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Medical Informatics Training and Research at Rennes University School of Medicine

Abstract: The University of Rennes Medical School has offered Medical informatics training since 1988; at the same time, research in medical informatics was started. This paper describes the teaching programs at both the undergraduate level and at the graduate level. Research topics comprise fundamental research on biomedical models, ontologies for medical knowledge representations, natural language processing, and research for diagnosis and therapeutic aids. We have developed a local area network which communicates between the School of Medicine and the University Hospital, both internally (Intranet) and externally by access to the National Research network (RENATER) in France, which is connected to the internet.

Keywords: Medical Informatic, Education, Training, Graduate Program, Research.

1. Introduction

Medical informatics training at the Rennes University Medical school started in 1988 at both the undergraduate level for medical students and at the graduate level, with a national training program for PhDs in conjunction with the universities of Paris 5 and Paris 6 [1].

More recently, in 1995, we started a Professional Master's Program (DESS: Specialized diploma of medical and hospital informatics) for professionals willing to follow a specialized training in medical and hospital computing applications. Research work was also started in 1988 and includes several topics such as computer-assisted diagnosis and training, medical knowledge representation for large knowledge bases, computer models for cardiology, medical natural language processing, classification and nomenclatures research using the UMLS, and the development of web servers for education and research.

In this paper we will first describe the teaching curriculum and the main research topics of our laboraratory. Most of these descriptions are available on our web server (www.med.univ-rennes1.fr) in French and, partially, in English.

2. Medical Informatics Teaching

When we started our activities at the University of Rennes Medical School in 1988, undergrade teaching in biostatistics and epidemiology was already being given by the Department of Public Health and Epidemiology. Therefore, we had to develop both the undergraduate training for medical students and training at the graduate level for research in medical informatics.

In 1995, we merged the two laboratories (Epidemiology and Public Health) and the Laboratory of Medical Informatics in order to better coordinate teaching and research in health information and medical informatics. However, we are still separate departments within the University Hospital which has 1,500 beds for acute care and 500 beds for rehabilitation and care of elderly people.

2.1 Undergraduate level

The teaching of medical information and informatics is mainly done during the second and third years of medical school in order to train medical students early in the curriculum. They have free access to a computerized "mediatheque" where they can use microcomputers connected to the French Education Research Network connected to the Internet.

The first course (10 h) is mandatory and devoted to the basics of computer science applied to health and medicine: hands-on microcomputers to handle text processing, spreadsheets and small databases, using Claris Works, medical

CD/ROMs and, soon DVD, (Digital Video Disc). Besides, they have courses in biostatistics and epidemiology (20 h).

The second course (10 h) is mandatory and devoted to the basics of computer networks applied to health and medicine: hands-on micro-computers to handle electronic mail (Eudora), News, Gopher, Wais and web clients.

An optional course in Medical Informatics is also available (40 h) to teach the basics of algorithmics (Visual Basic) and small database design (Access).

These courses are a prerequisite to follow the more advanced course called the C2 Certificate in Medical Informatics (100 h) which contains three main parts : the first one is advanced programming in Visual Basic and database design on relational databases (SQL), the second is on web applications (HTML and Perl Language), and the last part on medical artificial intelligence and hospital and clinical information systems. Besides formal teaching, we developed a teaching network which is available both at the Medical School and within the University hospital wards to the students and residents while they are clinically trained. The project is based on the existence of a regional and national university network for academic research and universities. These networks are interconnected: for instance, the university network is connected to the regional network in Brittany (ROR, Reseau Ouest Recherche) which is itself connected to the national RENATER network and to Internet [2]. The use of the network is free of charge for academic endusers, since the network has been promoted and financed by local regional and national public funds. The project started in 1992 at the Medical School of Rennes by developing a research network based on the university network connected to the Internet. In 1993 we were connected to the French Research and Academic Network, and in 1994 we obtained support for developing a teaching pedagogical network connected to the University Hospital, which has three main hospital sites in the city of Rennes.

2.2 Graduate level

At the graduate level we are responsible for two training programs: one is professional and all the courses are done at the University of Rennes, the other one is national and research-oriented and is organized in cooperation with the University of Paris.

2.2.1 Professional Diploma in Medical and Hospital Informatics

With the development of information technology in medicine, the objective is to train high-level professionals in the field of medical data processing able to manage and develop computerization projects in health, including the PMSI (Program of Medicalization of Information System) and the HIS (Hospital Information System), clinical research, a telemedicine project, and health professional networks.

The DESS (Medical and Hospital Data Processing) is a diploma of the third cycle (graduate level) prepared in 1 year; a possibility of spreading it out over 2 years for continuing education is also available.

The prerequisite is a diploma of second cycle of the university (Master level) or equivalent (medical or engineering degree). The program contains 350 hours (Table 1).

The mandatory courses are scheduled between October and March and a professional project is scheduled between April and July. The formal training courses are followed by a 4-months full-time project in a professional organization and an oral presentation to the Faculty together with a report. The oral presentation is made at the beginning of September.

The graduate students may apply for jobs in different types of institutions: Department of Medical Information, hospital data processing, health service of local authorities, hospital and private clinics, laboratories of biomedical engineering, clinical and biomedical research, pharmaceutical industry and biomedical engineering; software companies and data processing consultancy firms.

Table 1: Courses for the DESS degree.

Medical Informatics
Medical databases
Biomedical and hospital data-processing networks
Telemedicine
Medical decision-making
Man-machine communication
Hospital Information and Informatics
DRG and medico-economic indicators
Medical and hospital information systems
Processing of physiological signals
Computerized medical imaging systems
Computerized laboratory systems
Hospital management: tools and methods
Biostatistics and Epidemiology
Biostatistics and clinical research
Epidemiology and evaluation methods
Methodology of therapeutic tests

2.2.2 Advanced Research Diploma in Medical Informatics

The DEA (Advanced Research Diploma) of medical computing is open to the holders of a Master of Sciences degree, or an engineering diploma, or a second cycle of medical, odontological, pharmaceutical or veterinary studies, supplemented by a Master's of Biological and Medical Sciences. Its objective is to train high-level specialists in data processing research in the health and life sciences. The prerequisite is good knowledge in Data Processing and Biostatistics.

The one-year teaching program (beginning in October) includes theoretical courses (160 hours), practical work and personal projects, as well as one period of 6-months training in a research laboratory.

The content of the theoretical courses are given in Tables 2 and 3.

Mandatory courses are held in Paris, optional courses in Rennes or Paris. The mandatory and optional lessons are evaluated on the basis of written tests or personal projects. The research training is evaluated by a written report following the rules of a scientific paper, and oral presentation.

3. Research

Our research topics include four main fields: (1) deep modeling of physiological or biomedical processes; (2) large knowledge bases and web servers; (3) medical ontologies, nomenclatures and classification; (4) and medical natural language processing.

3.1 Biomedical Models

A first topic is model-based biomedical systems. A first project has been done in neurology [3, 4], and a second, more advanced project in cardiology [5, 6], referred to as the CARDIOLAB project.

The CARDIOLAB project is dedicated to the development of computer assisted instruction (CAI) and computer-aided diagnosis systems in cardiology. CARDIOLAB is a framework that incorporates different kinds of computational models of the cardiac electrical activity. The goal is to provide users with an environment capable of predicting and explaining rhythmic disorders. By prediction, we mean computing the hearts cardiac activity, when modeled physiological parameter values are given as initial conditions. By explanation, we mean the task of deriving the possible causes of some observed data. Because of these two aspects, CARDIOLAB's field of application also includes basic, clinical, and pharmacological research and, ultimately, intelligent monitoring system design.

CARDIOLAB's first task is to simulate cardiac electrical activity. A central concern in simulation studies is the adequacy of a model with respect to its intended goal. Models of cardiac electrical activity may differ in complexity, level of description, and representation. Depending on the desired level of detail, analytical, cellular automata and qualitative models can be used [7]. Their advantages and shortcomings can be summarized in terms of space and time complexity, ease of interpretation, and clinical relevance. The framework incorporates all three kinds of models, allowing a spatio-temporal multi-level approach for studying cardiac electrical activity [8]. Since the clinical context is of prime importance, factors relevant for studying cardiac arrhythmia and ischemia are taken into account. They include the durations of cell phases that characterize impulse formation and conduction (e.g., slow diastolic depolarization), and adaptative properties such as rate-dependent repolarization duration, or recovery-state dependency of conduction speed. Transmembrane potentials are computed for simulating the ECG.

CARDIOLAB's second role is to explain and diagnose. Explaining an ECG requires qualification and reasoning capabilities. This assumes that explicit descriptions of simulated processes can be derived from the appropriate representations and the corresponding inference engines. Heart functions and components are made explicit in the qualitative model. How-

Table 2 : Mandatory courses (120 hours).

- Advanced methods of artificial intelligence in medicine
- Research Methodologies
- Biomedical digital simulation and neural networks
- Medical decision-making
- Analysis and interpretation of digitized biomedical images
- Analysis and interpretation of medical natural language
- Modeling of medical information systems
- Pharmaco-therapeutic information systems

Table 3 : Optional courses (40 hours, made up of 2 optional modules).

- Data processing and molecular biology
- Modeling and simulation of the biological systems
- Co-operative work and man-machine interfaces
- Clinical systems for hospital care
- Networks for imaging, modeling and 3-D reconstruction
- Modeling of health and medico-economic indicators
- Decision analysis

ever, quantitative analysis of rhythmic disorders may require detailed numerical models. For instance, re-entry in ischemic tissue or PVB-induced ventricular fibrillation can only be reproduced by models with a great number of individual elements. In this respect, the system incorporates 2-D and 3-D cellular automata models composed of thousands of elements.

To summarize, CARDIOLAB is an intelligent framework, where both qualification and quantification interact to simulate and explain arrhythmias in a multi-level approach. Because of these capabilities, it could be part of future developments in the design of knowledge-based CCU monitoring systems.

3.2 Large Knowledge Bases

In our Medical School and University Hospital we have developed several medical databases and knowledge bases which are now available on the Web [2]. In our Medical Information Laboratory we started in 1993 to explore the Web applications in medicine in order to make new man-machine interfaces for existing databases and knowledge systems. This has been done by building common man-machine interfaces to existing data or information systems, including existing databases, textbooks,and various software applications.

Since 1993, we have developed interfaces to various existing multimedia systems using HTML and Web clients. We have used a classical methodology to interface or transfer any type of data and documents on a Web server: databases, knowledge bases, nomenclatures, icons, and video sequences. Specific CGI (Common Gatway Interface) script have been developed using the Perl Language including ORAPERL to access the data and present it in a HTML format.

We have investigated the possibility of developing cooperative resources in a manner similar to the IAIMS project [9] by supporting a project and system called W^3M^3 (World Wide Web MultiMedia in Medicine) [2]. The laboratory of medical informatics has now developed several applications using these tools: for diagnosis, therapeutics and medical knowledge bases, access to medical nomenclatures and classification, computer-assisted instruction [10], and medical imaging databases.

Computer-assisted Medical Diagnosis

The ADM system is a large medical knowledge base. It was created 20 years ago and has two main goals: helping physicians in making diagnoses and enabling rapid access to medical information through telematic networks [11]. The current knowledge base deals with all medical domains. It contains the descriptions of 15,600 diseases, syndromes and clinical presentations. It includes a data dictionary of 110,000 entities and a dictionary which containing 45,000 words. The database is implemented on a relational database management system. It is composed of several tables with descriptive entities (diseases, signs, etc.) and with a specific vocabulary of medical entities. It is regularly updated by physicians. There are many possibilities to use the system: diagnosis evocation, strategy for requesting complementary tests, interaction between disease and drug, between disease and pregnancy, and an electronic encyclopedia.

The system was available on French telematics Minitel up to 1996, then it was transferred to the web. The system may be accessed only by physicians after we have given them a password. They can use menus and text to interact with the system. On the web, it is essentially the encyclopedic aspect that has been developed.

Other functions, particularly the diagnosis evocation module, are currently being improved. It can be consulted by students and researchers on the university network using the web interface. This research project includes diagnosis assistance on the emergency ward [12]. This knowledge base has been interfaced with the web for consultation of disease descriptions. The hypermedia links also allow navigation through description and disease lists easily and quickly, without losing context. An extension for diagnosis evocation produces a list of diagnoses which fits a set of signs or symptoms. This system is currently used by more than 2,000 private practitioners in France.

Therapeutic knowledge bases

The purpose of the ATM system is to provide practitioners with a tool to help them choose the best drug for a patient. The drugs proposed by the system must take into account associated diseases, general background, such as like renal failure, hepatic failure, pregnancy, physiopathological mechanisms of the disease, and pharmacotherapeutic properties of drugs. The system takes into account both the disease with the associated problems, the physiopathological mechanisms (when known), and the pharmacologic and therapeutic properties of drugs. The answers are ordered according to three criteria: chemical class, pharmacological class, and therapeutic property.

The database is composed of the drug database and the drug side-effects database. Data organization is complex and is composed of three sub-databases linked together.

The medication sub-database contains information about classification, composition, and form of administration. The dosage sub-database deals with information required for prescription in relation to an indication. The contraindication sub-database indexes different levels of contraindications in relation to a substance or a drug class.

The system allows multiple item queries such as, which drugs may be prescribed for a 72-year old patient suffering from angina pectoris associated with auricular fibrillation. The software distribution is made through an Intranet network using the web interface. Two modules are available: the consultation module and the prescription help module.

Iconoweb medical imagery textbooks and clinical cases

More recently, we developed a medical iconographic web server based on a large set of clinical cases. These cases are now available on the web consisting of a set of 15,000 images and 4,500 clinical cases, covering most of the typical pathological medical imaging cases used for teaching medical students. The clinical cases are indexed using the ACR and indexes of Radiology. We also have a set of on-line electronic medical imaging textbooks which are connected to the cases for student rehearsal.

The goals were to collect and provide access to multi and hypermedia documents on a World Wide Web server of the Medical University of Rennes through the Internet [2].

These documents deal with clinical cases and images on any medical domain with electronic on-line textbooks in Radiology, and with documents of practical use in Orthopedics on the OrthoWeb base.

IconoWeb includes the transfer of several hundreds of cases produced by 250 Radiology departments all over France, from the IconoCerf-HyperCard application to the HTML format and from the Medimag video disk. A collection of textbooks on Radiology in different sub-specialities of Radiology has been translated into HTML format.

The intended users include medical students, residents, and medical staff of radiological specialities and medical or surgical practitioners They contain clinical history and manifestations which are summarized with several X-rays, tomodensitometry, MRI or ultrasound zoomable images. Cases are indexed by the Index of Radiology, the American Codification of Radiology (ACR) and by the ADM - Index dictionaries.

Thoracic and pediatrics electronics books are available for electronic reading. OrthoWeb is a presentation of anatomy, traumatology, orthopedics pathology an d techniques of surgery. We have also connected the clinical cases to the ADM knowledge base by using the ADM medical dictionary to index both the clinical cases, the electronic textbooks, and the ADM. Current research is done to index all the cases using UMLS.

3.3 Medical Nomenclature and Terminology Server

Medical terminologies that support computerized applications must be represented and displayed in a powerfull way in order to be available for several purposes. The MAOUSSC (Model for Assistance in the Orientation of a User within Coding Systems) project has focused on medical procedures [13]. It has been realized in cooperation with the Group IMAGE (Public Health School in Rennes), the University Hospital of Marseille and, the University Medical School of Nancy.

The objectives were:

- to define the dimensions that describe a procedure,
- to formalize the rules that are associated with this model,
- to get an operational structure of concepts for each axis,
- to be able to calculate the proximity between two terms.

The MAOUSSC system allows a compositional representation of complex procedures in terms of elementary procedures and optional modifiers. Elementary procedures are described according to a multi-axial model. The axes may be mandatory for any kind of action nature (it describes the method applied), topography, instrumentation, approach, or they may depend on the kind of action performed. A set of rules and patterns are implemented for making the description standardized and reproducible. A frame is designed for the formal representation of the nature of each act. A base of concepts is linked to the model. Up to now, we have used the UMLS Metathesaurus and the UMLS Semantic Network to fill in this model for several medical specialities [14]. The last part of the project was to develop a web server in order to give access to the model and several versions of procedure catalogs to all the participants [15]. The aim of this application is to build a terminology server which can help the user to find a medical term, concept or nomenclature entry by entering a free-text sentence. We can re-use the ADM word dictionary module for managing the lexical level and then browse through the UMLS Network. Futhermore, disparate modeling methods severely limit the interoperability and potentiality for sharing terminologies. The way to address this problem is to lead toward a shared understanding and a unifying framework. This is the purpose of ontology development in medicine. Our experiment using the UMLS as a medical knowledge source [16] and other developments in the area of medical knowledge bases are the first steps in our work on medical ontologies.

3.4 Medical Natural Language Processing

The team of the Laboratory of Medical Informatics was involved in the development of the MENELAS AIM (Advanced Informatics in Medicine) project. The overall goal of Menelas (an access system for medical records using natural language) was to permit exploitation of the medical information held in patient discharge summaries written as free text. The system is based on natural language processing (conceptual graph approach) and information retrieval techniques [17].

Experience with existing Hospital Informations Systems (HISs) highlights that most relevant medical information is stored in narrative form in Patient Discharge Summaries (PDSs). These PDSs aim at the transmission of a minimal but sufficient set of data to be used for the next visit of the patient. They are dictated and stored in a computer by the secretary. The overall goal of this project is to provide better access to this information through a variety of services. The strong underlying hypothesis we support is that better access to information allows better quality of stored medical information and leads to better use of the HIS. These services should hence reduce cost and enhance the quality of health care:

- Faced with an atypical patient, clinicians can search the stored reports for patients with similar characteristics, and find the treatments they received (diagnosis aid).
- Nomenclature codes are automatically produced for each report, and can be included in standardized discharge summaries (medico-administrative manage-ment).
- Public-health researchers can test clinical research hypotheses on the basis of the available patient sample (clinical research and public health).

Menelas is a multilingual project supporting the French, English and Dutch languages. The system employs techniques from the Artificial Intelligence and Computational Linguistics communities that draw on linguistic, common sense and medical domain knowledge sources in order to transform ordinary texts into a computable form. Menelas also produces a standardized representation of extracted information, in the form of international nomenclature codes: (ICD-9-CM codes) [18]. The system has been designed to be extensible to different application domains; it was applied to the domain of coronary diseases.

4. Discussion and Perspectives

The objective of our pedagogical network supporting clinical training is to encourage medical students to use a comprehensive set of medical information servers and to stimulate the faculty staff to produce clinical cases and information reusable in the university hospitals. Furthermore, this project shows that cooperative work can be productive as the Iconoweb project in medical imaging is now becoming operational on a national basis and will be extended to the European level.

The notion of a professional cooperative network for acquiring, analyzing, processing, and consultation of common data is now recognized as necessary in the medical field. The objectives were to make available to all health professionals the existing knowledge and data and information bases which have been developed in our institution, as well as those available elsewhere.

In the long term, this distributed work will enable the development of federated medical information centers that will coordinate and aggregate the production of timely information and knowledge for the entire medical community. This should also be the case for clinical and therapeutical information produced on a world-wide basis. We are following these objectives to build a Medical Virtual University for continuous medical education [19].

5. Conclusion

Modern medicine is an information-intensive domain which requires permanent and immediate access to knowledge and information, continually updated by clinicians and scientists. Rich and evolving production of multimedia materials for teaching and research purposes with free and world-wide access provided through the Internet are now readily available on the desk of students, physicians or researchers. Medical and health informatics is now recognized as a discipline [20] in most of the developed countries and requires high-level researchers and specialists to meet the expectations of end users.

The Internet became a tremendous success in the medical field during the last years, and the development of web servers to access multimedia data can be used for training as well as for clinical use or research.

In this context, it is necessary to train medical students in the daily use of these tools in the clinical environment. New research topics imply sophisticated indexing and information retrieval through this huge mass of information. We have now produced a comprehensive set of information servers which can be used to build sophisticated models and to integrate, index, and retrieve all types of data or documents found in the Medical School or the University Hospital.

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