

A Freshman General Education Bioengineering Course on the World Wide Web

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Abstract

A new bioengineering course, Introduction to Bioengineering: Focus on Medical Imaging, has been designed for non-majors as well as freshman engineers and biologists at the University of Illinois. The course is taught from notes available on the World Wide Web. Computer and written exercises can be submitted via the conferencing or bulletin board software. Asynchronous learning technology is helpful in communicating among instructors students and for coordination of group project work. The educational goal of the new course is to motivate further study in science and engineering, while making efficient use of faculty time.

Introduction

Introduction to Bioengineering: Focus on Medical Imaging is a new bioengineering course at the University of Illinois at Urbana-Champaign (UIUC). It introduces an interdisciplinary field of science and technology to engineering and science students, as well as non-science, non-engineering majors. Since the course is being developed to satisfy the UIUC General Education Requirement in the area of science and technology, one of the course goals is greater scientific literacy and enthusiasm for science and technology. This course is also a part of the UIUC Discovery Program in which freshmen can enroll in small classes (20 students or fewer) with direct contact with a faculty member. It is being developed in consultation with members of the UIUC Education College Department of Curriculum and Instruction, with whom both teaching methods and materials are shared. The course will be taught for the second time during the Spring 1996 .

The course meets three times per week, although one of the meetings is often used for computer lab exercises or visits to local medical and veterinary facilities. Students are required to complete homework exercises approximately every other week, a term paper, two examinations, and computer administered quizzes. The term paper is done in two stages. Each student writes an individual paper, due at midterm, on an agreed upon theme. The students are organized into groups according to themes. Then they revise their papers and integrate them into a group report, with an accompanying oral presentation.

Course Content and Goals

The course is divided into four parts, focusing on X-ray (including computed tomography (CT)), nuclear medicine, ultrasound, and magnetic resonance imaging (MRI). The course content is selected for comprehension by freshmen, many of whom have not had college calculus, physics, or physiology. The first goal is to give students an integrated understanding

ranging from the basic physics underlying a particular medical imaging modality progressing through an explanation of the technology needed to make a practical device. Following this, case histories are introduced in which imaging forms an important part of the diagnosis. This leads to a discussion of how the physiological properties which distinguish one disease state from another translate into distinctive physical properties and into an image which can be read by a radiologist.

A second goal is to motivate students in their basic science and math courses by selecting mathematical, physical, and physiological problems which are studied in more detail. One example is the development of the idea of the attenuation coefficient, which plays a pivotal role in most imaging modalities. A second is the concept of a frequency or energy spectrum, and the filtering of that spectrum, which occurs with the familiar phenomena of visible light and sound, but also in X-ray, CT, nuclear medicine and MRI in forms unfamiliar to students. Mathematical and computer homework exercises are completed to explore these phenomena.

The following case histories have been developed: dental, with X-ray; pneumonia, with X-ray; a brain aneurysm, with CT; breast cancer, with mammography; pregnancy, with prenatal ultrasound; ruptured disk, with lumbar MRI; and kidney clearance evaluation in animals, with nuclear medicine.

World Wide Web Notes

All notes for the course are available on the World Wide Web. They were adapted from a complete set of lecture notes, written by Prof. Andrew Webb of the UIUC Electrical and Computer Engineering (ECE) Department, which was available as a Microsoft Word document. Since these notes were written for a junior class in engineering, annotations were added to assist students in their reading. These take several forms, the most basic of which is the linking of specific vocabulary items to a glossary written for the course. The advantage to leaving the notes relatively undisturbed is that the same set of notes can be used with the upperclass course without need for re-editing. Upperclass students are not distracted by the annotations, yet can take advantage of the links to acquire background information.

Since the UIUC has access to Encyclopedia Britannica on-line, it proved to be most efficient to link to Britannica entries for most of the glossary items. An additional advantage is that students now know that they have an immediately accessible source for further information about this material and any other material. Britannica entries are quite appropriate for freshmen.

A second study aid is an outline which accompanies the notes. This outline clearly states what is important for freshmen to understand. It is easy to open two windows, one with the text and one with the outline, as a study aid. Framing features newly available on the web make it possible to see both in the same window.

Automated Quizzes

This semester we are introducing automated quizzes, which are, at present, limited to multiple choice questions. Students' scores are automatically recorded in a grade book under a program known as Mallard, which has been developed by Prof. Donna Brown of the UIUC ECE Department. Included are questions regarding content of images which are displayed simultaneously with the questions. The quizzes are used primarily for reinforcement. We are also testing the use of the World Wide Web for short answer questions which are to be individually graded by an instructor. The web will be used to pose the question with a blank

space for the answer. Completing the question initiates an electronic mail transfer to an instructor.

Imaging Exercises

Four computer imaging exercises were created using the public domain program NIH Image, which runs on Macintosh computers. The first exercise introduced students to the use of the image manipulation software. Succeeding exercises demonstrated features of X-ray, CT, and MRI medical images as related to diagnosis. Students were required to inspect images, label them anatomically, and identify presence or absence of a disease. These proved quite challenging. Students could download, complete, write up, and submit their computer laboratory reports at one sitting at a campus computer site.

A drawback of the exercises was their restriction to a single computer platform, which necessitated most students to visit the campus computer sites even if they had network linked computers in their dorm rooms. For that reason we are replacing the exercises with equivalents which are integrated into the course web pages.

Conferencing and Bulletin Boards

We have used conferencing software (PacerForum) in the first course offering and found that it was useful for exchange of files in group projects. Students were able to post their term papers, and successively and successfully edit them into finished documents.

However, with the small class it proved to be difficult to establish a continuing dialog with special conferencing software. Asynchronous communication is now implemented using a bulletin board service easily accessible via course web pages and electronic mail.

Maximizing Use of Course Materials

Although the development involved in creating the curricular materials is extensive, it is planned that, in steady state, this course can be taught efficiently. This is necessary, as it is likely to be taught only as an overload and may be team taught. To meet Discovery Program goals, faculty time with students must be maximized. Savings in time must come from reduced grading and organizational time. The goal of the on-line quizzes, which are integrated with the course materials, is to provide a highly effective reinforcement teaching tool which operates with little faculty intervention. Short answer materials can be graded by upperclass undergraduates. Faculty still need to construct exams, and grade term papers and oral reports. Organization of the course is implicit in the web materials and need not be repeated.

As mentioned above, significant material was borrowed from an upperclass medical imaging course, and the materials developed here are supportive of students taking that course. We also believe that these materials can be extended to different populations, including high school students interested in medicine or engineering, and secondary science teachers who are searching for materials for use in their classes.

Summary

We have developed a new bioengineering course which uses World Wide Web networking extensively. It now integrates most course activities using a web browser in order to provide platform independence for students. The web materials include lecture notes and outlines, reinforcement quizzes, computer exercises, and a bulletin board. It is hoped that, once course

development is completed, faculty time can be directed primarily toward interaction with students. Additionally, it is anticipated that the course materials can be utilized by other courses and by other populations, including high school students and teachers.

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