A DISTANCE LEARNING LABORATORY DESIGN EXPERIMENT IN UNDERGRADUATE DIGITAL SIGNAL PROCESSING

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ABSTRACT

Competitive pressures in the global marketplace have forced companies to form teams from the best talent available irrespective of their geographical location. As it comes online, the National Information Infrastructure will be increasingly used to support such interactions. American companies are far ahead of the universities in realizing systems to support such geographically distributed interactions. Universities must catch up by exposing their students to such design environments. In addition, universities should help define and evaluate network-based information dissemination systems by serving as testbeds for new interactive strategies. This paper presents initial results in a distance teaming experiment at the University of Colorado, George Mason University, and Rice University.

1. BACKGROUND

Companies frequently team their employees over widespread regions when undertaking large and detailed projects. At present, these enterprises use leased analog and digital communication lines and will no doubt switch to computer networks as the "Information Superhighway" becomes a reality. From a pedagogical point of view, this modern approach to teaming requires that educators develop in their graduates the skills required for this new reality. These skills include, among others, identifying expertise and interest within a larger distributed group, segmenting tasks in a meaningful fashion, integrating designs across a high-speed network, verifying performance against specifications, and compiling and writing a comprehensive final report.

To better prepare engineering students for modern national and global professional practice [1], we want to introduce collaborative learning experiences into the university classroom by cohesively interweaving our three schools about the area of digital signal processing. As an integral part of this process, we will be substantially modifying existing undergraduate courses in signal processing at each of the respective Universities along with introducing a common senior technical elective explicitly designed to exploit the areas of expertise of the faculty involved.

2. DISTANCE TEAMING GOALS

To confront this challenge to engineering education, faculty from three diverse Universities - the University of Colorado at Boulder, George Mason University, and Rice University - are developing experiments designed to implement team learning and team teaching using the Internet [2-5]. Specifically, we are modifiying undergraduate signal processing courses and developing new undergraduate signal processing courses so that they have a heavy emphasis on distributed experimentation. These modified and new courses will be located at each university and will be supported by connected multimedia laboratories at each University. The equipment is being planned to support audio and video transmission necessary for facilitating real-time student interaction over the Internet. Relevant experiments and learning aides are being developed; they will be disseminated electronically through standard Internet services and through the development of a multimedia textbook

3. CURRENT EXPERIMENTATION

The three collaborating universities are quite different institutions: George Mason University is a moderate-sized public university, Rice University is a small private institution, and The University of Colorado at Boulder is a large public university. Each university has strong educational and research departments, especially in Electrical Engineering.

3.1. Fall 1994 Semester

Our initial experimentation into distance teaming unites students in the existing undergraduate digital signal processing courses at George Mason University (GMU) and the University of Colorado at Boulder (CU). Three types of student teams were formed for the project assignments:

- teams consisting of three undergraduate students from CU and two undergraduate students from GMU,
- teams consisting of four undergraduate students from CU and one working engineer from the Denver metropolitan area, and
- teams consisting of five undergraduate students at CU.

Project assignments were given with a time-frame of three weeks for performing the assignment. The projects were developed by Professor Delores Etter at CU and Professor Geoffrey Orsak at GMU, and involved collecting real signals in addition to working with simulated signals.

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Project 1. Collect a digital signal from an engineering application. Describe the collection process and discuss sampling and any prefiltering or preprocessing of the data. Analyze the time and frequency content of the data, and include corresponding plots. (For example, one signal was obtained from a pulse oximetry machine, which measures the oxygenation level of arterial blood using a noninvasive technique. This signal was collected by a team with a member that worked as an engineer at Ohmeda, a biomedical engineering company.)

Project 2. In an effort to simulate the effects of collecting and analyzing real data, a relatively clean signal from Project 1 (the pulse oximetry signal) was corrupted by adding an unknown interfering tone along with background noise. All the student teams were then given the same data file to analyze. The objective was to design digital filters to remove as much of the contaminating signals as possible. Constraints in the filter size were given to represent real-time constraints.

Project 3. For this assignment, the team divided into two subteams. One subteam generated a signal, and then decimated it by a factor of 4. The decimated signal was then sent via email to the other subteam which then performed an interpolation by a factor of 4. The subteams then together evaluated the performance of the interpolation both in the time domain and in the frequency domain.

3.2 Spring 1995

In the spring, we plan to continue the experimentation with an Independent Study (technical elective) course with a small group of students who completed the digital signal processing courses in the Fall. Using professor teams and student teams, three topics in digital signal processing will be presented:

Adaptive Signal Processing
- Professor Etter

Speech Processing
- Professor Orsak

Array Processing
- Professor Johnson

Each student team will contain members from each of the three locations. Nine hours of lecture (equivalent to three weeks of lectures) on each of the topics will be videotaped by the corresponding professor and made available to each of the three sites. Students will then be given two additional weeks to complete a project assigned during the lecture portion. Additional course materials and related digital signals will be made available using Mosaic and the Internet. We also plan to use signals currently stored in the Signal Processing Information Base (SPIB) that is stored at Rice University [6].

3.3 Fall 1995

We hope to have connected multimedia laboratories available in the Fall to support distance teaming of students in the introductory undergraduate digital signal processing courses at each of the three Universities. With the capability to collect and transmit real-time audio and video signals, the projects can be expanded to include new components and can be an integral part of the course.

3.4 Spring 1996

We plan to revise the materials for the three topics taught in the Spring 1995 semester so that the new connected multimedia laboratory is fully integrated. In addition, we will develop a large-scale team project that requires interaction and coordination using the Internet. We expect to test a prototype virtual document system at this time, thereby bringing the best networked multimedia environment to bear on collaborative engineering design.

3.5 Fall 1996

This semester we plan to extend our distance teaming by adding additional universities to the program. Since our interests focus on uniting diverse schools using network technology, we will be actively seeking schools from different parts of the country and with diverse student bodies to extend and verify the approach.

4. CONNECTED LABORATORIES

The network-based interactions required to support the learning and teaching environment we have discussed require networked multimedia laboratories. We envision that the "connected laboratories," will be comprised of multimedia work-stations that support audio, video, and data information transmission as well as digital signal processing computational tools (Matlab and Simulink, for example). Most importantly, these distributed laboratories will allow students and faculty from each university to interact across great distances in a seamless fashion. The laboratory also serves as a natural testbed for the teaching of timely applications in signal processing. Audio and video are transmitted across computer networks by filtering, sampling, and compressing before transmission, then reversing the process upon reception. Our experience indicates that the students instantly grasp the subject's importance because they can sense what signal processing can and cannot do.

Not only will it be necessary for successful interaction to exchange the students' voices and pictures, they will also need to argue over and mark up documents shared across the network. Toward this end, we conceive of developing the idea of "virtual documents:" trans-network documents over which students at each university can all brainstorm and develop ideas. By nurturing in the university environment software that can support this type of multimedia information exchange, the universities can begin to lead rather than follow global engineering design environments.

To complement pedagogy, Modulus Technologies, Inc., a company specializing in distributed software systems, is not only donating their shared system software that supports multimedia conferencing but will develop the interactive graphics system---the virtual document---with the aid of this consortium of three Universities. This advanced technology is not generally available and, in many ways, allows the project to leap ahead of current interactive software, which tends to only support preconfigured, point-to-point communications. The interactive systems Modulus Technologies supports is capable of supporting fully dynamic audio and video conferencing (participants can enter and leave the conversation at will), thereby allowing multi-way brainstorming and organizational sessions crucial to successful teaming.

4. EVALUATION

We plan collect data from student evaluations during each semester, using a course evaluation written specifically for the types of activities contained in the modified and new courses---these remarks will not be available to the instructors until after the course has been completed in order to encourage the students to be comfortable in making constructive comments. Some of the results from the Fall 1994 semester indicate that the students have learned a number of new things about the internet and email. We also found that they wanted more formal lectures on the internet and how to use it, and more discussions on team dynamics. They also felt that the projects gave them more real-life experiences and that they were able to learn a lot from their teammates. Nearly all the students involved thought that the distance teaming had been valuable and had ideas for improving it.

For future semesters, we plan to devote one period near mid-semester to discussions on the activities of the course, with the main objective being to obtain student input. As an example, if there are communication problems between groups or individuals, we can as a large group discuss and make suggestions based upon the experiences of all the teams. These informal discussions will be summarized by the individual faculty and will be distributed and discussed among the faculty using the videoconferencing capabilities of the laboratories.

To obtain more objective evaluations from university and industrial perspectives, two widely recognized experts in digital signal processing - Dr. John Treichler, Applied Signal Technology, Inc., and Professor Richard Johnson, Cornell University - have agreed to evaluate this program at the end of the 1995-96 and 1996-97 academic years.

5. CONCLUSIONS

Experimentation in distance teaming with connected laboratories has already begun. George Mason University and the University of Colorado have begun an experimental intertwining of their undergraduate signal processing courses. This experience convinces us of the project's viability and has served to focus on what hardware and software would be needed. Because of the seamless interconnectivity of multimedia laboratories, we anticipate that student teams will identify one of the members of the faculty team as a project supervisor based on their shared technical area of interest rather than their geographical location. This in our view is one of the great advantages of this new distance learning paradigm: clearly departments cannot support faculty with expertise covering all areas of electrical engineering (even within the field of signal processing); however, through this collaboration, our departments may effectively pool their expertise to offer our students greater access and opportunities in the various areas of signal processing within representing the diversity of engineering.

6. REFERENCES

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