Architecture of an Intelligent Tutoring System Applied to the Breast Cancer Based on Ontology, Artificial Neural Networks and Expert Systems

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***Abstract*— This paper presents an Intelligent Tutoring System (ITS) applied to the teaching of breast anatomy and pathology, more specifically of the breast cancer, the type of cancer that kills more women in the world. This paper aims to elucidate the importance of using these systems, lift requirements for the development and designing of an architecture of ITS. Through resources and applications of Artificial Intelligence techniques this ITS has the capacity to acquire the profile of its user and define teaching methodologies to build interactive and dynamics environments, based including in the use of Virtual Reality. The architecture of this ITS consist on four modules: Tutor Module (Artificial Neural Network), Student Module (Expert System), Domain Module (Ontology) and Interface Module (Adaptive Hypermedia Systems). The use of this ITS provides a didactic help to students and health professionals to the understanding of the explanations and practical applications needed to this domain of knowledge.**

Keywords - Intelligent Tutoring System; Expert System; Artificial Neural Network; Ontology.

I. Introduction

This article presents an Intelligent Tutoring System (ITS) – a system which incorporates Artificial Intelligence (AI) techniques – applied to the breast cancer [1]. This is the most common type of cancer that affects women and causes more deaths among them in the world. In 2008, 23% (1.38 million) of new cases and 14% (458.400) of deaths were caused by this disease [2]. In 2012/ 2013, 52.600 new cases of breast cancer are expected for Brazil, with an estimated risk of 52 cases in each 100 thousand women [3].

In order to provide improvements in both education and quality of life, the areas of health, education and information technology have been working together to develop education systems and disseminate information about prevention of diseases [4].

The first educational software used were the Computer Aided Instruction (CAI) Systems, designed in the 50's with the aim to provide to the students improvements on learning. However, these systems could not differentiate the individual abilities of students, because they used to implement same actions to all users [5].

Carbonell (1970) proposed the creation of the ITS in order to create an environment that allows a more individualized interaction between the student and the system [1], which has proven the effectiveness in improving the performance and motivation of students [6].

The use of AI techniques gives ITS a great capacity to store knowledge about the learning virtual environments and about the apprentice's characteristics. These characteristics are used, on the scope of Education, to define which strategies and tactics can be used to get the best teaching process [7]. The strategies describe the required process to achieve learning and they are based in theories as Behaviorism and Constructivism, among others; the tactics refer to specific resources used to facilitate the teaching, as images, videos, texts, among others features.

Most of develop ITS is composed by four modules (Student, Domain, Tutor and Interface), however this pattern is not always used. Basically, the Student Module stores the apprentice's characteristics; the Domain Module stores the content to be taught; the Tutor Module decides which ways the content shall be presented, adapting the Interface to the apprentice's characteristics, to display the content through an immersive, interactive and intuitive environment [8].

The aim of this article is to elucidate the importance and lift requirements for the development and designing of an architecture of ITS, including its possibility to use this ITS in a Medical Simulation Environment (MSE).

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The remainder of this paper is organized as follows. In the next section we discuss related works. In Section 3 we describe the material and methods, which comprises the domain, student, tutor and interface modules. In Section 4, we discuss about the functioning of the ITS. In Section 5 is presented the conclusions and future work.

II. RELATED WORK

Several researches have been carried out to develop an architecture of an ITS which can capture some learner's information and use it to present an interactive and dynamic interface to the user.

Many different techniques to implement an ITS have been used, including the use of ontology to represent the knowledge, the apprentices characteristics [9] and the teaching strategies [10].

Some techniques to develop an Expert System were used to acquire the Learning Styles [11] of the apprentice to be stored in the Student Module and used as a parameter for the presentation of the content in the interface [12][13].

Tutor Module controls all the system and an Artificial Neural Network type Interactive Activation and Competition (ANN IAC) was used to implement this Module [12], which updates both the Interface Module and the Student Module [14]. An ITS can be integrated in a MSE which enables the learner to obtain experiences with a wider variety of structures and peculiarities, even being possible to repeat or redo procedures training free of charge [15].

The use of these architecture using tools, ontology, expert system and ANN IAC, including the Adaptive Hypermedia Systems shows up as a new approach to the development of ITS. Due this type of system involves various areas of knowledge applied with a common goal, the adaptation of the system in teaching to a particular student profile and its dynamicity is actually achieved with this approach.

III. MATERIAL AND METHODS

The first version of this ITS was developed as traditional architecture (Figure 1), which consists of four modules: Domain, Student, Tutor and Interface [14][16][17].

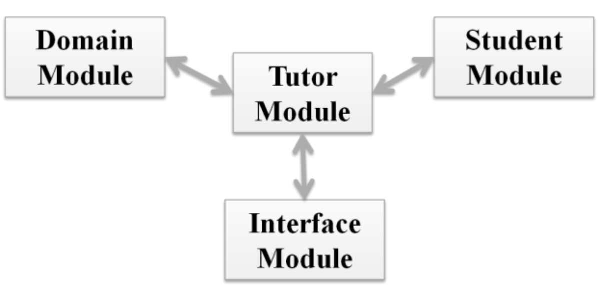

Figure 1. Architecture of the ITS.

A. Domain Module

The Domain Module was developed as an ontology model (Figure 2) that allows an easy way to organize and formalize the knowledge and ensure access with a single vocabulary. It can also represent organizational structures of a large complex domain and reason about itself [18].

The Protégé Software [19] from the Stanford University was used to build this Module. This software is based on Java and consists of a free open source ontology editor and knowledge-base framework that can be exported into a variety of formats including Resource Description Framework (RDF), Web Ontology Language (OWL) and Extensive Markup Language (XML) Schema.

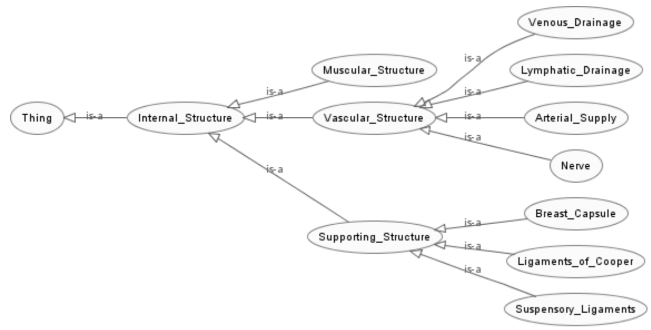

Figure 2. Breast Ontology (Protégé)

The idea of use ontology came from the fact that is needed to represent multimedia content as well as the medical vocabulary associated with the anatomy of the female breast and it's most important pathologies, including several types of breast cancer and other anomalies.

The Domain Module will include all the elements needed to represent the knowledge as well as a mechanism for automatic information retrieval (Figure 3). The ontology model is named ONTOMAMA-Model and the computational mechanism for information retrieval is known as ONTOMAMA-Engine.

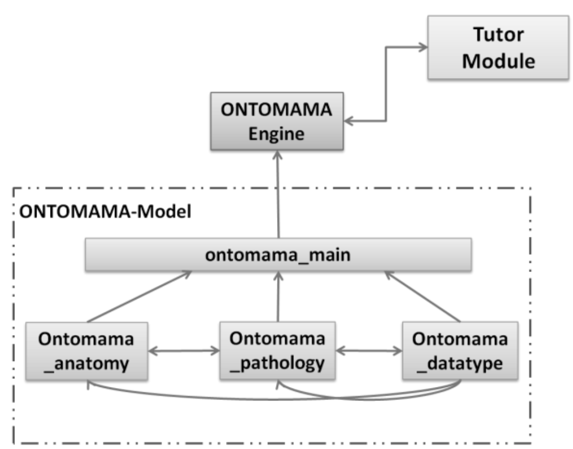

Figure 3. Ontomama Model.

The ONTOMAMA-Model is comprised by four distinct and interconnected OWL files (ontomama_main.owl, ontomama_anatomy.owl, ontomama_pathology.owl and ontomama_datatype.owl). The ontology was segmented to favor reuse and understandability of the model. While the file ontomama_main.owl will contain the model instances and their associated multimedia contents, the other three files

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will represent the medical vocabulary that depicts the anatomy and pathology of the female breast.

The ONTOMAMA-Engine has been programmed in JAVA by using Protégé API and Web Service technology. From this, it is intended to provide services in open standard format that might be consumed to retrieve any information in the ONTOMAMA-Model.

The challenge of the Domain Module of this ITS was to provide an efficient mechanism of tutelage where the requested of the apprentice can be intelligently delivered in the interface.

B. *Student Module*

The first version of the Student Module was developed as an Expert System (ES) – a system in which is possible to simulate the behavior of an specialist before a given situation - using the shell Expert Sinta [12][20]. This shell, developed in Delphi, uses a knowledge representation module which is based on production rules and probabilities and has an easy way to build screens and menus and a good inference engine shared. Because there is difficulty in integrating systems developed in Delphi in conjunction with other developed in Java, it was necessary to change the used shell.

The second version of this ES (Figure 4) was developed on Java Expert System Shell (JESS), a rule engine and scripting environment written entirely in Sun's Java language by Ernest Friedman-Hill at Sandia National Laboratories [21]. Similarly to Expert Sinta, JESS has the capacity to reason using knowledge supplied in the form of declarative rules. It is one of the fastest rule engines available, using an algorithm called Rete, which consists of a very efficient mechanism that organizes the rules as a tree, where similar rules are grouped at the same branches [22].

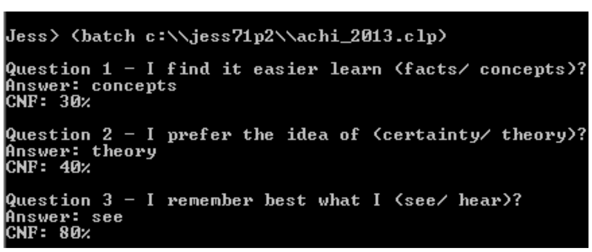

Figure 4. JESS Interface - Example of questions (CNF: degree of certainty of the learner's response).

The JESS Interface is not very friendly, which may cause the learner does not want to answer the questionnaire. To solve this problem a friendly and more attractive interface was created (Figure 5), so that the user does not feel unmotivated to answer the questions.

The Student Module is subdivided into two sub-modules. The first one is used to apply the initial questionnaire to the apprentice to identify his learning styles; this ES is intended to obtain qualitative information about the learner to enable the system to make decisions about the interface. The second one is activated when the user choice some different way to the interface present the content. Thereby, this modification caused by the user will both update the Student Module and the Interface Module.

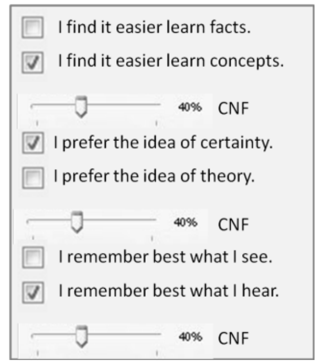

Figure 5. JESS Interface.

The Student Module stores information about the apprentice's characteristics in a database (Figure 6) to facilitate the access of the needed information.

Name	Age	Sex	Carrer	Time Experience (years)	Learning Styles (%)	
Victor	53	Male	Teacher	25	Active	35
					Reflexive	15
					Intuitive	40
					Sensitive	75
					Verbal	80
					Visual	70
					Sequential	30
					Global	60

Figure 6. Student Module Database.

C. *Tutor Module*

The Tutor Module was developed by a mechanism of parallel distributed processing known as ANN IAC [23]. This topology is composed by units of processing (neurons) organized in groups that represent similar concepts, presenting characteristics of Bidirectional Associative Memories (BAM) [24].

This Module is responsible for all the behavior of the system, choosing what and how to present the content on the interface. For this purpose, the ITS will make use of the Student and Domain Modules that will provide information about the apprentice's behavior and the content used during the learning activities. From this, the ITS will adapt itself according to the individual profile and characteristics of each student.

D. *Interface Module*

The Interface Module was developed as an Adaptive Hypermedia System (AHS), which builds a model for each user based on their desires, preferences and knowledge stored on the Student Module and applies it to adapt to various visible aspects to the system. These systems work the concepts for the construction of hyperdocuments for presentation and navigation to suit to the user's needs [25].

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IV. FUNCTIONING OF THE ITS

The first step is to login and create a password to the ITS. When it is done, the user must have to answer some questions about him (name, sex, age, career, time experience and a questionnaire to acquire his Learning Styles). This questionnaire consists of 22 questions, represented by 44 declarative rules described in the ES developed at JESS. Once the user has answered the questionnaire, all the information will be stored in a database which will serve as a parameter to the Tutor Module decides what is need to do in some occasions.

The second step is to choice the content that will be presented at the interface. Once the user has chosen the content, the Tutor Module will send to the interface the correct content in the correct type of media, according to the learning styles of the student stored on the Student Module. The Domain Module delivers multimedia contents to the Tutor Module which includes text, pictures, medical photographs, videos and animations. All of these to enrich the apprentice learning experience throughout a VR environment provided by the Interface Module.

The Tutor Module have as input values the apprentice's characteristics, that will be supplied by the Student Module; as output, the ANN IAC will have values related to the attributes (e.g., medias, videos, text, icons, images) stored in the Domain Module [14]. By means of the interactive activation feature, the ANN IAC can have as input values related to the attributes – actions of the apprentice – that will be back-propagated to retrieve values matching the apprentice's characteristics.

Due to this work in a bidirectional way, the network can both update the Interface Module by processing the apprentice's characteristics and the Student Module by processing the apprentice's actions in the Interface environment, thereby, representing the Didactic Ergonomic Knowledge (Figure 7) [7].

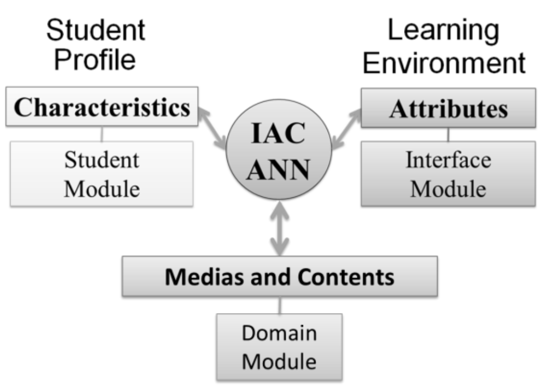

Figure 7. ANN IAC operation: update the learning environment according to the student characteristics and update the student profile according to the student actions in the learning environment, selecting the correct media type to be shown on the interface.

Besides retrieval by apprentice's characteristics and actions, ANN IAC also allows assignment of plausible default values in case of missing information and generalization over a set of instance units.

The Interface Module will present the attributes which will be related to the characteristics detected by the Student Module. The environment will supply icons, bottoms, media, text and images, in short, the resources available to the user to get a better preview of the content. If the learner wishes to define a different interface, modifying the type of media presented, he/she will have autonomy to select other way to represent the content. In this case, the Student Module will be updated storing the new characteristics related to this new media presented on the interface; and the Interface Module will be modified for the next screen there will be presented the content with media related to this updated done on the Student Module.

As mentioned before, once the questionnaire of the Student Module is correctly answered and converted to numeric values, representing the student profile, it will be an input to the ANN IAC. This input will create/ activate the student profile and this respective value will be inserted in the Ontology by the ONTOMAMA-Engine. The ONTOMAMA-Engine will choice the respective media of the content supplied by the Domain Module, and it will be given back to the ANN IAC. The Tutor Module will, then, show on the Interface the content adapted to the student profile.

Therefore, the validation process of this ITS is in progress because the class period has not yet started. Three Universities will be participating in this process: the University of Brasília (federal) and the Catholic University of Brasília (particular), both located in Brasília city in Brazil, and the Universidad de La Frontera (federal) located in Temuco in Chile.

V. CONCLUSION AND FUTURE WORK

This work has a great relevance on the scope of Education and Health areas, since this system helps in the teaching learning process of the female breast.

The architecture proposed in this paper proves to be ideal in order to submit a facility in the organization and changing the knowledge, including the sharing of information with others systems, through the use of ontologies.

The identification of the profile of the learner through the ES proved to be very effective and this information, used to determine the media which is going to be displayed in the interface, was quite consistent with the user request.

The use of an ANN IAC in this ITS was very efficient due its capacity to associate the apprentice's characteristics to the contents and its dynamics process of updating the media on the interface and the profile of the learner, during the use of the system.

Intended future works refer to: a) integrate this ITS in a MSE based on VR, in which will be constructed 3D models using real images and an interaction based on the touch of organs and others structures to make possible the embodiment of invasive medical procedures related to the study of the female breast. This tactile interaction will use an Haptic Interface [26][27] called Omega 7 [28], a dispositive that works together with a graphic interface designed to promote a tactile simulation; b) to improve the development

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of the Student Module terms of access to information in the database and providing this information to the Tutor Module by using fuzzy logic techniques.

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