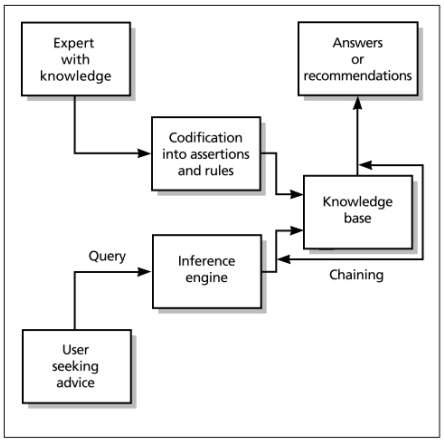

Fig. 1. Anatomy of an expert system.

3 Inference Engine: Bayesian networks

The inference engines used rules in various ways, in particular the method of reasoning will be based on probabilistic classification with Bayesian networks. This method is characterized by a multivariable representation of data to be processed, which allows to describe complex relationships of certain elements and nonlinear, they represent causal relationships, thus allowing handling uncertainty in events unobserved [4].

A Bayesian network represents a joint probability distribution on a 4-tuple (G, f_x, Q, Θ), where:

- (G, f_x, Q) its a causal network,
- G its an acyclic digraph,
- The set x of nodes G its defined by $\{x_i | i \leq n\}$, of random variables with r possible states and Θ its a set $\{\theta_i | i \leq n\}$.

So the expansion of the joint distribution is:

$$P(Y|f, \ldots, f_N) \simeq \prod_{i=1}^{N} p(f_i|Y) \cdot P(Y).$$

For the posterior probability of how it can be the status of variables in a Bayesian network, Bayes' theorem is used.

3.1 Probabilistic Classifiers as Artificial Learning

Learning from the perspective of Artificial Intelligence, it is considered as a process of induction of knowledge that allows us to generalize behaviors from an unstructured information provided in the form of examples incorporating design workable solutions to problems through the study of the computational complexity of these.

The computational analysis and performance of machine learning algorithms is a branch of statistics known as Computational learning theory. Different learning algorithms are grouped into a taxonomy based on the output thereof. Some types of algorithms are:

- **Supervised learning**. The algorithm produces a function that establishes a correspondence between inputs and desired outputs of the system. An example of this type of algorithm is the classification problem, where the learning system tries to assign a label or classify a series of vectors using one of several categories (classes). The knowledge base system consists of labeled examples above. This type of learning can be very useful in biological research problems, Computational Biology and Bioinformatics.
- **Unsupervised learning**. The entire process of modeling is performed on a set of examples formed only by system inputs. There is no information on the categories of those examples. Therefore, in this case, the system must be able to recognize patterns to assign labels to new entries.
- **Semi supervised learning**. This type of algorithms combine the above two algorithms to classify properly. Marked and unmarked data is taken into account.
- **Reinforcement learning**. The algorithm learns observing the world around him. Your input information is the feedback you get from the outside world in response to their actions. Therefore, the system learns based on trial and error.
- **Transduction**. Similar to supervised learning, but not explicitly constructed a function. Tries to predict future categories of examples based on input examples, their respective categories and examples new system.
- **Multitasking learning**. Learning methods using knowledge previously learned by the system face to face similar problems to those already seen.

3.2 Records of Semiotic Representation

Semiotic representations are representations that use signs, they can expressed in natural language or algebraic, graphs or figures geometric. These semiotic representations are the means through which a person can externalize their mental representations in order to make them visible or accessible to others. The ability to change the records of semiotic representation is necessary in the mathematics learning and the importance of coordinating the different registers of semiotic representation. Many difficulties experienced by students can be described and explained as a lack of coordination between representation registers, in particular graphic, numeric and algebraic [5].

4 Methodology

The expert system has several components, modules and persistent entities. Optimization problems are working and interacting with students through a virtual tutor who tells the procedure to be followed at all times. As shown in Figure 2, the student begins to access the pretest module, where it presents a diagnostic test that, through various reagents, assesses student skills and deficiencies.

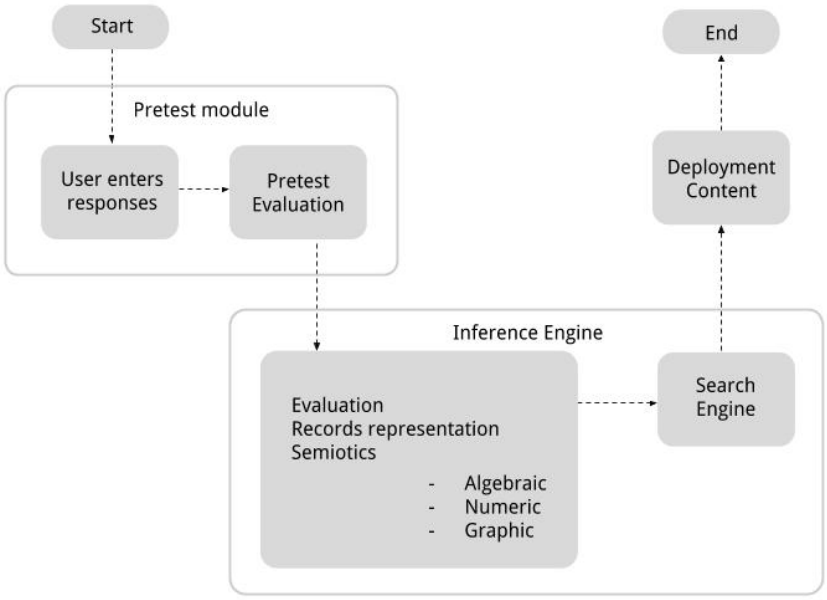

Fig. 2. Flow user action with the expert system.

Figure 3 shows an example of the graphical user interface (GUI) provided to the student to work with the pretest. This interface provides the user with the following elements: the problem statement, a descriptive picture, different options to choose in response to problem and mechanisms of recurrent asynchronous storage.

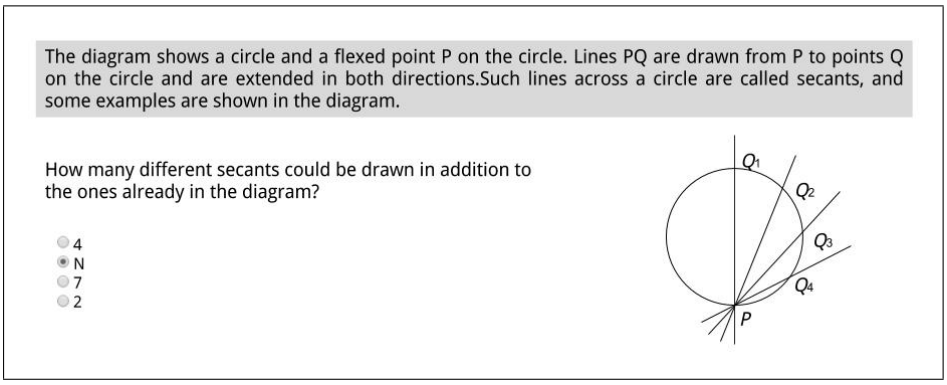

Fig. 3. GUI pretest for a record graphical representation.

To determine which register of semiotic representation has the highest efficiency is assigned a score according to the complexity of the reagent. The evaluation is carried out in the inference engine using probabilistic classification based on Bayesian networks.

The search engine takes the result of the inference drawn and creates a data structure ramified from a collection of associative structures that link resources, activities and teaching materials. This collection is stored in a database. Finally an exhaustive search is performed to determine the optimal route learning, that is to say, the set of suggested activities for the student.

4.1 System Overview

The expert system consists of a set of applications and Web services that engage in the following modules:

1. **Users**. In this module the user has the ability to create your account, manage your profile, change personal data and set your preferences. To create an account requires an username, an email address and a password of at least 6 alphanumeric characters. The system accepts only valid email accounts and does not support existing usernames. Once the account is created, the system assigns by default the role of student and notifies the creation of the account to the user through email. The module also offers users the ability to create accounts with other roles with different access levels. The system administrator is the only user with privileges to create accounts with the

role of teacher and supervisor. This module is responsible for controlling the restricted access to the system.

2. **Control of students**. It allows to monitor student progress by monitoring system access and viewing activity logs and pretests presented. It provides the user with the role of teacher the ability to generate reports and statistics showing the student's behavior on the platform. The roles of supervisor and administrator privileges feature in this module by default.
3. **Administration**. The user administrator role is the only one with access to this module. It allows management of secondary modules and specific components of search engine and inference. Enables the creation of accounts with higher privilege roles and activity monitoring them. Management roles and privileges associated with each role are managed in this section. It also allows the administrator to schedule frequent tasks.
4. **Management pretests**. Since this module creating, editing, and deleting query evaluation tests for the student is managed. The role of teacher has the privileges to access this module. By using monitoring each student activity associated with their respective pretest its provided. It also allows the display of the scores for each record representation by accessing the evaluation history. creation and editing of questions for each pretest, and generating reports and statistics is also possible.
5. **Content management**. Enables management activities, resources and learning materials enabling the creation and editing content paths. These routes will be used by the search engine to determine the learning path that suits the profile of each student. The inference engine is responsible for composing the profile based on the records of semiotic representation.
6. **Activity logs and backups**. This module has tools that allow the export of records stored in the database through the scheduling of full or partial backups in plain text with SQL format. By default, the administrator user accesses the backup module, however it is possible to enable export in excel format records activity and results of evaluation tests for other users. Similarly, the module provides functionality for audit activity logs of all system accounts.

4.2 Expert System Architecture

This architecture includes both business functionality encapsulated as standardization of communication infrastructure. The service is the central component and implements business functions.

In the architecture used (SOA) functionality is divided into services. These can be found distributed through various nodes in a network. The services combine to achieve a desired result and may provide data or be coordinated by other services.

Services, therefore, are the fundamental components of any SOA, largely replace the functionality of conventional applications and is characterized by a low degree of coupling, implement business functions and be isolated components that define their independent interfaces technical implementation environments.

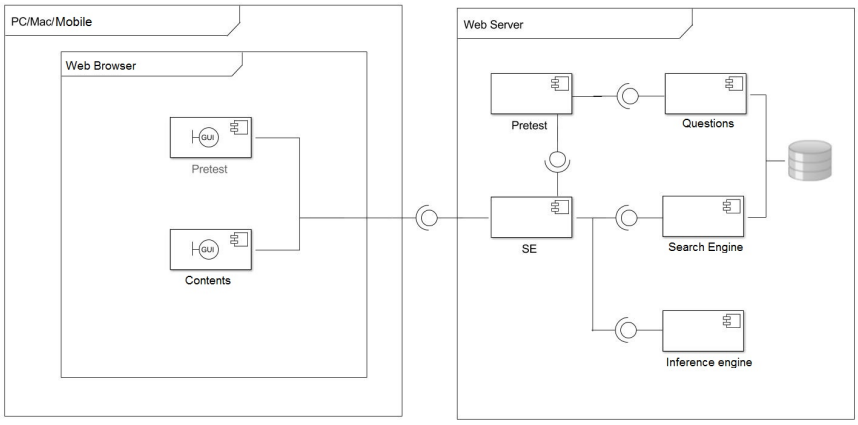

Fig. 4. Expert system architecture.

They have two types of communication services:

1. Orchestration model. Defines the behavior and how to carry out the events so that they are monitored centrally.
2. Model choreography. It is based on the behavior to be observed before both parties to communicate.

Services in an SOA-based architecture must meet the following:

1. Be reusable.
2. Provide a formal contract.
3. They are loosely coupled.
4. Seek to "composition".
5. They can not have been.
6. They must be discovered to be used or consumed.

SOA is based on open standards like XML, JSON, SOAP, WSDL, REST, BPEL, etc. In particular REST is an architectural technique Stateless, which works directly with the HTTP protocol, which means that the resources made requests (resources consumed and service) only have a system image formed by the action towards which performs the request through the respective connector, that is to say a client-server application is independent of the following requests.

REST is the protocol used for architectural development of distributed component of the proposed framework, this because REST shows the following advantages over SOAP:

1. Using HTTP protocol.
2. Support requests GET, POST, DELETE and UPDATE.
3. Possibility of using different data transfer formats such as XML or JSON.

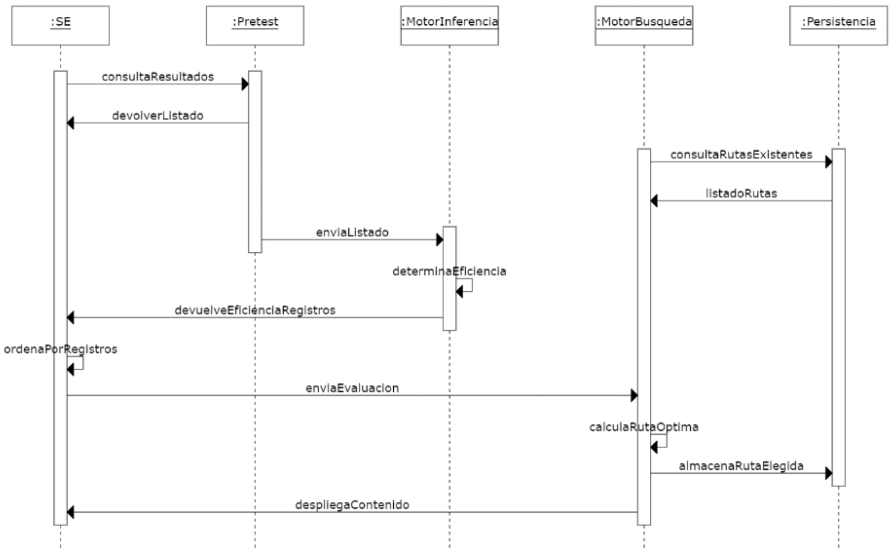

Fig. 5. Classification sequence and decision making (screenshot in Spanish).

4. REST services present less coupling SOAP.
5. Enough potential to work with any client application.
6. It not required to publish in WSDL.

5 Conclusions

Probabilistic classifiers used to implement inference engines in an expert system, allows a multivariable representation of data to be processed, which in turn displays a description of complex relationships of certain elements, considering also, the uncertainty management. By using records of semiotic representation (graphical, numerical and algebraic) as primary elements of classification, is parameterised an appropriate way to present aspects of learning paths the area to reinforce the student.

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