Teaching Information Engineering to Everyone

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Abstract

The first offering of a course in "Information Engineering Across the Professions" is being held in the Spring semester of the 1996-97 academic year at WPI. This course is offered by the ECE Department, but is intended to be relevant for students from virtually all disciplines, and is specifically intended for students who are not majoring in electrical engineering. The authors have developed this course based on substantial interviews with faculty and students from across a broad spectrum of disciplines, including economics, English, history, chemistry, management, and biotechnology. This paper reports on the use of the World-Wide Web for preparation of course materials, and on lessons learned to date in developing and offering the new type of electrical engineering service course.

Introduction

Opportunities for fundamental changes in many professions have arisen due to new modes for information creation, storage, transmission, retrieval, management, and display. However, familiarity with the use of the technologies central to this revolution is often limited to a small population of individuals with a deep (and rather narrow) education in electrical engineering or computer science. Currently, only students in these disciplines are apt to become familiar with state of the art capabilities and applications of computer and communications networks. However, professionals in virtually all fields, including engineering, science, management and finance, the health professions, law, education, social and political science and journalism, will encounter opportunities to be more effective practitioners and leaders in their disciplines if they can make good use of information technologies. Hence, there is a need for students in all disciplines to become acquainted with the underlying principles of modern information technologies [1].

A new course titled “Information Engineering Across the Professions” addresses that need, and provides an introduction to concepts such as the nature of information, representation of information as bit streams, means for data compression, bandwidth, types of transmission and storage media, and the fundamental principles governing information technology. Through the use of laboratory project-based "personality modules" customized to address different student disciplinary interests and backgrounds (e.g., mechanical engineering, the sciences, the arts, management), the course will expose students to professional applications of these technologies.

This course is being developed with support from the National Science Foundation’s Course and Curriculum Development program. Following are the overall goals of the WPI project:

- Stimulate the new area of “Information Engineering” among students and faculty,
- Teach “real” engineering and technology without extensive prerequisites,
- Write a Web-based textbook,

- Also publish a conventional textbook,
- Successfully disseminate both the course materials and the course philosophy.

Since this course is quite different from existing courses, it is appropriate to highlight what it is not, as well as what it is intended to be:

- It is not a course about how to run specific software packages (although various useful software packages will be introduced and applied),
- It is not a repackaged course from the regular ECE curriculum,
- It is intended be a complement to, and very different from, our traditional "EE for non-EEs" course,
- We hope it is an example of engineering as the "new liberal arts."

A previous paper [2] has provided details on the background and topical content of the course. This paper will focus on the materials which have been prepared for the course, and on lessons learned to date.

Overview of the Course

Because of the wide potential audience for this course, a primary objective is to develop it in such a way that it is easily transportable, not only to other institutions, but also to different types of student audiences. This can be achieved by development of new and different modules customized to provide the applications exposure central to the course. Following is a summary of the significant technical and pedagogical aspects of this course:

- Introduction to concepts of information, communications, networking, human interface,
- Presentation of inter-related information-related concepts from a variety of disciplines in a quantitative manner,
- Use of teaching methods adopted to make efficient use of modern technology, while involving students with the technology,
- Design for cost and educational effectiveness with large class sizes.

PC-based laboratory exercises which exploit network resources will be integral to the course, and will be the primary format for carrying out the discipline-specific modules.

Course development has involved students and faculty from departments across the university, and a substantial evaluation plan is in place. Course materials will be disseminated via the World Wide Web, as well as by publication of a textbook. The course is intended for first or second-year students who are not majoring in electrical or computer engineering; the formal prerequisites are intentionally kept to a minimum. They are: knowledge of college algebra and experience with any computer programming language. While formal prerequisites are few, it is definitely the intent that the course build on students' previous experience, particularly including: mathematics, computer use, communications skills, and science knowledge.

The course has been developed based on some rather fundamental principles and practices which can be referred to as "information engineering." The authors believe that these concepts are very broadly applicable across all disciplines, and it is our intent to enable non-engineers to understand both the substance and the importance of these principles. This paper will emphasize lessons learned from the initial offering. Challenges in developing the course include the vast number of concepts and range of material, and the desire to teach "principles by application" rather than teaching "use of packages."

Process of Course Development

Extensive interviews with faculty in a broad range of disciplines (including Humanities, Biomedical Engineering, Civil Engineering, etc.) were conducted. The intent was to learn the specific aspects of information usage and processing that were most relevant and needed in that discipline. Following is a selection of comments from those interviews:

- “Students need to learn how to use packages like spreadsheets, presentation graphics,”
- “Geographic databases linked to GPS are becoming important,”
- “MRIs are recorded on film only because that is the medium radiologists expect,”
- “I don’t see much impact yet beyond word processors,”
- “The web is vital,”
- “The web is minor.”

Comments such as the above indicate that while considerable specific information was gathered in the interviews, there appeared to be a rather low level of appreciation by the faculty of the potential for information technology in their discipline. In retrospect, the authors do not find this surprising; in fact it helps motivate the need for the course!

Following are examples of specific information and/or communications systems relevant to individual disciplines that were identified during these interviews:

- Civil Engineering: the Global Positioning System, geographic data bases,
- Medicine: Information resulting from diagnostic imaging, merger and organization of patient data obtained at different times, locations, etc.,
- History: collaboration of many researchers from different locations on one topic, data bases of texts, images, scholarly papers, etc.,
- Management: real-time data on production processes or sales for inventory control, process improvement,
- Mechanical Engineering: “paperless engineering” incorporating design documentation, simulations, manufacturing information, etc., sensor systems for real-time control (engine controls, process automation, etc.).

Textbook and Course Material Preparation

No existing textbook which addresses the topics of this course was found to be available. The authors are in the process of writing the text, and are using initial draft versions for the course offerings. It is planned to publish the text commercially. This textbook and other course materials are being produced using the “single base document” strategy. This approach integrates several components:

- Multi-person authoring of the course text,
- Printed and Web accessible course textbook for student use,
- Software for student labs/demonstrations exist within the textbook as Java Applets,
- On-line dissemination and communication among faculty worldwide.

The textual materials are being prepared in latex with “latex2html” enhancements. The resulting material can then be “formatted” as either a paper-based text or as an HTML Web document. The resulting material is almost completely free of any platform dependence. Java and HTML are described in many references including [3].

Java-based and Traditional Experiments

The laboratory component of this course is quite important in making abstract concepts more real. Two types of laboratory experiences are included: those based on simulations written in the Java language, and more traditional hardware-based lab exercises. The traditional exercises begin with very fundamental tasks, such as scanning images and digitizing audio. The first goal is simply familiarization with the procedures, but the more important goal is for the student to learn what is happening to the information content as formats are changed.

The Java applets are excellent examples for the students of the new capabilities of information technologies, but they are used in the course primarily because they are the right tools for the job of providing concrete illustrations of abstract concepts (such as the conversion of an analog signal to digital format). This would be possible in a hardware-based lab, but the equipment would be much more involved for these non-EE students to learn to operate. The results would certainly be more "real," but at the level of this course that reality would not serve a significant educational purpose. Of course, hardware implementations of the experiments would also be much more expensive and inflexible with respect to lab location and hours.

As an example Fig. 1 shows a screen print of the Java applet which demonstrates the effect of noise on binary transmission. The dynamic nature of the applet is lost in the figure. Students enter the desired binary string and signal-to-noise ratio, and the waveform is constructed on the screen in a progressive fashion. Readers are invited to access the applets at http://ece.wpi.edu/infoeng/. The lab exercises ask students to use the applets to perform certain tasks and report the results. For example, students might be given the task "Transmit a string of 10 alternating ones and zeros with a +20 dB SNR. Report what the time signal looks like." This could motivate a discussion of timing recovery for baseband data signals, including the difficulties that occur with long strings of ones or zeroes with no transitions.

Following are the other Java applets which have been developed to date: Binary-decimal conversions, including floating point numbers, ascii conversions, FFT of several types of time signals, signal sampling and reconstruction with bandlimiting and quantization, sound reproduction, PCM encoding with band-limited transmission, PCM detection with noise, image data encoding, including run-length coding, median filtering, frame difference coding.

Following is an example of some of the conventional lab tasks which the students are given:

- Find an image representing your discipline, scan it into the computer, represent it in various forms (full color, monochrome, bit map, vector graphics, various resolutions). Calculate the resulting size in bits. Explain the significance of each to the purpose of the image.
- Produce a web page specific to your discipline with several information types.
- Given a page of text, determine the amount of information, and the number of bits required to transmit the page via: fax, ascii coding of the text, encoded audio.
- Store a sample of your voice using the PC sound card, plot the time waveform, find the bandwidth, determine effect on intelligibility of bandwidth restrictions.

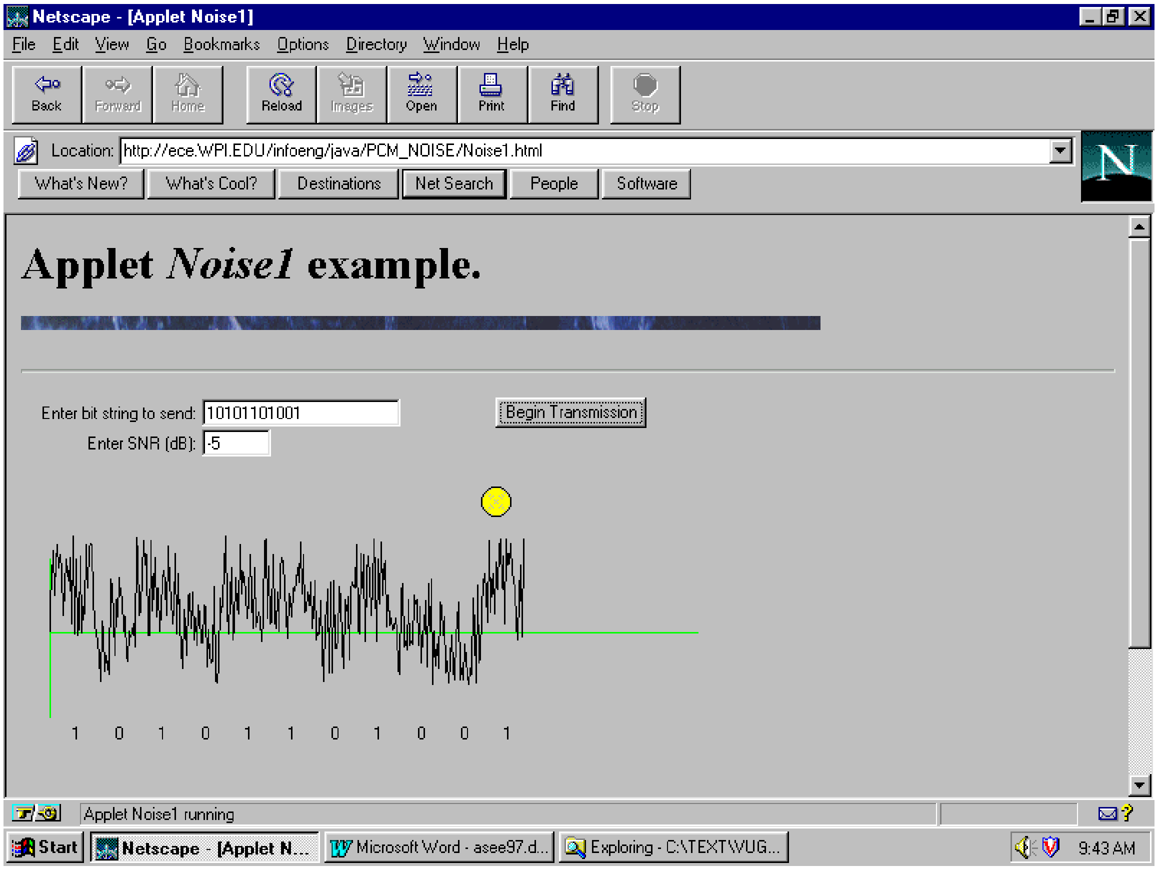

Fig. 1 Java applet screen print showing the effect of a -5 dB signal to noise ratio on the baseband transmission of the indicated binary sequence.

Conclusions

Several lessons have been learned in the process of developing the course:

- ECE students, not just non-ECE students as originally targeted, could benefit from the course material,
- The potential impact of information technology is often not recognized,
- Students may be ahead of the faculty in their disciplines with respect to information technology in some cases,
- Basic literacy must precede fluency (i.e. it is important to insure that students learn basic skills in information manipulation before attempting to teach sophisticated concepts of information theory),
- The web can do almost (but not quite) everything; "real" labs have a place alongside "virtual" labs.

A "snapshot" of the current status of the course material is available on the Web at http://ece.wpi.edu/infoeng/. The presentation of this paper will include knowledge gained from the first offering of the course which is ongoing as the paper is written.

Acknowledgment

The support of the National Science Foundation for this effort is gratefully acknowledged.

References

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Biographies

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