EVALUATION OF A VIRTUAL TEACHING LABORATORY FOR SIGNAL PROCESSING EDUCATION

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ABSTRACT

This paper presents our experience in teaching a digital signal processing (DSP) course in an Australian postgraduate program entirely using virtual tele-lectures. A virtual teaching laboratory was designed for this purpose, allowing students to receive fully interactive, real time lectures delivered from a remote international location. We present the methodology and technology used to develop a complete set of tele-lectures and online tools for a course entitled 'Signal Processing and Applications'. An evaluation of student opinions towards the virtual teaching laboratory revealed that 90% of students rapidly became comfortable with the use of this new educational facility, among other results. The overall experience with the VTL was that signal processing can be effectively and naturally taught in this mode and that there are great potential benefits in connecting the signal processing research and educational community.

1. INTRODUCTION

In recent years, the traditional local 'lecture only' classroom environment has been enhanced by such educational aids as the smart classroom [1] and online tools such as JAVA applets [2], [4], [6], [9]. These enhancements have been shown to promote faster learning of key signal processing concepts in an environment where students' expectations of mixed-mode delivery methods are increasing. Signal processing education relies strongly on keeping up to date with the technologies constantly being generated by new research in the field [3].

Video conferencing is an example of a mixed-mode tool that has been available for distance learning for quite some time. The advantages of classical video conferencing [6], desktop video conferencing [7], and more recently ATM-networked multimedia desktop video collaboration [5] and MSP Data Control tele-lectures [8] are gradually becoming more widely recognized. These methods all suffer from a lack of appropriate visual and contextual realism since they do not adequately allow for natural and spontaneous interaction between the lecturer and the students.

This paper describes a real time interactive virtual teaching laboratory (VTL) established at the School of Electrical Engineering and Telecommunications, University of New South Wales. It consists of state of the art video conferencing facilities including a voice tracking camera, a wireless LAN, wireless microphones and control consoles, and visual collaboration tools such as plasma displays, a large touch-screen electronic whiteboard and a document camera to provide an optimal distance learning environment.

2. VIRTUAL TEACHING LABORATORY DESIGN

2.1. VTL for multiple sites

This laboratory was originally designed and fully tested to cater for three sites to be connected simultaneously, using ISDN-based video conferencing and internet-based electronic whiteboard technology at multiple locations. The objective was to enable students to follow a lecture delivered at the remote location in an interactive manner and in real-time, with appropriate visual and contextual realism. The technology also permits full three-way audio and video communications between the remote lecturer and the students.

A key aspect of the design is the use of a 72-inch, Internet-based Rear Projection SMART Board electronic whiteboard with touch-sensitive surface, which has the capacity to project PowerPoint slides and display markings by electronic pen. PC-based applications can be annotated using the electronic pen, so that the lecturer can work naturally at the board without casting a shadow over its content.

In designing the VTL, the use of the PolyCom ViewStation (H.323) camera with multiple-site high quality enhanced video connectivity capabilities allows up to four sites to be connected via a 128 kbps ISDN link, or fewer sites at higher bit rates. A further feature of the VTL design is the use of a second, voice-tracking camera pointed towards the lecturer at multiple sites. This allows several teaching scenarios, for example:

- A local lecturer delivers a class to remote students with or without local students present.
- A remote lecturer delivers a class to local students with or without remote students present.

The two cameras can be switched depending on the teaching scenario. Fifty-inch, 1280x768-pixel plasma display screens were used in the VTL to provide high-resolution pictures. Additional tools of the VTL include a document camera, wireless microphone system and a wireless LAN for student laptops.

2.2. VTL for two sites

In this paper, we report the operation of the VTL in a two-site mode, as shown in Fig. 1. Only a remote lecturer and local students were present during the delivery of the course. Extensive use of the Internet-based electronic whiteboard was made for projecting lectures, viewing diagrams or text transmitted from the remote location, and full two-way interaction using an electronic pen for completing examples, drawing diagrams and writing questions intended for the remote lecturer. As seen in Fig. 1, it is only necessary to enable the student ViewStation camera at the local end and the lecturer camera at the remote end for this mode of operation.

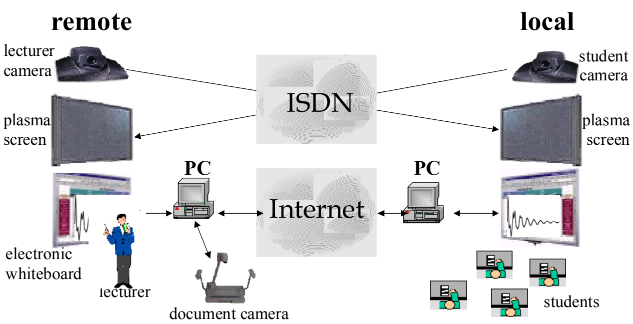

Fig. 1. Virtual teaching laboratory design in two-site configuration.

3. DEVELOPMENT OF TELE-LECTURES

3.1. Lecture format

For this project, the course 'Digital Signal Processing and Applications' was offered from Athlone Institute of Technology, Ireland to 30 postgraduate students of the University of New South Wales, Australia, in tele-lecture mode. The course was delivered in 3-hour lectures weekly over twelve weeks during session 1, 2002. The course content covered digital filter design, frequency domain analysis, multi-rate signal processing, adaptive filtering, time-frequency analysis and speech processing applications.

Each lecture consisted of approximately 60 PowerPoint slides, including text, diagrams, equations and relevant examples, and projected using the electronic whiteboard, in addition to being made available on the Internet in advance of each lecture. The lectures were interspersed with interactive examples live via the electronic whiteboard. Live MATLAB simulations were also carried out at the remote end to demonstrate practical principles covered in the lectures.

The PowerPoint lectures designed for this mode of delivery were different from slides that might be prepared for a traditional mode of delivery in the sense that maintaining student concentration is paramount. Thus, the slide format was varied regularly throughout each lecture, and particular care was taken to intersperse thought-provoking examples regularly throughout the conceptual material. This gave the opportunity for frequent use of the electronic whiteboard by the students, thus helping them maintain their concentration on the lecture material.

The electronic whiteboard is a key element in the success of the VTL, since it allows the annotation of the slides to be synchronized with the lecturer's speech, thus linking the audio and visual content in a natural manner.

Additional online resources offered included MATLAB examples, audio files, and Java examples (see section 3.2). One academic staff member was made available to provide additional support at the local location when required during the lectures, and to deliver six hours of additional tutorials, bringing the course duration to a total of 42 hours of lectures and tutorials. Assessment of the course comprised a mid-term quiz, a final examination, paper-based assignments, and a MATLAB-based mini project.

3.2. Java-based examples

In addition to the formal lectures, interactive digital signal processing examples developed using Java [4] were made available as a resource for the students explore at their own pace. Approximately 20 applets were developed in order to make the signal processing teaching material more interesting, to illustrate the mathematical concepts, and to allow students to assess their understanding for themselves. These examples were optional for the students, and were designed to augment the parts of the core lecture material by providing alternative routes for understanding of the lecture concepts.

Despite the attractiveness of Java-based education, applets are very labor intensive to develop, and require programmers with both signal processing and sophisticated Java skills. Further, not every core concept can be easily illustrated using Java.

4. EVALUATION

A major objective of this project was to evaluate the experiences of the staff and students with the virtual teaching laboratory-based tele-lectures. At the completion of the course, a survey was conducted among the students to gauge their responses to this new mode of delivery. The survey comprised 21 questions, covering the technology, including the electronic whiteboard, the pedagogy, the learning process, interaction with the lecturer, ability to concentrate on the lecture material, the signal quality and the time delay between audio, video and electronic whiteboard signals. Out of the 30 members of the class, 28 responded to this survey.

5. RESULTS

5.1. Student experiences

The students were asked about the naturalness of delivery. As seen in Fig. 2, 61% of the students were in favor of this mode of delivery.

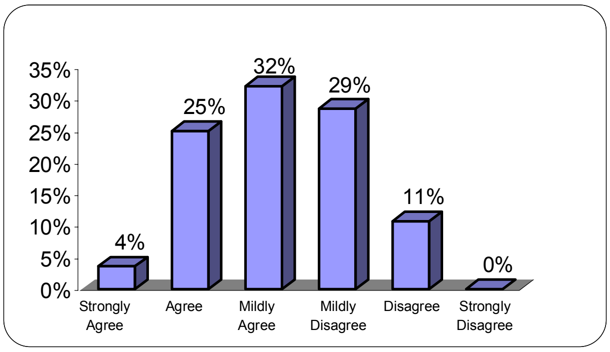

Fig. 2. Student responses to the statement "Interaction with the lecturer was straightforward in this mode of delivery".

As regards to their opinion on how essential it was to have a lecturer physically present in class rather than at a remote location, 68% of students thought that delivery from a remote location was acceptable.

Other highlights of student responses include (percent agree):

- The audio signal quality was satisfactory (100%)
- The delay between the arrival of the audio signal and the appearance of writing on the electronic whiteboard was acceptable (96%)
- Video presence is necessary, but poorer video quality can be tolerated (52%)
- It is not more difficult to concentrate in a lecture given from a remote location than one received when the lecturer is present in the classroom (59%)
- The use of colorful PowerPoint slides and colored electronic pens is important in helping to maintain concentration (96%)
- It is easy to follow PowerPoint slide progression on the electronic whiteboard (89%)
- Receiving lectures from a remote location does not take significant time to get used to (85%)
- It is useful to have local academic support in the classroom (96%)
- Overall this method of receiving lectures is just as good as the normal method, where the lecturer is present in the classroom (68%)

Almost all of the students (90%) felt that the virtual classroom-based modules did not take a significant time to get used to, and that this mode of teaching should be made available in the future, as illustrated in Fig. 3.

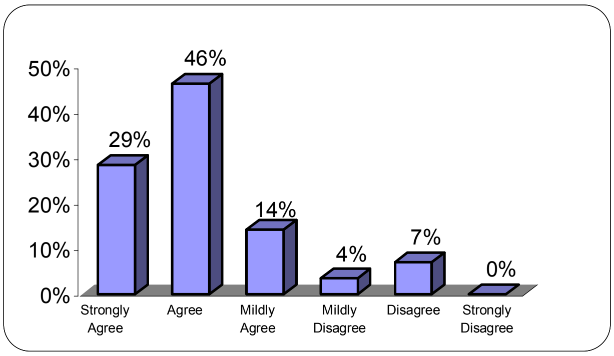

Fig. 3. Student responses to the statement "This Virtual Classroom Module should continue to be offered to future students".

Additional comments from the students indicated that digital signal processing lent itself to this mode of delivery due to the ease of presenting effective practical examples and the opportunities for receiving lectures from experts from in the field from around the world.

5.2. Staff experiences

Although this mode of delivery will never replace face-to-face teaching, interaction with students through the VTL was more natural than expected. Students who followed the course through the VTL were examined using a traditional 3-hour written paper format at the completion of the course. With a failure rate of 10%, the examination results were no different from those obtained from conventional modes of course delivery.

In this type of virtual learning environment it is imperative that local support is maintained during classes. Informal, face-to-face interaction with local academic staff is especially important during tutorial exercises provided through the electronic whiteboard. Throughout the 14 weeks, we could sense how rapidly the students adjusted to this mode of delivery.

In our experience, implementing a virtual laboratory environment can be achieved without sophisticated networking equipment. We found that for this mode of delivery, the less expensive 128 kbps rate was quite sufficient for natural video, as the lecturer's movement is mainly around the electronic whiteboard. The cost associated with maintaining an ISDN link throughout the 36 hours of lectures is a significant factor in the viability of running tele-lectures. IP-based videoconferencing would reduce the costs as long as the video and particularly sound quality is not compromised.

CONCLUSION

We have developed a virtual teaching laboratory for the delivery of digital signal processing tele-lectures from a remote location. Our experience, combined with student evaluation, demonstrates that this mode of lecture delivery is acceptable as an alternative to more traditional educational techniques. The advantage offered by the VTL is opportunity to integrate face-to-face teaching with interactive tele-lectures delivered by experts in the field, regardless of their physical location. Hence, this educational paradigm provides encouragement for faculties around the world to join a growing network for sharing expertise and providing collaborative learning solutions. Future applications of the VTL include sharing knowledge and developing collaborative projects to the point where PhD students can be co-supervised by academics at other universities around the world.

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