DEVELOPMENT OF MEDICAL IMAGING CURRICULUM BY A MULTI-STAGE TEACHING MODEL

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Abstract

Medical imaging technologies widely applicable to both clinical and basic science research are crucially important to the biomedical engineering field. Teaching medical imaging becomes a key component in biomedical engineering education. For undergraduate students who learn medical imaging technologies, however, the "classroom-only" teaching style suffers from many limitations that make it difficult for students to gain a complete understanding of a particular system. We developed a new medical imaging curriculum by associating a series of courses with 1) on-site lecturing in research and clinical laboratories and 2) a set of Internet accessible imaging simulation tutorial programs, and formed an integrated teaching program. This program provides students with medical imaging knowledge in live, effective and interactive formats.

Introduction

Biomedical engineering has been emerging as a multi-disciplinary engineering area since the end of last century. As a key component in this field, medical imaging education, combining physics, mathematics, electrical engineering and computer engineering together, provides students with a broad view of information technologies applied to biology and medicine. The curriculum for medical imaging education usually involves tremendous amount of prerequisite background knowledge, such as physics, mathematics, programming, biology and even human anatomy. Medical imaging systems have their common basis but are also different from each other. Typical medical imaging systems include radiographic imaging (X-ray, computed tomography (CT)), magnetic resonance imaging (MRI), ultrasound imaging, positron emission tomography (PET) and other nuclear medical imaging systems. It is very difficult for an instructor to provide students with in-depth knowledge in the setting of a single course. The detailed course contents that are potentially available must be cut down to size to fit into the available class hours.

Ongoing advances in novel imaging techniques, particularly those used in research laboratories, should be consistently and steadily integrated into the medical imaging curriculum. It is nearly impossible, however, for textbooks to remain steadily up-to-date with respect to these novel, continually evolving technologies. Clinical laboratories are where equipment setting and system integration of an imaging system that is used for patients can be described to students in reality. Bringing students to these laboratories will give them firsthand knowledge and provide them the opportunity to practice the knowledge they have just learned if they are involved in research projects in laboratories. In recent years, Internet and intranet developments have greatly expanded the possibilities for medical imaging instruction [1-3, 6-7]. Advanced web sites of medical imaging have been well developed mainly for graduate study or for research purposes. Image processing techniques for medical imaging are usually of interest primarily to the software engineering industry. In fact, however, these techniques are an inherent part of imaging systems and are closely related to imaging principles.

Aiming at the development of medical imaging curriculum for undergraduate students, we designed a multi-stage teaching model that was performed by a multi-department and multi-laboratory teaching team in classrooms, on-site laboratories, and computer simulation laboratories. To develop the Internet-based computer simulation software, several graduate students participated in this project and were involved in related research. Moreover, as a result of this development, resources of medical imaging facilities in clinical and research laboratories were fully utilized.

Methods

We set up a three-stage teaching model for medical imaging curriculum for biomedical engineering students. Regular classroom teaching offers students a series of courses, including medical imaging systems, medical imaging applications and advanced medical imaging (for graduate) in consecutive semesters. This traditional way gives students lectures that regard explanations of physics principles, mathematical derivations, system descriptions and textbook materials [5, 8-9]. Homework and tests are related to these instructions.

Laboratory classroom teaching is the second stage of teaching. We establish a multi-department and multi-laboratory teaching schedule for students' visits to medical imaging systems that are on-site in actual laboratory settings. Students can absorb new ideas much faster when they are exposed to the real world than by learning from textbooks, especially in those subjects involving items of equipment [4, 8]. These visits are not pure observations, instead students are facing professors or technicians who give lectures and communicating with professional medical imaging experts directly. Students can also make use of these opportunities to seek for their senior design projects or even their career direction. Pictures on next page record these activities. Students in clinical laboratories (Department of Radiation Oncology) listened to a professor's lecture about the principles of CT and therapeutic electronic accelerator (left panel). A professor in the Department of Radiology opened a MRI machine's cover to show students the structure of the magnetic coil when he gave lecture about MRI machine's principle and setup (middle panel). Students in a research laboratory (Department of Neurology) watched a professor and a technician to perform radio-isotopic autoradiographic cerebral blood flow study (right panel).

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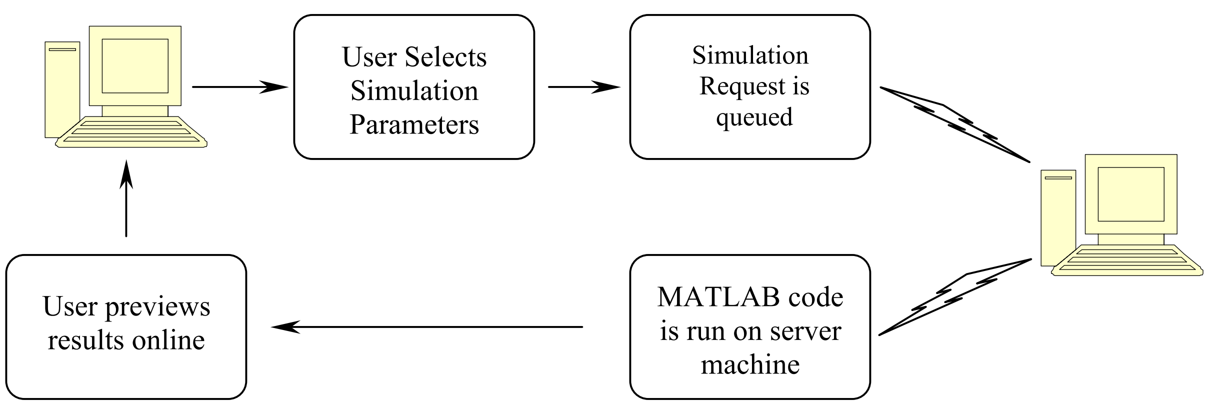
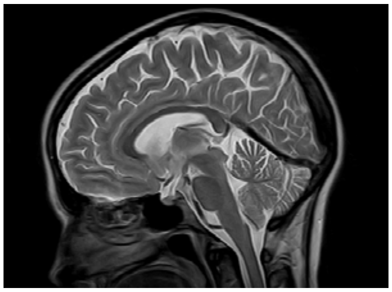
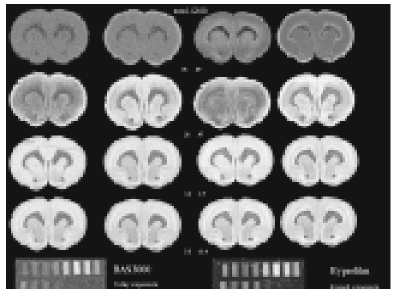
Laboratory practice is the last stage of teaching. We established an Internet-based computer software simulation system (http://mis.eng.miami.edu). This system links advanced websites for medical imaging technologies. Students can read these web sites for additional knowledge and run demonstrations (if executable programs are available). Students are also given projects to simulate learned medical imaging systems, such as X-ray, CT, MRI and PET. They can compare their simulations to the results obtained from our simulation system to perceive any difference in these comparisons. The established software simulation system is accessible through the Internet. The host server (i.e., mis.eng.miami.edu) runs as a MATLAB server that performs simulations of data collection, quantization and reconstruction in different imaging systems. This simulation system is configured as following illustration figure. The interface of this simulation system is shown on next page. Algorithms are written by the MATLAB language and illustrations are performed by the Director software.

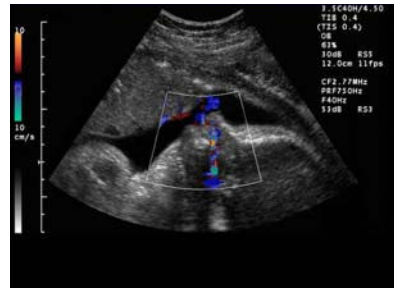




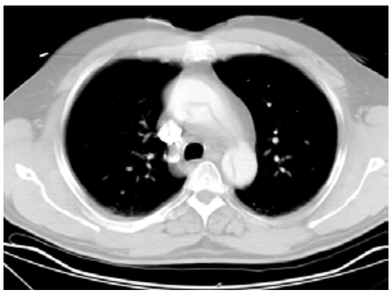
MRI



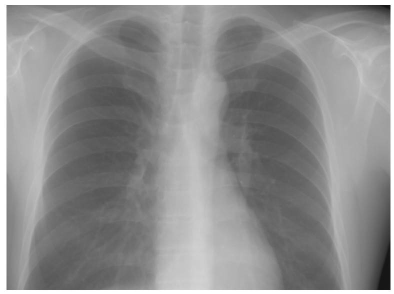
Autoradiography



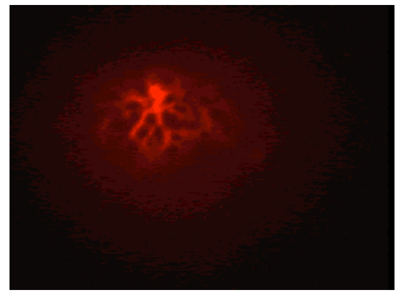
Ultrasound



CT

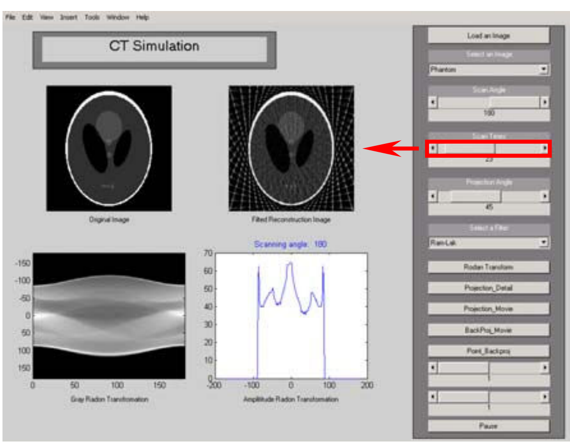


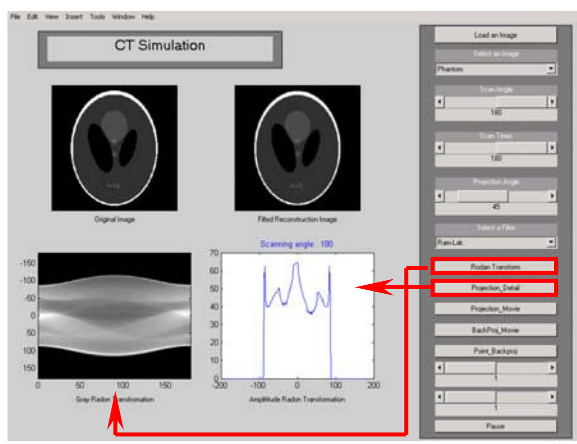
X-ray



PET

This simulation package also provides a review of the physical principles of these systems. Lecturing while demonstrating a "live" physics or mathematics process can efficiently and actively explain these principles. For a simple example, X-ray's decay characteristics in a given object that has uneven densities (students can upload their objects), whose pixel intensity can be used to simulate the object density, can be dynamically displayed when the function of "display photon decay" is requested. The remaining number of photons can is displayed while the simulated photons are passing through the object. When presented in conjunction with equations, the instructor is easily able to explain the decay principle. An example of CT simulation is described as following. After selecting the CT imaging modality from the main





interface, one will see the CT simulation interface showing as the above figures. For the CT simulation prototype, the simulation system includes web pages illustrating principles of X-ray, X-ray tubes and receivers, and the projection controller. Students can upload a user-defined object, and then to see the whole process step-by-step dynamically, from projection to back projection, to filtered back projection etc. They can select different algorithms and modify reconstruction parameters to view the different simulated results as well.

Conclusion

This three-step teaching program has brought a broad view for students in their knowledge acquiring. Students learned in-depth medical imaging technologies from textbooks as well as from clinical and experimental research laboratories. The onsite laboratory lecturing provides students with opportunities to follow new imaging techniques developed for ongoing research requirement, to learn real configurations of medical imaging equipment, and to seek for their potential projects or even career direction. Meanwhile, resources of medical imaging facilities in clinical laboratories and federal funded research laboratories can be fully utilized. The medical imaging simulation software, as our developed teaching material, serves students as a virtual laboratory to review and practice what they learned in classroom and laboratories. The completion of this simulation software has the potential to be shared by students with different majors from different schools, such as for the basic review of medical imaging principles for premed students, or students from nursing school. This program, when combined with courses in medical informatics, bio-signal processing, and medical intelligent systems, comprises the basic curriculum for students electing the biomedical information technology option.

Acknowledgments

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Biography

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