

Putting Artificial Intelligence Techniques into Distance Education

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Abstract. This paper reflects on how some Artificial Intelligence Techniques may positively affect the operation of a distance education platform. It addresses to a particular distance education platform at which specific characteristics are incorporated, such as the adaptation to different users profiles as much to diagnose as to determine a plan for the most adequate teaching strategies. The use of Bayes nets and neural networks are mentioned in the evaluation process and a summarized example is included in the use of the platform.

1 Introduction

In recent years, computer aided teaching has been strongly impacted by incorporating artificial intelligence techniques, as a form of approaching the strategies that artificial systems get closer to the way in which humans take decisions and solve problems in education. This idea is not new, Papert and Minsky regarded computer sciences as an instrument for positively modifying the way in which people learn and not only as a form that allows to explain this process [6].

The very first artificial intelligence application in the field of education has been the implementation of intelligent tutorials, i.e., systems with the capability of adapting the instruction process to student's characteristics. This goal is achieved by creating a relationship between the four basic system components: expert module, student model, pedagogical module and interface. The expert module level is the one that solves the problems intended to be taught; consequently it must have a broad knowledge and an ample structure of the subject to allow for an optimum management of them. The student model is a database that represents the student knowledge at any given time. The pedagogical module is the one in charge of managing in which sequence the subjects are to be presented according to the information gathered from the student model determining when and what kind of help the student needs. The interface supplies backing to the student activities and methods used to carry out such activities. The interface must be easy to use in such a way that the student waste a minimum time in learning on how to use it and concentrate in the learning process of the subject.

Many specific systems like these, their goals and structure have been discussed in detail by different authors [11, 10, 9]. Today, some efforts are focused on incorporating artificial intelligence techniques into Adaptive Hypermedia Systems (AHS), which appear to be a promising option in computer aided education, mainly due to Internet and WWW. Brusilovsky defines it as "a system based in Hypertext and Hypermedia that reflects some user characteristics and applies this model to adapt some visible aspects of the system to user" [1].

This work introduces artificial intelligence techniques at a distance education platform and whose novelty lies in considering aspects like learning strategies adaptability, communication tools and student profile evaluation: their learning styles and knowledge, these issues have been found partially only in revised platforms both in literature and through Internet.

2 The Distance Education Platform: MISTRAL

This platform shares common features with many similar projects in use today, but it differs in the way on how it adapts to all sorts of student's profile, suggesting activities, providing tools and more appropriate mechanisms for correcting detected misunderstandings.

The course structure adapts to a particular student features such as prior knowledge configuring activities and sequence of contents. In addition, the course structure adapts to the student's learning style. The platform automatically measures different students' styles and then chooses the best strategy for each one of them. Once students have developed the proposed sequence of suitable activities the course structure itself adapts to the student's learning capability. If students do not reach the required qualification, the platform proposes a series of complementary activities different from the previous ones that allows it to enhance the learning process. In section 5 a course example is shown to clarify the platform operation.

In summary, different functionalities of the platform can be highlighted as follows:

- It allows for the management and automatic generation of different distance courses in multi-user modality.
- It makes the knowledge acquisition easier in contents and varied in activities for a particular course.
- The platform has the necessary knowledge for detection and diagnosis of the learning capabilities in a specific unit, and the necessary activities required for improving the learning process.
- It generates a Virtual Classroom, personalized for each student, with discussion groups that adapts to different learning styles and a mailing system that includes a tracking mechanism for warning if the interaction level of a student in some activity is lower than required.

A general scheme for MISTRAL is shown in figure 1.

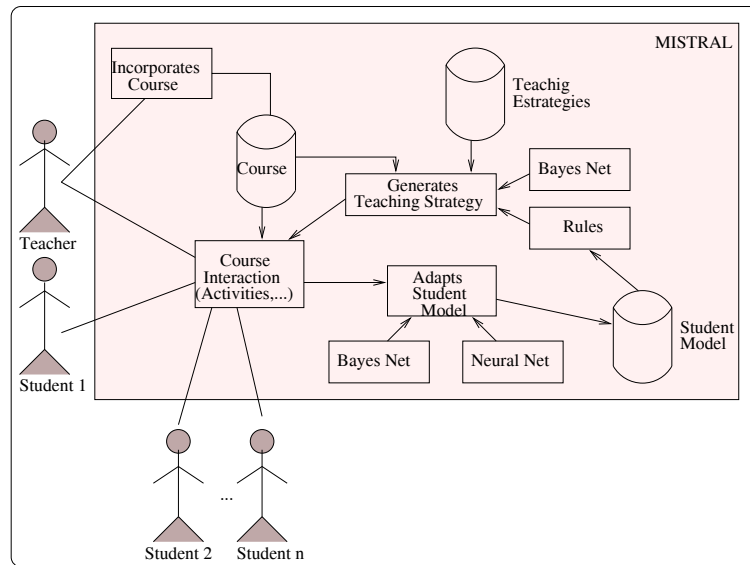


Fig. 1. MISTRAL: The basic components

3 Using the Platform

From the instructor's point of view the use of this platform can be explained through two main concepts: the course development process and the platform operation process. The course development process describes the facilities that help the instructor when creating a new course; this is the way and sequence in which the material will be handled out according to the student particular profile. The platform operation process describes the way in which both the instructor and the student will use this platform and tools given by it during the course development.

3.1 The Course Development Process

This process is carried out through two phases: the first phase is the **identification of requirements** and the second one is the **creation of contents**. In the identification of requirements phase it is necessary a previous planning of the work that must be done to get an effective teaching. An adequate plan has to answer questions like what, how and when to teach. The answers to these questions highlight different issues taking into account: the student, his environment and psychosocial features (the user profile where the learning style is considered), the goals to reach, the contents, the activities (didactic resources) and the correct sequence considering these steps along with evaluation instruments. In computer programs in general and in a knowledge-based distance course development in particular, the planning process is related to analysis, which has been

traditionally developed in manual form. The analysis required for developing a course using this platform will affect two components in the system: the student model and the pedagogical module.

In order to analyze the learning-teaching material both books and expert knowledge are fundamental from which a clear view about contents are to be handled out, also the possible sequences to consider and different ways to submit and evaluate are taken. This phase aims to structure the acquired knowledge about the learning strategy, the sequence of contents for different profiles and the sequence of contents for different learning styles. This arrangement can be observed in figure 2. The learning styles taken into consideration here are four: Concrete Experience (CE), Concepts Abstraction (CA), Active Experimentation (AE) and Reflexive Observation (RO) [3].

Teaching Strategies

(CE) Concrete Experience Modify Add Back

(CA) Concepts Abstraction

(RO) Reflexive Observation

(AE) Active Experimentation

(CE):	1	2	3				7	8		10	11	12	13
(CA):			3	4	5							12	
(AE):		1	2				7	8				12	13
(RO):		2		4		6	7	8	9			12	

Objective: Introduces basic object-oriented concepts and approaches. Explores basic object technology and cites its advantages.

(CE) (CA) (AE) (RO)

Information Instructor Students Course

Listo Intranet local

Fig. 2. Sequence of contents for different styles

For the creation of contents the learning-teaching material mainly relies on the expert and in books. To this end, the material representation (frames) and the used mechanisms (semantic networks) are needed. In figure 3, a possible sequence of contents determined for different user profiles is shown, allowing the establishment in a semantic network, of the sequence of contents (previous and further knowledge) for users that present particular characteristics and knowledge.

In order to automatically build a distance course the characteristics of domain's knowledge are required to be provided. Most courses have a structure at a pedagogic level that attempts to represent contents and skills to be delivered to

students and the relationship between contents necessary to ensure an effective learning, i.e., in the pedagogic organization of the teaching material.

For instance in the course Object Oriented Analysis and Design, the pedagogic level features are:

- Instructional goals to be accomplished in the course (general and specific objectives).
- In this platform the task of basic learning units is placed as activities, allowing storing of theoretical contents, as the definition of polymorphism, or practical contents or procedures such as the modeling of a problem using object orientation.
- In order for the platform to evaluate the student, different tests and exercises are created.

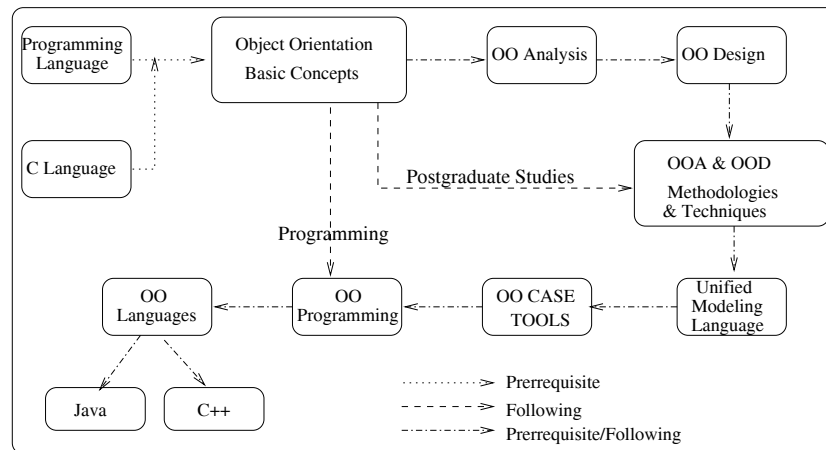


Fig. 3. Sequence of contents for the Object Oriented Analysis and Design Course

3.2 The Platform Operation Process

As the instruction process goes on the system will use the guided method in which this platform after providing a series of activities suitable for a user profile will allow the students to develop these activities by placing the results into a personal portfolio (a repository to store the results of activities accomplished by the student), so that the system generates another sequence of activities suitable for the student. Different authors characterize learning styles in many diverse ways, but in general they locate people between two points in a continuous space. In this work the learning style of David Kolb has been used [3], to discover the learning style of users using this platform, aimed to adapting the more appropriate activities for students to increase one style and support the others. The

reason for using Kolb's work is that it represents the classification suggested by the educational authorities in our country.

4 Artificial Intelligence into the Platform

Tasks that need to be performed in order to accomplish a distance course are:

i) Didactic material preparation adjusting contents from the Expert Module, where the experienced person decides the most suitable materials and activities to tackle such content for different students' profile.

ii) Teaching learning strategies contained in the Pedagogical Module that determines the most appropriate sequence of activities to the different student's profile.

iii) Evaluation, assigned to determine the amount of acquired knowledge by the student which will modify the pattern within the Student Model.

iv) Dialogue among students, between student and instructor.

v) System administration.

Different techniques used in AI have been incorporated into the platform. Following, there is a summary of ways in which these techniques are inherent to the didactical material preparation, evaluation and teaching-learning strategies.

Frames. Most all the knowledge available from the subject (didactical material) and about the student (learning style, amount of knowledge acquired) is structured into frames. The arrangement of didactical material in the platform consists of a semantic net of frames. For the actual course construction using this platform the didactical material must be classified in: *General Objective* (course guide), *Specific Objectives* (leading to specific topics) and relative relevance to each objective, *Contents* (components of the specific objectives) and relative relevance to each content. Activities according to different profiles and difficulty levels, and impact ratio for each activity. Difficulty levels are defined by the instructor, based on his/her experience in teaching the particular topics and impact is rated by considering how the specific topic is related to the general objective for the proposed activity. There is a frame type where the information associated to each of these types of material is stored. An example of a frame to model the subject matter is the one presented below. Here we find a collection of attributes identifying the entity "Activity" that stores knowledge of contents of a course to develop.

Node Type: [reading/solving/programming/modeling/simulation]
Code Activity: [n]
Description: [text]
Scoring: [integer]
Probability to answer to the activity since its content is already known
Probability to answer to the Activity since its contents is not known
Previous Knowledge: [integer]
Activity Type: [analogous/empiric]
Learning Style: RO, CE, AE, CA [text]
Guessing: [real], Impact: [real], Difficulty: [real], Oversight: [real]

In this frame, among other slots we can identify:

- *Learning Style*, this activity may favor a specific learning style more than others or a particular one (RO, CE, AE, CA); this slot will store knowledge for each entity and allow further down to adapt a specific strategy related to this information.
- Several slots are used to store the necessary information to generate an activity similar to Computerized Adaptive Tests (CAT).

In order to adapt this platform to a specific student a model of this particular student must be established. The student model may be separated into two parts; the first one being the psychosocial with the psychological and social features to be taken into account in the teaching-learning process; and the second part of the student model is the knowledge model that allows to establish which are the contents that the student is learning and the objectives that is accomplishing. Same with the didactical material the information related to the student model is stored within a structure of frames.

Semantic Networks. Relationship between contents used by this platform are made explicit through a semantic network with predefined terms (is, uses, is-part-of, etc.). In order to organize the didactic material the instructor must first define the concepts as a whole with which he/she will be building the supporting frame of knowledge. These concepts and their relationships will be the groundings from which the student will learn according to his/her profile and previous knowledge. Semantic networks are a promising way to model static knowledge as they allow identifying concepts and their relationships in a given course. In addition, this allows students to be aware of the previous concepts before carrying on with the next step.

Production System. The course is built by selecting or generating a set of necessary rules and objects in terms of specified knowledge. This can be accomplished by an expert (the instructor) through tables that allow him/her to establish the sequence of activities based on the students' profile.

Teaching strategies are carried out in order to induce changes to the student behavior through well structured processes involving the use of didactic materi-

als. This kind of particular teaching strategy for a certain learning style of each student falls into a sequence of activities already defined in that particular didactic material. Selecting the most suitable sequence of activities is carried out by using a rule-based production system that incorporates its own pedagogical rules as such or from psycho-pedagogy. These rules are applied to the available structure knowledge under the frame format.

Neural Networks. Psychological and social variables of the student model are used by an artificial neural network previously trained to predict the students' probability of success or failure. This information is stored in a slot in the appropriate frame in order to be used at a later time by the production system that makes recommendations about the necessary activities required for success. This prediction supplies the necessary information for the different models of the student and the teaching strategy being able to split into two steps, first the one where the psychological features are encountered and second, the periodical that is carried out at the interaction process between the student and the platform [7].

Bayes Networks. The knowledge model of the student is updated through evaluations taken to the students using a Bayes net. The Bayes net is used to assess a degree of knowledge accomplished by a student in order to recommend the most adequate activities from the actual level of knowledge learning style and the student profile.

Diagnosis of the learning level of a student and the sequence of activities that are to be used for a particular student's profile are predicted through the probability theory using Bayes nets. The net consists of four levels or layers; the first layer contains the general objectives for the course; in the second are the specific objectives for the course, i.e., groups of contents aimed to particular purposes, that are a decomposition for the general objective. In the third layer, the contents and the minimal units for knowledge decomposition are located. Finally, in the fourth layer the activities for each content and for each learning style are located. These activities are prepared to generate knowledge: the instructor needs to specify a difficulty level, and an impact ratio for each activity. The platform needs this information to compute the conditioned probabilities that relate learning degree and activities to be accomplished, by using Item Response Theory [5, 8].

On the other hand it is possible to periodically diagnose through diverse techniques such as portfolios or computerized adaptive tests. The later, that uses Bayes nets allows choosing the best activity or questioning the needs of the student for knowledge.

CommonKADS. As a general methodology to model in a structured manner the knowledge of tasks, methods, inferences, rolls and concepts of expertise in each of the phases, necessary for the global distance teaching/learning function. This is a method used for analysis and organization of knowledge-based systems in an analogous way to the methods used in software engineering [2].

5 The MISTRAL Platform for a Course on Object Oriented Analysis and Design

A specific course has been developed, *Object oriented Analysis and Design* (OOAD) for students in a third year engineering, using this platform. The course structure adapts to particular student's features such as the previous knowledge in programming languages and modeling tools. The instructor has decided to offer the capability for choosing the language to use in the course or to begin with a specific programming language and choose the modeling tool (Rational Rose, Microsoft Visual Modeler, GPro, etc.). The OOAD is a course developed in a semi-present modality, so those students can achieve the objectives in restricted deadlines but according to their own learning capabilities.

Determining the general objective for the OOAD course. The objective for the OOAD course was established in the following manner: *Understanding the concepts of analysis, methodologies, design and programming pointing to objects, in order to apply this knowledge to the analysis software of systems development and using through the UML (Unified Modeling Language) and JAVA language.* From the preceding statement we conclude that for this particular case the possibility of choosing a programming language to use was not taken into account. Following the general objective it is necessary to specify the main objectives with a level of relevance in order to accomplish the general objective.

Determining specific objectives. The process associated to a specific objective finishes when the learning level of this objective is 100% accomplished since the instructor established that each objective must be satisfied completely. Thus, although the *relevance* to each objective may appear not to be important, the indexing of this factor was maintained to allow the student be aware of his/her progress. Once specific objectives are settled it is necessary to determine the contents that the student must learn in order to accomplish each one of them. Contents for the first objective are shown:

Contents	Relevance (%)
Objective 1	
1 Software quality	
1.1 Introduction	20
1.2 Software quality	50
1.3 Modularity, coupling, cohesion	30

Determining activities. This phase was the most difficult in knowledge acquisition. Even though a great variety of activities are used by different instructors it is necessary that a reduced number of activities for each content be worked out within a great amount of time frame in order to establish certain activities for different learning styles and also determine the appropriate

parameters. These parameters have been explained in [4] and its meaning are as follows:

LS: Learning Style (figure 1)

IR: Impact Ratio (one of the following values: 0.2, 1.2, 2)

D: Difficulty Level (1 to 10)

G: Guess Factor (0 to 100 %)

(Texts, exercises and examples referred to in the following table can be consulted in <http://152.74.11.209/pide/>, a course demo). Some of the activities associated to the content *Software Quality* are shown as follows:

Cont.	Activities	LS	G	IR	D
1	Software Quality				
1.1	Reading the text <i>1.1 Introduction</i> . Underline in the text whatever you consider more important and place it in your files folder as Act1-1	RO	0	0.2	1
	...				
1.1	Search in the Internet what conferences or seminars are at this time fully dedicated to object orientation, describe the subjects considered. Place this activity in your file folder named Act1-4	AE	10	1.2	3
	...				

In summary, it is necessary to structure and classify lots of activities that from the instructor's point of view and the Internet sources become important when the OOAD course is learned in order to meet proposed goals for each objective and different students. This course was improved incorporating new activities not considered in previous courses. This is the result of considering different learning styles and different teaching strategies. The strategy selection is done by the production system. Each activity created must be evaluated; therefore the simplest planned activity will be useful for the students. This evaluation is accomplished using Bayes nets. The platform allows to generate complementary activities automatically which are suggested through the neural net.

6 Conclusions

In this paper we have presented how the use of techniques of artificial intelligence can influence the teaching learning process when a platform for distance education is used. The use of neural nets as a mean for prediction related to the potential success in specific learning matters, proved to be an adequate mechanism considering that were also used to predict more appropriate activities to accomplish in case the students presented a sign of failure. The use of Bayes nets allowed automating the student range knowledge degree in the evaluation process thus different student profiles lead to a sequence of personalized activities that suit each particular learning profile, considering the previous knowledge acquired by the student. The instructor may verify through his experience whether

it is possible to reach a real personalized education using Internet or otherwise. Private discussion groups put students of different learning styles together. This aim strengthens these different styles so that successful strategies can be imitated. The ability to store different kinds of work in the portfolio allows the student and the instructor to check the learning process progress that constitutes an additional communication mechanism among the actors.

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