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## Research and Education

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### *Research and education directions in Medical Informatics at the Aristotle University of Thessaloniki*

**Abstract:** The field of Medical Informatics is one of the most active fields both in research and education at the Aristotle University of Thessaloniki. The nucleus of this scientific field at the Aristotle University resides in the Medical School and in particular in the Laboratory of Medical Informatics. Education programs exist in undergraduate, graduate and post-graduate levels, and are targeted towards medical students and doctors and information technology related students and professionals. Research projects cover a wide area of medical informatics including medical information processing and management, electronic health records design and implementation, medical decision support, biological systems simulation, telemedicine applications, integration and communication issues related to regional health information systems, and quality assessment of health services and systems. The description and brief presentation of the output of these educational and research directions shall be presented in this paper.

### Medical Informatics Education

#### Undergraduate Courses and Education

Although Medical Informatics (MI) is a well established discipline in most European countries [1], in Greece for a long time only the Medical School at the Aristotle University through the Laboratory of Medical Informatics offered Medical Informatics courses since 1990 [2]. At the undergraduate level the Laboratory of Medical Informatics offers two courses entitled Medical Informatics I and Medical Informatics II. These courses are offered to the students of the medical and dental schools of the Aristotle University of Thessaloniki. Each of the two courses are semester courses and last for 13 weeks and 32 hours of

lectures and laboratories. Medical Informatics I is a mandatory course for all medical and dental students whereas Medical Informatics II is an elective. Medical Informatics I is offered at the first semester while Medical Informatics II can be elected by students from the second semester and on.

The aim of the undergraduate courses in Medical Informatics is to make the medical students aware of the possibilities given by informatics and information technologies to the medical professionals as it regards the way the health services are practiced and delivered today and in the near future. The primary aim is to render the medical students good users of the IT solutions in health care. The students have to complete a number of applied projects, and as a reference, the Handbook of

Medical Informatics is used [3]. The laboratories and projects are completed in the premises of the Laboratory of Medical Informatics, which is the INTERNET provider of the Medical School, being one of the main network nodes of the network of the Aristotle University of Thessaloniki. Currently more than 2000 active users are registered in the Medical School's node.

More specifically, the thematic areas covered by the two courses are the following:

#### *Medical Informatics I*

- Introduction to computer and tele-matics systems architecture
- Introduction to Boolean algebra and binary logic
- Programming essentials and logic diagrams

- Introduction to Windows environment, INTERNET and networking tools
- Basic tools for data management
- Introduction to WWW tools for searching and navigating
- Introduction to HTML and multimedia information acquisition and set-up for use in the WWW

### *Medical Informatics II*

- Information Technologies (IT) for health in Greece and the European Union
- Principles of electronic health records
- Data entry mechanisms in electronic health records in diabetes and cardiology
- Principles and types of decision support systems
- Evaluation of medical decision support systems
- Telemedicine applications in the medical field

### **Graduate Courses and Education**

At the graduate level the Greek Ministry of Education launched in 1997 calls for the development of pilot graduate programs which would aid in bridging the technological and educational gap between Greece and the rest of the European Union (EU) countries. The call was under the umbrella of EPEAEK which was a joint initiative of Greece and the European Commission, (EC) for the development of educational activities in all levels of education. Especially in the context of higher education through EPEAEK it was the aim of the ministry to fund development of graduate programs with a unified approach in Greece, and to provide infrastructure such as digital libraries and technology for the development of graduate based research and development (R&D) activities. These programs were designed to lead to the acquisition of both Master and PhD degrees. The

pilot phase for this initiative started in 1998, and was co-funded by the EC and the Greek State.

After the submission of proposals from the Greek Universities and following the selection process, the following programs linked to Medical Informatics and the Aristotle University were accepted for funding.

- The graduate program on Medical Informatics of the Aristotle University of Thessaloniki (PROMESIP) coordinated by the Medical School, with the collaboration of the Informatics School and the Department of Electrical & Computer Engineering of the Aristotle University.
- The graduate program on Medical Research Technology of the Medical School of the Aristotelian University of Thessaloniki (PROMESI).

The above mentioned programs started their pilot phase in 1998, and they awarded the first degrees (Masters) in the year 2000. PhD degrees are expected to be awarded from the year 2003 and on. It is important to stress here that the ministry of education favors the development of collaboration with international Medical Informatics related programs especially those belonging to European Universities, and thus suggests that the course material should be developed both in the Greek and English language.

In particular, as it concerns the program with acronym PROMESIP, this leads to the acquisition of two degrees, Master of Science (MSc) and Doctor of Philosophy (PhD). This program is an inter-departmental program involving the medical school, the department of electrical & computer engineering and the department of computer science. The degrees are awarded from the medical school which acts as the program coordinator. The students who participate have a degree in electrical & computer

engineering, informatics, physics and mathematics. In this program, the Master lasts for two years (three semesters coursework and one for a thesis), and the PhD lasts for a minimum of two additional years. Coursework is offered in the following disciplines.

- Basics of Systems Physiology
- Basics of Systems Morphology and Anatomy
- Computer Networking
- Biomedical Signal Processing
- Biomedical Image Processing and Coding
- Applied Mathematics
- Electronic Health Record
- Medical Databases
- Simulation of nonlinear biological systems
- Telematics applications in medicine
- Medical Decision Support Systems
- Security aspects of health information systems
- Workshops and lectures of advanced topics in Medical Informatics

A full time student must take four courses per semester and in the fourth semester the student must prepare a thesis. Each semester, the student spends a minimum of 250 hours attending lectures and laboratories. Specialized workshops and lectures are also part of this program. The courses can also be attended by industry or hospital specialized personnel that needs quick access to advanced education for immediate applications in their working environment. The number of students registered annually in this program is in the order of 10.

The second graduate program available from the medical school of the Aristotle University addresses the issue of medical research methodology and technology bearing the acronym PROMESI. Medical students as well as students with degrees in biology, pharmacology or dentistry can participate in this program. This program

aims to give the medical student the background needed on technology and MI related tools that shall be used for any research endeavor the student shall concentrate on. In this program, the Master lasts for two years (three semesters coursework and one for a thesis), and the PhD lasts for a minimum of two additional years. Coursework is offered in the following disciplines.

- Mathematics, especially calculus
- Biostatistics and principles of research methodology
- Medical Informatics and Biomedical Engineering
- Office automation and data management techniques
- Advanced physiology
- Systems morphology and anatomy
- Molecular biology
- Biological systems simulation and identification
- Medical technology and telematics applications
- Medical technology and sensors – instruments
- Workshops and lectures on advanced topics in Medical Research Technology

The coursework of PROMESI aims to provide the medical students with links to the basic sciences so that they can use them in their routine clinical practice or clinical research. The Master degree is concluded with the submission of a thesis, and lasts four semesters, just as is the case with PROMESIP. Each semester the student spends a minimum of 250 hours attending lectures and laboratories. Specialized workshops and lectures are also part of this program. The number of students registered in the PROMESI program on a yearly basis is in the order of 15.

The students who received a Master from both PROMESI and PROMESIP at a rate of 35% continued with their dissertation, whereas the rest are working in the industry, the informatics

education domain, in hospitals, and in applied research environments.

#### *Medical Informatics Research in the Aristotle University*

Research in the wider field of Medical Informatics and Information Technologies is going on since the early 90's in the Medical School through the Laboratory of Medical Informatics. A large number of research projects usually funded through the Greek Secretariat of Research and technology, the ministry of education, and the European Commission have been carried out covering different facets of Medical Informatics and IT in health. More specifically the following areas were primarily addressed over the past 12 years:

- Electronic health records
- Integration of IT platforms for health care telematics applications
- Medical data security and integrity
- Versatile medical data representation and interfacing
- Medical decision making
- Simulation and modeling of biological and clinical systems for aid in clinical research
- Telemedicine and pervasive computing applications in home care delivery for chronic disease patients
- Biomedical signal and image processing & interpretation

Research and development in the above mentioned areas have resulted in a number of publications, project deliverables and products. The list that follows summarizes the most important results of the research and development that took place in the Lab of Medical Informatics.

- New electronic health record systems were developed in the context of the I4C project where a multimedia electronic health record was developed for cardiac patients focusing on the continuity of care [4], and

in the DIABCARD-3 project where a chip card medical information system was developed for use in the routine treatment and management of diabetic patients [5].

- New information processing techniques were developed based on neural networks (NN) and spectrotemporal analysis. For example, real-time ischemia beat detection techniques based on neural networks and non-linear PCA were developed usable in ICU settings [6],[7]. QRS/PVC classification based on non-linear transformations and NN were also developed [8], and ECG spectrotemporal analysis for use in the clinical environment for evaluating the success of thrombolysis and for explaining atrial fibrillation mechanisms in patients who underwent CABG are other examples of the research efforts of the team in the Medical Informatics Laboratory, in collaboration with the clinical teams of the A' Cardiology Clinic in the AHEPA hospital [9].
- In the image processing domain, research concentrated on the processing of angiograms for the extraction of the coronary tree, and for the quantitative measurement of the geometric parameters of the arteries using primarily watersheds and region merging techniques [10], as well as in the analysis of 4-D MRI data from the heart concentrating on the left ventricular wall motion analysis using NN, deformable models and wavelet techniques [11].
- Research was also conducted in the development of versatile and user friendly interfaces especially related with the use of the electronic health records and the information processing modules [12].
- In the context of the IST project with acronym CHS (Citizen Health System), we developed a generic contact center, though which we

were able to deliver monitoring and prompting services to chronic disease patients such as congestive heart failure (CHF) and diabetic patients [13]. Clinical trials for the production of evidence based material regarding the feasibility of using such approaches in regional health delivery enhancing quality of care and quality of life are currently carried out.

In the context of the IST project with acronym PANACEIA-ITV, the use of the iTV platform for the delivery of home care is addressed. In the context of this project research on the use of intelligent agents in regulating information and requests flow in a health provision environment based on the active service provision (ASP) model is very active at this moment [14].

Finally simulation of important physiological phenomena in easy to use platforms for research and clinical purposes using applied mathematics is another important area of research. Such examples are models of the cardiac tissue simulating infarction, and studying reentrant mechanisms by simulating wave propagation in microscopic level [15],[16], as well as looking into problems related to the most accurate modeling of the dipole function at a cellular level and using this in the propagation velocity estimation as well as in the estimation of the electrode distance from the surviving myocardium for use in the ablation procedure and in detecting the correct activation instant from fractionated electrograms for use in implantable devices [17].

A number of dissertations were produced through the above mentioned activities, six of them are finished already and another five are under development, showing the close relation of applied research and projects that run on national and European levels.

## Discussion

At the Aristotle University and more specifically in the Laboratory of Medical Informatics, considerable work started in the previous years in Medical Informatics related areas. Analogous attempts have been made both in Europe [18] and the USA [19]-[21]. In the present paper the program for Medical Informatics in the Aristotle University of Thessaloniki was presented. Medical Informatics in the medical school of the Aristotelian University is offered both at the undergraduate and graduate levels, something that is unique in the Greek University system. The experience with the application of these programs are quite encouraging. Today more than 2000 users both students and faculty use the INTERNET and networking facilities offered by the Medical School's node of the Aristotelian University which is the Laboratory of Medical Informatics. It is also a fact that medical students, when they start learning MI just in time, for example during their freshman year, they can become extremely competent network managers and can engineer innovative solutions for the management of medical information that will be subsequently used to confront medical problems. Also, the strength and practice of the young medical students seems to affect the older generation too, by increasing awareness of the use of MI in everyday clinical practice, and thus creates the need for continuing education programs. This is also a reason why there is a high demand for graduate studies in the field of Medical Informatics and Medical Research Technology at the Aristotle University, since a number of medical and IT students realize that the future lies in the combination of scientific disciplines, and that the domain of health is one of those domains, where collaboration of multiple disciplines is a must for the development of successful systems and services.

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