Bio-expert : Knowledge Management Platform and Experiment for Bio-Medical e-Learning

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***Abstract*—bio-expert project has been launched to cover user needs in terms of access to high level knowledge content with a user friendly interface tool. The problematic raised here concerns not only imaging technologies, knowledge management system and interfaces but also the organisation of the content allowing an easy access of the repository to the community of biologists.**

***Index Terms*—Medical Biology, Medical Imaging, Computer Supported Cooperative Learning, e-Learning, Knowledge Management, Web Based Training, Knowledge Based System.**

I. Introduction

Our aim is to present our project *bio-expert*, an experiment in designing and developing a bio-medical e-learning platform for professional staff. Bio-expert is a project gathering scientific research and technologic skills in medical biology, imaging and knowledge management. These skills have permitted, the identification of physicians requirements in e-learning at the first hand, and the proposition of models and solutions for the technical project achievement in the second hand. Our approach was based on the of state of the art technologies in imaging and in knowledge management for suit the needs of physicians concerning e-learning and diagnosis support platforms. These needs can be summarised in a high bio-medical e-learning quality of service. The quality is to be seen from a scientific view involving a reference content of bio-medical knowledge, and from a technical view involving perceptible ease of access and use of the on-line e-learning repository. Actually, in order to insure a scientific quality of service, bio-expert accounts among its players a bio-medical expertise network. A scientific committee insures the relevance and the quality of the content.

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Additionally, the access of images on Internet implies a compromise of their bandwidth transfer *versus* their perceptible quality. In fact, by compressing images, one may deteriorate some of their relevant details which has to be seriously considered to maintain a good and reasonable quality level of our bio-medical e-learning service. After validating our models and platform in the bio-medical domain, we will enlarge the validation scope to other medical fields.

II. Medical Biology Knowledge Assessment

In medical biology, the introduction of new technologies like imaging emphasizes on the problematic of professional staff information and teaching. Actually, it is obvious to understand that making available expertise content for medical analysis and interpretation methods is becoming more and more required. In every bio-medical field, there is an extensive use of imaging. In fact, images are a considerable didactic object enabling knowledge visualisation and accessibility. Hereby, gathering images in a common repository will not be sufficient to capitalise knowledge for insuring bio-medical teaching. Consequently, thinking and developing models of structured knowledge based repository is becoming necessary. Among other bio-medical fields that use imaging in every day life, we deal with Anatomy, Chemistry, Histology, Pathologic Anatomy, Microbiology, Bacteriology, Virology, Haematology, Cytology, Haemostasis, Haematological Chemistry, Immunology, Cellular Biology, Genetics, Molecular Biology, Physiology, etc.

Numerous medical disciplines use a considerable amount of images for diagnosis and treatments : Microscopic images, Radiographies, Scanner images, Magnetic Resonance Images (MRI). Hereby, neither Surgery, nor Neurology, nor Cardiology can nowadays deny needs in image storage and manipulation of these images. Techniques of storage and presentation of these images become necessary to constitute patient files. These techniques will help in insuring diagnosis, treatment monitoring, and also knowledge sharing between physicians. Moreover, the use of the medical files can be used either longitudinally for the patient health control or transversally for therapeutic results analysis for a group of patients. Structuring medical knowledge will also help to control and evaluate a laboratory technique in Medicine, Surgery, Radiology or Biology.

In conclusion, collection, storage, accessibility, presentation of medical data and particularly medical images is increasingly becoming a hot topic of research and development. Bio-expert project aims to exploit its network of bio-medical experts and develop a model structuring bio-medical data (*e.g.* radiographies, microscopic images, video, slides, texts, etc.) for offering structured specialised information repository for bio-medical e-learning support. Actually, the experts participating within bio-expert evolve in hospitable milieu but are also professors in universities of Medicine, Pharmacy or Dental Surgery. Nowadays, bio-expert consortium handles several databases composed of different types of images and analysis results, and selected for their diagnosis interest. The consortium possesses important amount of multidisciplinary training multimedia objects. These objects have been created for teaching biologists during their resident medical studentship or active biologists. Additionally, bio-expert consortium handles considerable quantity of documents, written by the experts or by medical equipments constructors, and describing operational guides for laboratory automata ease of use.

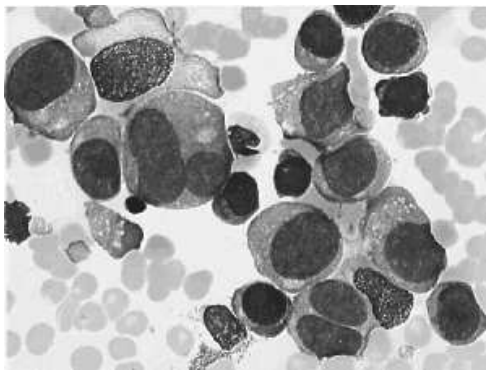

Fig. 1 Blood cellules of an anaemia case. These kind of images of blood cellule and haematopoietic organs have been digitalised on a acquisition system embedding a high resolution microscope, and a 3CCD camera.

Laboratory examination results can be on different formats : graphical results (*e.g.* images, diagrams, curves, etc.) but also textual comments conducting to a diagnosis then to a medical treatment. Decrypting theses laboratories examination results require a knowledge either of technical constraints or medical requirements. Databases of images and laboratory examination results with their interpretations, associated to laboratory techniques validation procedures and to considerable didactic multimedia objects represent an important expertise databank in medical biology. Based on this content, bio-expert has developed its online knowledge database for biologist community e-learning. This base can also be used to develop tools insuring computer supported medical case diagnosis.

III. Imaging Technologies Applied to Medical Biology

Due to increasing use of medical images in Biology, among other problems that need pertinent solutions, we can mention images and videos storage, processing, exchange, copyright protection, etc. New standards, like JPEG2000 and MPEG4, are in final phases of specification by international standardisation organisms. They promote the use of reliable representation techniques of images and videos. Otherwise, the development of techniques related to the use of medical images on Internet becomes significant from the point of view of means of acquisition, transfer, exchange, search, indexing by content and visualisation. Nowadays, this technological development enables the achievement of innovative tools, reliable and suiting Internet medical imaging requirements. In order to develop new tools for bio-medical capitalisation, bio-expert benefits from its international gathered skills in imaging and video quality recognised by many normalisation groups (*e.g.* Video Quality Expert Group).

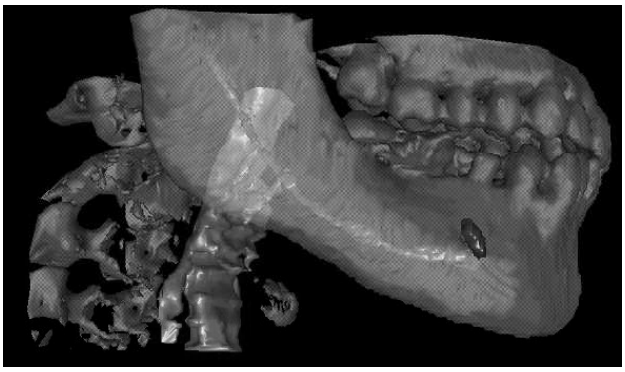

Fig. 2 3D Visualisation from a sequence of scanner images (LISA).

Bio-expert, additionally, puts its imaging partners skills into application in bio-medical imaging e-learning. For instance, figure 2 shows a sample of results obtained by a software package developed by LISA Laboratory of CPE Lyon [1], which is one of bio-expert partners. Otherwise, bio-expert aims to provide online information with taking into account problems of access service quality and content proprieties. Actually, NETIMAGE is an SME partner of the project that developed a image identification service using the technique of watermarking for automatically searching an image by its key identifier. By handling, among others, information on intellectual property rights, this service will enable to insure intellectual propriety of bio-expert database images. The watermarking consists on hiding these propriety information in non accurate parts of the image. Thus, the image will be identified without deteriorating neither the image visibility nor its visual quality. In order to obtain a solid and resistant marking to usual image manipulations, the smallest fixed size marking has to be used. As this marking must be unique, it contains a key delivered by a registration authority that keep a safe trace of all registered objects. This registration key is formed by 64 bits, in accordance to the standard JPEG ISO 10918-(3 and 4) [2]. By these examples of 3D visualisation, image property protection and watermarking image search, bio-expert tries to federate imaging technologies in the unique aim of capitalizing bio-medical knowledge for insuring medical staff e-learning.

IV. Knowledge Management and Cooperation Technologies for Medical Biology e-Learning

Among advantages of e-learning environments, we can mention time, deployment, hosting and travelling expenses economy, management of virtual classes, fast evolution through e-learning knowledge, customisation of training paths, etc. Even if e-learning environments have been widely developed, they have not reached the maturation level and are still concerned by several problems. Actually e-learning

environments require the deployment of new techniques and methodologies for suiting current needs. These techniques methodologies will insure knowledge repositories to be up-to-date, constantly available and e-learner centred. Additionally, they will enable e-learning platforms to provide pertinent knowledge keeping the e-learner scientifically trained and competitive on the market place. Actually, some standardisation organisms results on e-learning are still emerging, for instance Instructional Management Systems (IMS) [3], Advanced Distributed Learning (ADL) [4], and Aviation Industry Computer Based Training Committee (AICC) [5].

Two main problems are to be tackled for improving e-learning environments : didactic support quality improvement and knowledge transmission quality. For instance, to improve the didactic support, one has to attend to training document structure, to offer content based document search mechanism, etc. While improving the knowledge transmission quality deals with embedment of pedagogic support, offering training path customisation instead of static scheduling, building an e-learner centred methodology instead of having a system centred pedagogy, etc. In order to tackle these problems, we present three important technologies that will help to develop reliable e-learning environments : knowledge management, and cooperation technology.

A. Knowledge Management Technology

Knowledge Management gathers different techniques of analysis, synthesis, cartography and management of knowledge and know-how of a group of persons within a community in order to capitalise and then to share it between the members of the community [6]. Otherwise, knowledge management is the challenge of transforming information to knowledge [7]. In order to develop a state of the art bio-medical e-learning content, our approach is composed of four indispensable steps :

- Step I – Management of knowledge related to the syntactical structure of the didactical medium : This step deals with designing and modelling training module structures. The access to the bio-medical knowledge database will be through this structure. This structure will contain training sessions which are based mainly on knowledge acquisition modules. These modules will gather references to structured information (*e.g.* in databases), semi-structured information (*e.g.* XML -eXtensible Markup Language- repository), and non-structured information (*e.g.* in file management systems). The pair duration/complexity must be taken into account for iterative subdividing of each pedagogic module into sections, subsections and topics which represent the elementary pedagogic units.
- Step II - Management of knowledge related to the semantic structure of the didactical medium : This step deals with modelling the structure describing the training modules. Actually, multimedia object semantics within training modules can be extracted and represented by different ways using semantic networks (*e.g.* conceptual graphs, RDF - Resource Description Framework-, etc.), hierarchical indexing trees, classification structures, metadata files (*e.g.* XML documents, etc.). The aim of this semantic structure is to enrich the syntactical structure with indexes accelerating the search and the access of information and then interconnecting easily semantically related training modules.
- Step III - Management of knowledge specific to the training field : This step deals with designing and modelling a dictionary of concepts related to the e-learning field. These concepts will enable to instantiate the semantic structure in order to connect training module and thus to explore their structure pertinently. Hereby, knowledge syntactical structure will be decorated and illustrated with multimedia objects specific to the expertise field : texts, images, graphics, videos, sounds, composite objects, etc. These objects, formatted in accordance to standards (*e.g.* JPEG2000, MPEG4, XML, etc.), will compose the knowledge database.
- Step IV – Collection and deployment of e-learning modules : This step deals with structuring the collected training modules according to the syntactic structure resulting from the step I, then deploying the semantic structure resulting from the step II, feeding it with the dictionary obtained from the step III, and finally using on both structures to project objects composing training modules and connect them to obtain a knowledge repository profitable pertinently and efficiently.

B. Cooperation Technology

In order to improve the quality of embedded pedagogic methodology of an e-learning environment, the complexity of the training modules that it proposed has to be controlled. This will facilitate knowledge transmission to the e-learner and then compensate asynchronous aspects involved by e-learning. Hereby, integrating cooperation technology to e-learning environment and particularly workflow management technology becomes indispensable.

As shown in figure 3, services offered by computer supported cooperative work (CSCW) systems cover three functional spaces : production, coordination and communication spaces, according to [8].

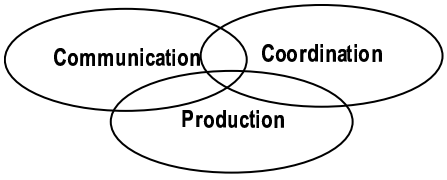

Fig 3 Functional services of a (CSCW) cooperative system (*e.g.* a cooperative learning platform)

Production space gathers objects resulting from a group activity (*e.g.* a book, a cinema film, a software package, etc.) within common repositories (*e.g.* document co-authoring space, etc.) and local spaces for private uses (*e.g.* repository of own documents). Coordination space define actors, groups, roles, tasks and their scheduling, association actor/tasks. And finally, communication space permit to the cooperating users to exchange information. (*e.g.* chat, videoconference, forums, e-mail, etc.). Depending on cooperative systems, the three concepts have not the same importance, co-authoring tools emphasize on production services, workflow systems on coordination services and media-spaces on communication services [9].

The integration of CSCW mechanisms within e-learning systems have produced new e-learning environments : computer supported cooperative learning (CSCL) [10, 11]. This integration permits to e-learners to cooperate with each

other improving thus knowledge transmission. Additionally, embedding coordination mechanisms (*e.g.* workflows, to do lists) within e-learning environment allow the e-learner to control its learning evolution. A pedagogic contract, structured as a workflow, can be proposed by the system. The respect of this contract terms will permit the e-learner to access progressively to didactic elements according to his skills, validated modules, and chosen modules. This will allow the e-learner to be supported without neglecting his owns preferences. Actually, the use of a workflow tool to improve several by new functionalities like : expression of pedagogic contracts with prerequisites rules (cf. figure 4), customisation of pedagogic paths with respect to prerequisite rules, customisation of help and assistance according to the current e-learner evolution, controlling e-learner actions history, monitoring of e-learning process, e-learner behaviour support -spent time by modules, evolution quality, evaluation results-, coordination between e-learners and e-teachers, etc.

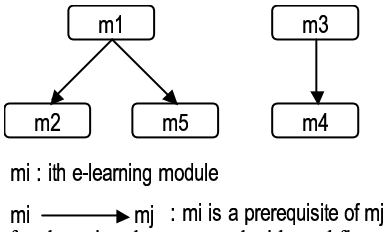

Fig 4 Examples of pedagogic rules expressed with workflows.

Figure 4 shows an example of advantages integrating a workflow system within an e-learning environment. At each instant, the e-learner will be aware of the modules that can attend with respect to the initial pedagogic contract (*i.e.* set of workflow prerequisite rules). The e-learner can thus organise his timing and attend modules sequentially (all sequential permutations of modules m_1, .., m_5 respecting workflow prerequisite rules are possible) or in parallel (all parallelisations of modules m_1, .., m_5 respecting workflow prerequisite rules are possible). This methodology will give the e-learner more freedom as far as the e-learning environment will propose him to choose modules dynamically for arriving to a pedagogic objective.

After developing this experiment, it becomes clear that integrating technologies like knowledge management, and cooperation technology is indispensable for developing reliable and user friendly e-learning platform.

V. Bio-Expert Prototype Implementation

Bio-expert has implemented his bio-medical e-learning repository on a lightweight knowledge database model. This model is based on concepts of multimedia objects, reference cases, scenarios, knowledge acquisition modules and e-learning sessions. Reference case is the term describing a multimedia object in Haematology for the characterisation of pathologic cellules. Scenarios present concrete clinical case of a patient (with respect to medical privacy). Knowledge acquisition modules are general presentations according to levels as defined by speciality colleges. They combine synthetic schemas summing up main diagnosis approaches, training processes based on practical scenarios. This hierarchical bio-medical knowledge structuring allows progressive access to didactic elements insuring thus an interesting acquisition of bio-medical expertise elements. Bio-expert collaborative e-learning platform [12] is composed of a simple file system based multimedia object management component, a MySQL knowledge database component, and a web based easy to use PHP interface. Hierarchical representation gives an intuitive exploration of knowledge repository. Hereby, we visualise our knowledge database as a electronic book with chapters, sections, multiple levels of subsections gathering topics (*i.e.* elementary pedagogic units). The e-learner can either progress through the repository by exploring a particular node of its hierarchical structure or search a topic by keywords. The hierarchical repository has been visualized as a common graphical tree reproducing the same behaviour of file systems exploration trees. We will experiment other interesting visualisation alternatives of the knowledge repository (*e.g.* hyperbolic trees [13]).

VI. Conclusion

The experience gained into the development of bio-expert knowledge management platform is now followed and continued by the enrichment of the repository addressing biology bio-expert.com. The model specified, implemented and experimented within the project can be applied to different application fields in order to help into sharing and disseminating technical or scientific knowledge among the concerned community.

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