A WEB-BASED COLLABORATION APPROACH FOR TEACHING IN MEDICINE

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Abstract – Teaching medicine requires developing a vast range of manual, intellectual, visual and tactile skills as well as taking into account large amounts of factual information. Traditional medical teaching and individual learning in particular, can be complemented with electronic web based systems. One of the main impacts of e-Teaching in education resides in the fact that it provides opportunities to create resources that turn the learning process flexible. This implies a different relation between teachers and students and even between institutions, in the sense that the students participate on their own formation and the vertical hierarchy tends to become increasingly more horizontal. Awareness of the knowledge constructing process is increased, and consequently more satisfaction gained from learning. In this paper we describe a web-based collaboration approach for teaching that is being developed to simulate conversational dialogue in the area of Medicine, that enables the integration of highly heterogeneous sources of information into a coherent knowledge base accessed from web-based interfaces, either from the tutor's point of view or the development of the discipline in itself, i.e. the system's content is created automatically by the physicians as their daily work goes on.

Keywords: multi-agent systems, e-learning, educational aid, web-based simulation.

I. INTRODUCTION

Traditionally, medical teaching is based on texts, lectures and bedside teaching, with self-guided individual learning from books being the mainstay. It is believed that traditional medical teaching and individual learning in particular, can be complemented with electronic systems delivered on the Internet/Intranet. Teaching medicine requires developing a vast range of manual, intellectual, visual and tactile skills as well as taking into account large amounts of factual information. One of the main impacts of e-Teaching in education resides in the fact that it provides opportunities to create resources that turn the learning process flexible. This implies a different relation between teachers and students and even between institutions, in the sense that the students participate on their own formation and the vertical hierarchy tends to become increasingly more horizontal. Awareness of the knowledge constructing process is increased, the satisfaction gained from learning. As an overall result, medical teaching can be more effective and efficient [12].

Web-based teaching via Intelligent Tutoring Systems (ITS) is being considered as one of the most successful enterprises in artificial intelligence. Indeed, there is a long list of ITS that have been tested on humans and have proven to facilitate learning, among which we may find the well-tested and known tutors of algebra, geometry, and computer languages. These ITS use a variety of computational paradigms, as production systems, Bayesian networks, schema-templates, theorem proving, and explanatory reasoning. The next generation of ITS is expected to go one step further by adopting not only more intelligent interfaces but will focus on integration. This paper describes some particularities of an e-teaching system that is being developed to simulate conversational dialogue in the area of Medicine, that enables the integration of highly heterogeneous sources of information into a coherent knowledge base accessed from web-based interfaces, either from the tutor's point of view or the development of the discipline in itself, i.e. the system's content is created automatically by the physicians as their daily work goes on[10]. This is a huge challenge and will encourage students to articulate lengthier answers that exhibit deep reasoning, rather than to deliver straight tips of shallow knowledge. The goal is to take advantage of the normal functioning of health care units to build on the fly a knowledge base of cases and data for teaching and research purposes.

II. MULTI-AGENT SYSTEMS

Autonomous agents are a technique from the field of Artificial Intelligence that can be used to implement a complementary style of interaction. Other research has proposed the use of agent technology to wrap functionality to obtain context information (e.g. user's profile, preferences, activity, location and used devices),

which influence the way a service is accessed or service results are presented to the user. Multi-agent systems set a new methodology for problem solving, endorsing intelligent systems evolution, task substitution or delegation, a matter that is usually carried on by human beings [8,21]. However agent based systems have some drawbacks, namely in terms of global system control, and some lack of confidence and/or fear of competence in the delegations by humans. Indeed, to delegate tasks, bilateral confidence relations have to be established [23]. This methodology is based on dividing the problem in several sub-goals, as independent and autonomous as possible, allocating agents to perform tasks to reach the system's goals [25,26,17,7,14]. As an example we present a brief description of the agents that embody our multi-agent system for medical teaching (figure 1):

- the Profile Agents that perform interface optimisation and keep record of the user's profile;
- the Evaluator Agents that generate the user interface evaluating the user's preferences and tasks;
- the Information Producer Agent that prepare the information (e.g. medical imaging studies, exams, case-studies, interfaces);
- the Research Agent that look for information according to the user in the knowledge base;
- the Question Agent that provide replies for user questions;
- the Anonymous Agents that produce anonymous replica of medical information.

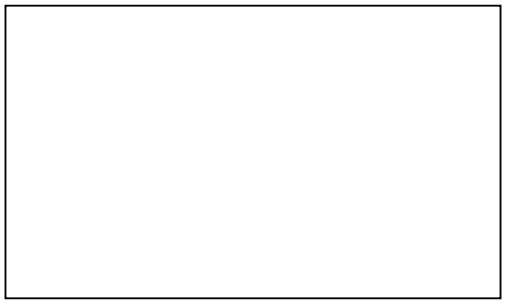

Figure 1 - Multi-agent system architecture

III. E-LEARNING

Learning includes observation (e.g., video watching or book reading), verification (e.g., the accuracy of some information or looking for clues), searching of hypotheses (e.g. diagnostic), induction of rules (e.g., program generation) and problem solving (e.g. deduction). In this work, learning is goal-based and role-played, built upon a web-based framework and involving lessons or tutorials. In goal-based learning, students work on a context-dependent scenario activating a precipitating event and requiring a fast response. In role-play learning, students play with possibilities and alternatives making the approximation between simulation and game. E-learning should arise from how people learn naturally [15,16].

Today, the importance of training during lifetime is due to new technologies that are constantly emerging and the professional world that is more and more dynamic. Returning to the school would be necessary for success, but time management is a hard task. E-Learning may be a solution receiving benefits from the technological revolution, the need of professional qualification, the demographic and social changes in education and the educational paradigm evolution based on globalization and mobility. E-Learning can be seen as a variant of distance education, breaking time and physical limits, a kind of self-learning without persistent communication and collaboration, supported by technology and online both side communication. A wide set of applications and processes, accommodating different styles at any time and in any place, at the preferred student rate, such as Web-based learning, computer-based learning, virtual classrooms and digital collaboration may be covered, including the delivery of contents via Internet, intranet, audio and videotape, interactive TV, CD-ROM, and more (Edwards et al. 1996) [1]. Travel time and travel costs are reduced and students can select learning materials, according to their level of knowledge and interest. It can be synchronous or asynchronous. The synchronous e-Learning simulates a classroom, offering real time training with conversational methods. The asynchronous e-Learning provides a training package and communication with the teacher can be established by email. When developing a e-learning system many dimensions have to be taken under consideration:

- issues of academic and administrative affairs;
- pedagogical dimensions;
- technological infrastructures;
- the design of the website or portal, contents and usability;
- evaluation;
- information and knowledge maintenance and distribution;
- support;
- ethical, social, cultural, legal and geographical dimensions;
- security.

IV. E-TEACHING

E-teaching is also related with simulation. Teachers and students use the system to participate in a dynamic artificial environment where conditions or hypotheses are created in order to study or experience real facts or activities. Simulation is very popular in the area of Education and Training. In particular, simulation of real-time environments has been focused as a tool for

teaching in many areas, especially in medicine where pedagogical practices carry out high risks and costs, in professional and law points of view, enabling the creation of artificial environments for pedagogical purposes. Students can learn making mistakes in safe environments. Simulation researchers need to focus more on developing practical methods for building simulations that use the web and producing quality simulation software and flexible services [27].

On the other hand, web success is related with an exponential growth of Internet use on the last few years. New rapid web advancements are emerging, transferring technology benefits sometimes without a solid theoretic underpinning. Although web browsers support many features that facilitate the development of user-friendly applications and allow users to run application anywhere without installing flat software packages in order to run remote applications. Storage and information access over the web encourages the information and knowledge re-use and the offer of global information and resources. The vitality of a web-based system lies in its integration potential, in supporting communities of virtual entities and in the gathering, organization and diffusion of information. Operating on the web means the use of documents or programs that contain images, audios, videos and interactive tools in addition to text. Scripting languages such as PERL, ASP, ASPX, PHP, DHTML and JAVA are used to build high level programs improving distribution, as well as information and knowledge sharing, increasing quality software and reducing costs [18,19,20].

V. THE E-LEARNING SYSTEM

Our strategic option in terms of implementation was to cover:

- The medical imaging field going from data acquisition and storage to physicians, teachers and students front-ends;
- The electronic medical record that covers horizontally the health care unit and makes possible the analysis of medical records along the several services, units and treated pathologies;
- The information system for other diagnostic purpose.

These databases are, of course, immensely valuable resources for teaching.

As the prime provider we have a PACS (Picture Archiving and Communications System) at the hospital that has been in routine use for several years now [11]. Storing every imaging study digitally together with the radiologist's report resulted in a huge database of diseases and their imaging presentations as well as normal anatomy. Storing every imaging study digitally together with the radiologist's report resulted in a huge database of diseases and their imaging presentations as well as normal anatomy. This resource is, of course, an immensely valuable resource for teaching.

The second provider is the EMR (Electronic Medical Record), that is a problem oriented set of standardised documents directed to the register of actions and medical procedures.

The third provider is a collection of several kinds of clinical diagnostic oriented reports (e.g. from clinical laboratories) forming a huge repository of cases in which its data may be processed in order to confirm series, tendencies and evolution.

However, access to this kind of stored information for educational purposes is currently limited by the lack of specialised software that presents images and diagnoses in a didactic fashion, along with the medical background information required to accomplish the learning goal. Designing software for the medical environment is a great challenge. At the core of the developed system lies a large database of video, images and text. This information is complemented with meta-information that defines its structure, and classifies and defines the relationships between its parts. The next level consists of the multi-agent system that accesses the information and presents it according to the meta-information and the specific task they are designed to do, which could be anything from pure textual referencing to a guided tour through a defined subject matter to a three-dimensional annotated image reconstruction of an organ system. Another class of agents will allow updating and adding to the content database: authoring tools and medical data, and in doing so, will have to assure consistency. To lead with information coming from heterogeneous sources, an agency for archiving, integrating and diffusing of medical information has been developed. Its purpose is also to diffuse this information for medical research and teaching.

VI. AIDA

Information sources in a healthcare unit are distributed, heterogeneous, large and complex; integrate medical equipments that speak different languages; are built around information systems customized by several companies using different operating systems, languages, applications and hardware [9]. Communications are sometimes limited by old infrastructures and new projects collide with financial restrictions and bureaucratic delays. The homogeneity of clinical, medical and administrative systems is not possible due to financial and technical restrictions, as well as functional needs. The solution is to integrate, diffuse and archive this information under a dynamic framework, in order to share this knowledge with every information system that needs it. AIDA – Agency for Integration, Diffusion and Archive of Medical Information - is an agency that provides intelligent electronic workers, here called pro-active agents, and in

charge of tasks such as communicating with the heterogeneous systems, sending and receiving information (e.g., medical or clinical reports, images, collections of data, prescriptions), managing and saving the information and answering to information requests, with the necessary resources to their correct and in time accomplishment [10]. AIDA also supports Web based services to facilitate the direct access to the information and communication facilities set by the humans; i.e., AIDA's construction follows the acceptance of simplicity, the conference of the achievement of common goals and the addressing of responsibilities; the main goals are to integrate, diffuse and archive large sets of information from heterogeneous sources (departments, services, units, computers, medical equipments); AIDA also provides tools in order to implement communication with human agents based on web based services. Under these presuppositions, a Healthcare Information System (HIS) is addressed in terms of (figure 2):

- The Administrative Information System (AIS), which intends to represent, manage and archive the administrative information during the episode (an episode is a collection of all the operations assigned to the patient since the beginning of the treatment until the end);
- The Medical Support Information System (MIS), which intends to represent, manage and archive the clinical information during the episode;
- The Nursing Support Information System (NIS), which intends to represent, manage and archive the nursing information during the episode;
- The Electronic Medical Record Information System (EMR);
- The Information Systems (IS) of all the departments or services, in particular of the laboratories (Labs), Radiological Information System (RIS) and Medical Imaging (PACS - Picture Archive and Communication System), which deals with images in a DICOM format [28].

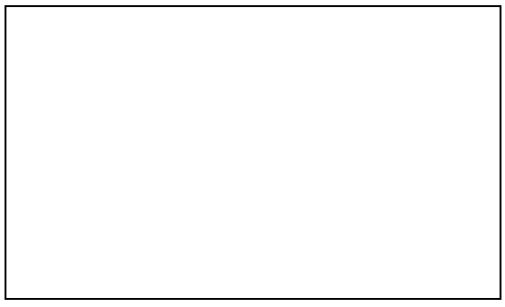

Figure 2 – The Aida agency

In order to implement this system, distributed by nature, intranet technology was used on the side of the end user. All the system interfaces are user-friendly, Web based and low cost. It uses freeware tools or software packages already licensed by the Portuguese Health Ministry (e.g., Oracle RDBMS). The intranet was implemented using computers with LINUX as operating system. Communication among agents will be specified by defining the transportation (i.e., the process that allows for a message to be sent or received), the language (i.e., the meanings of a message), the ontology (i.e., the conversational structure) and the architecture (i.e., the system links according to given protocols).

VII. MESSAGES

A message is sent by an agent using XML. According to the ontology, the message is processed, integrated and archived in large databases. The ontology is defined by the administrators and can be managed using web tools and SNOMED CT (a well known terminology including over 370 000 concepts, 900 000 descriptions and 1 300 000 relations) is used [2]. SNOMED CT provides a framework to manage medical dialects as well as clinical terms and qualifiers. The healthcare network is used for physical transportation [2].

XML is a meta-markup language and stands for Extensible Markup Language. It is a set of rules to define semantics tags in documents, which are broken into parts. The language defines a syntax in which other field-specific markup languages can be written (e.g., HTML and TeX). HTML and TeX define a fixed set of tags that describe a fixed number of elements. In XML, data is not formatted to fit into paragraphs, text fields, list items, table cells or others general categories. Tags can be documented in a Document Type Definition (DTD); i.e, a vocabulary and a syntax for some kinds of documents. XML has an excellent format for the interchange of data among different applications because it is free to use and easy for both human beings and computers to read and write. It is an obvious choice for exchange and share data, programs or languages between agents. XML also provides a client-side include mechanism that integrates data from multiple sources and displays it as a single document, what is very useful when working with large information repositories like RIS (Radiological Information System), PACS, EMR and AIDA. RDBMS (Relational Database Management Systems) applications (e.g, Oracle, MySQL, Microsoft) provide multiple programs to create, extract and parse XML documents from databases using Perl, Java, PHP or any other convenient language. AIDA uses XML documents to communicate between external data sources and operational databases. XML is also embedded in PHP programs that provide user interfaces.

VIII. PICTURE ARCHIVE AND COMMUNICATION SYSTEMS

The computational architecture that supports *Medical Information* in the area of *Imagiology* is an example of an external data source for AIDA (figure 3). To get the knowledge required to construct these systems, one must be involved and familiarized with the various imaging modalities (e.g., Computer Tomography (CT), Magnetic Resonance (MR)), the DICOM standard, modality procedure documentation and debriefing of radiologists and technicians [5]. It also involves the regular participation of the authors in meetings at the premises of the healthcare unit.

Since their introduction, *PACS* have attracted a mixed reaction, mingling excitement at their potential with dissatisfaction with their various limitations.

The DICOM image server supports the medical interface – this window sets the via for the visualisation and exploration of original DICOM data from CT, MRI, and so on. It provides the user with interactive image visualisation functions, like gray level windowing [4,11,13].

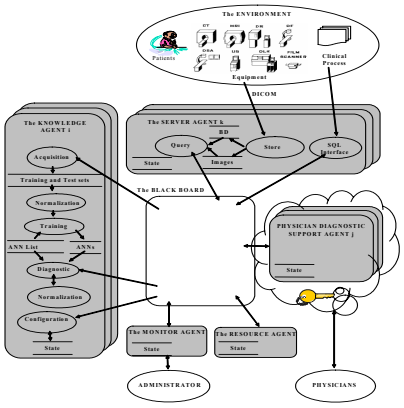

Figure 3 – The picture archive and communication system

IX. DATABASES

Relational Database Management Systems (RDBMS) are widely used by healthcare units for maintaining data that documents everyday operations. The applications that update such operational data or transactions make typically small changes and a large number of transactions. RDBMS have been optimized to perform reliably and efficiently those operations, usually named online transaction processing (OLTP) applications (i.e., applications that support many users executing small transactions).

Current and historical data has also to be comprehensively analysed and explored, identifying useful trends and creating summaries, to support decision making. These operations are referred as decision support applications. On the other hand, and in the last few years, SQL has been extended with new constructs to support it, performing new indexing and query optimisation techniques to run fast complex queries. For example, one technique that has gained popularity in applications involving complex data access is the use of views. Queries on views can be answered by evaluating the view definition when the query is submitted and pre-computing the view definition can decrease answer time. Healthcare units can consolidate information from several databases into a data warehouse by receiving data from many heterogeneous sources into a location or materializing a view defined over several tables. Those views are created, managed and used by specialized agents of the AIDA environment.

A data warehouse is addressed by building manageability into the database engine and by making facilities, and reducing the staff of database administrators to maintain it. It must support a large population of users where the data volume is the challenge. Data warehouse is there to help manage the business system and must also deal with changing worlds or environments. It must support at the same time small transactions, executed by users, and very large transactions, executed by software agents, during the loading of data into the data warehouse, processes that can occur at times when online warehouse users are accessing the database, searching online updated records.

X. CONCLUSION

Web-based collaboration for teaching in medicine is becoming a powerful means of developing educational contents.

Issues on agent development were discussed and a multi-agent system to simulate conversational dialogue in the area of Medicine that enables the integration of highly heterogeneous sources of information into a coherent knowledge base accessed from web-based interfaces for teaching was presented.

Much work designed to develop our understanding of the factors that contribute for each successful or unsuccessful web-based collaboration experience is still needed.

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