MD/MS in Biomedical Informatics
dual degree program

UMDNJ-Robert Wood Johnson Medical School
and
UMDNJ-School of Health Related Professions
Department of Health Informatics
and
New Jersey Institute of Technology
MD/MS in Biomedical Informatics

Program Description

Computing systems and technologies have become increasingly essential for modern practice of medicine, pharmaceutical and clinical research, efficient and effective management of health care, and health professions education. To address an increasing demand for well-trained researchers, educators, and managers in the expanding field of biomedical informatics, and a growing critical need for informatics training, UMDNJ-Robert Wood Johnson Medical School along with UMDNJ-School of Health Related Professions and New Jersey Institute of Technology (NJIT) jointly offer a comprehensive curriculum leading to MD/MS in Biomedical Informatics.

Biomedical Informatics is the study, invention, and application of computing systems and solutions to models of scientific and medical phenomena. As a field of study, biomedical informatics incorporates the knowledge of the health sciences with computer science, management and decision science, biostatistics, and engineering and information technologies. Biomedical informatics involves the integrated use of several approaches and techniques from these sciences to solve problems relevant to health care delivery, health sciences and pharmaceutical research, education, and clinical/medical decision making. This integration culminates in new knowledge and techniques that become the foundations of biomedical informatics.

The course work includes the theoretical foundations and the current range of applications of biomedical informatics within contemporary health sciences, and health care delivery systems. The curriculum contents focus on structures, algorithms and design of efficient logic necessary to organize, store, retrieve and analyze data, and on developing computational solutions to produce new knowledge and understanding about, and approaches to: cognition and representation of biomedical knowledge, management of health care/hospital systems, clinical decision making, research in biomedical and pharmaceutical systems, and design and development of interactive multimedia systems for education. Besides core courses, electives and directed research projects, students can pursue an in-depth study in one of the following areas of specialization:

- Clinical Decision Support Systems
- Hospital/Health Care Management Systems
- Bioinformatics/Biotechnology Systems
- Health Sciences /Multimedia Systems
- Biomedical Imaging and Image Analysis
Examples of biomedical informatics application include:

1. Reducing diagnostic uncertainties and improving clinical decision making by using computing techniques and information technologies (e.g., develop clinical decision making tools for determining the probability that an ER patient with chest pain or other related symptoms actually has acute cardiac ischemia or should be admitted to rule out myocardial infarction).

2. Designing interactive consultation systems to treat patients more efficiently and cost effectively by using national databases referencing a broad range of clinical experiences and pertinent variables.

3. Improving research designs and outcomes of clinical trials, epidemiological studies and health services research.

4. Developing computing systems and solutions that will help design more effective and more informative clinical trials to cut years out of drug development process.

5. Utilizing computational approaches and modern computer-based techniques in drug design, molecular genetics and cellular genetics to solve complex clinical problems.

6. Designing and managing clinical, pharmacy, radiology, laboratory or hospital information systems.

7. Designing and implementing a system that will emancipate more time for healthcare providers to spend on more important aspects of patient care through delegation of some information handling and processing tasks to computers.

8. Designing a computer simulation suitable for analyzing medical and health care problems, or for constructing solutions to optimize decisions concerned with efficacy of information transfer, productivity and resource utilization in a health care facility.

9. Performing quality assurance activities, patient education software development, etc., in a health care facility at that facility’s request.
MS IN BIOMEDICAL INFORMATICS

This program is available to Robert Wood Johnson Medical School students after completion of the second year. Full-time study may result in program completion in 18 months. All students complete at least 36 credits hours of which at least 30 hours must be formal course work. This includes: (a) 18 credit hours of core courses, (b) six credit hours in an area of emphasis/specialization, (c) six credit hours of electives, and (d) six credit hours of directed thesis or project. In addition to core courses, electives and directed research projects, the student can pursue an in-depth study in one of the following tracks: (1) Hospital and Health Care Management Systems, (2) Clinical Decision Support Systems, (3) Health Sciences Education/Multimedia Systems, and (4) Bioinformatics.

Program of Study

M.S. in Biomedical Informatics Curriculum

I. CORE COURSES: 18 Credits

Health Care Information Systems

The course focuses on the general systems theory applied to health care systems and information technology. Computer-based information system operation and management functions in the context of various professional settings, and impact of information technology on health care management are reviewed and discussed.

Or

Bioinformatics Database Systems

Study of database design and management in relation to human genome and similar projects. Topics covered include: nature and properties of databases for bioinformatics; data models; semantic and object-oriented modeling of application domains; statistical database query languages and query optimization; advanced logic and query languages. The course emphasizes software tools and techniques for scientific data management.

Biomedical Modeling & Decision Making Systems

This course introduces the use of differential equations and relevant mathematical concepts to describe health care and physiological systems. The course focuses on the methods and resources of computer simulation and modeling, which are suitable for analyzing medical and health care problems under broad categories of conditions, for constructing solutions to
optimize decisions concerned with important variables, both in health care organizations (such as efficacy of information transfer, productivity and resource utilization), and in physiological systems (in such areas as drug dosage, pulmonary transport, cardiac output, kidney function, etc.).

Visualization in Biomedical Sciences

The course introduces the students to the fundamentals of biomedical signals processing and image processing. Techniques including image digitization, display, and processing algorithms will be discussed. Particular emphasis will be given to areas related to computer systems, processing methodologies, and display of images. The course will provide hands-on experiences in visualization procedures using tools and technologies for 3-D representation of images, animation and image manipulation.

Introduction to Biomedical Informatics

Students are introduced to both mainframe and microcomputer interactive computing environments. Theories of biomedical informatics, structures and algorithms of medical information are discussed. The course covers essentials of computational techniques for solutions of problems in health care and biological sciences.

Data Structures and Algorithms

Intensive study of fundamentals of data structures and algorithms. The emphasis is on the design of efficient algorithms and data structures, proofs of their correctness and complexity analysis.

Research Methods in Health Sciences

Topics include current uses of the computer as a tool for scientific inquiry, techniques for searching the computer-based databases containing research literature, ways of formulating problems and hypotheses for statistical analysis of educational, health services, laboratory and clinical data, use of computers in management and analysis of health science data.

II. Areas of Emphasis/Specialization

The program is designed to allow its graduates to pursue the study of informatics in their area of primary interest. The student will select one of the following track areas:
Track I: Clinical Decision Support Systems:

Clinical Problem Solving and Decision Making

An overview of computer methodology in clinical decision making, application of decision trees to clinical and health care problems, estimation and revision of probabilities, artificial intelligence, expert systems and decision-making techniques for their implementation as decision support systems in clinical settings.

Data Management System Design

This course is intended to acquaint the student with fundamental notions of relational database technology. Mathematical properties and usage of database programming languages, methods of database design and conceptual modeling, methods of physical storage of database information, fundamental notion of concurrency control and recovery in database systems are discussed.

Track II: Hospital and Health Care Management Systems

Health Care Decision Support Systems

An overview of methods of decision support in health sciences. Discussion on the need for such methods motivated by psychological literature on human perceptual and judgmental limitations. Examples of methods for aiding decisions and enhance diagnostic accuracy include: AI, Bayesian methods, classical multivariate analysis, dynamic screening (Markov) models. Theoretical and empirical limitations of these decision methods are stressed.

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Track III: Bioinformatics/Biotechnology Systems

Topics in Bioinformatics

An extensive review of computational biology necessary to take understand research and developments in bioinformatics. Topics include: covalent bonding, quantum mechanical basis of bond formation, 3-dimensional structure of molecules, reaction mechanisms, catalysis, polymers, enzymes, thermodynamics and kinetics, metabolic pathways, and sequence and structure of macromolecules.

Advances in Molecular and Cellular Genetics

The course makes extensive use of computer approaches to cover the following important areas: cell structure, intracellular sorting and signaling; structure and function of proteins, enzymology, membrane structure and function, DNA structure, replication, transcription, mutation, cell fusion, chromosomal mapping and gene transfer, and immunological principles applied to genetics.

Track IV: Health Sciences Education/Multimedia Systems

Intelligent Instructional Systems

The course is designed to integrate scientific knowledge about learning in the health sciences with current developments and trends instructional technology. The course examines the processes of perception, learning, motivation, problem-solving and decision making in relation to the design and development of intelligent tutorials, health professions training and educational modules.

Interactive Learning Systems for the Health Sciences

Introduction to the utilization of interactive videodisc technology and CD-ROM technology for producing health sciences instructional software.

Track V: Biomedical Imaging and Image Analysis

This track addresses the problems fundamental to modern medical image analysis, teleradiology and management of image databases. Students learn latest techniques and methods for data acquisition, extraction, manipulation of multi-dimensional data sets, analysis, and interpretation through the application of expertise from Biomedical Informatics, and reconstruct high-resolution images for use in diagnosis, surgical planning, remote surgery, and treatment planning.
Imaging Technologies and Medical Diagnosis

Detailed survey of magnetic resonance imaging as applied to medical diagnosis, and principles and technology of medical ultrasonic imaging. Covered are magnetism, spatial encoding principles, Fourier analysis, spin relaxation, imaging pulse sequences and pulse design, contrast mechanisms, chemical shift, flow encoding, diffusion and perfusion and a discussion of the most relevant clinical applications. Fundamentals of wave motion; properties of ultrasonic fields; methods of measurements and mechanisms of attenuation and scattering; pulse-echo imaging; Doppler methods and color flow imaging; transmission mode imaging; clinical applications and image artifacts.

Medical Imaging and Networking

Core technologies and applications related to clinical multimedia and medical applications on the internet. The topics introduced include multimedia systems architecture, medical imaging modalities, medical imaging standards, multimedia image databases and interface standards, image compression—decompression, multimedia technologies and data and file format standards.

For further information on the programs contact:

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