EXPERIENCES WITH AN ELECTRONIC WHITEBOARD TEACHING LABORATORY AND TABLET PC-BASED LECTURE PRESENTATIONS

Eliathamby Ambikairajah[1], Julien Epps[2], Ming Sheng[1], Branko Celler[1] and Peter Chen[1]

[1]School of Electrical Engineering and Telecommunications
The University of New South Wales, Sydney, NSW 2052, Australia
[2]National ICT Australia (NICTA)
Australian Technology Park, Eveleigh 1430, Australia.

ambi@ee.unsw.edu.au, julien.epps@nicta.com.au, m.sheng@unsw.edu.au, b.celler@unsw.edu.au, p.chen@unsw.edu.au

ABSTRACT

This paper presents our experience in constructing an electronic whiteboard-based computer laboratory for teaching Digital Signal Processing (DSP) courses in Australian undergraduate and postgraduate programs. Student interaction with the electronic whiteboard-based tutorial class environment is also reported. Away from the laboratory, DSP lectures were presented using a Tablet PC as a digital whiteboard. This supported high quality handwriting annotation of lecture slides, and overcame the limited flexibility present in the existing PowerPoint mode of lecture delivery. For selected self-paced tutorial questions, solutions were provided in electronic format comprising the lecturer's handwritten explanation on a blank slide, input using the Tablet PC, combined with audio commentary. An evaluation of student opinions towards this multi-mode delivery of DSP education was illuminating, and the overall experience with these technological aids was that signal processing could be effectively and naturally taught with high student attention span.

1. INTRODUCTION

The traditional 'lecture only' classroom environment has been enhanced recently by the use of educational software tools and online tools that open up new and different interaction possibilities among the participants in educational sessions [1], [2]. These enhancements have been shown to promote faster learning an environment where student expectations of mixed-mode teaching delivery methods are increasing.

Presentation tools are also increasing in popularity. An interactive electronic whiteboard is an excellent tool for distance learning, where participants can be physically at more than one site concurrently. It has been demonstrated that the use of the electronic whiteboard in a virtual classroom environment, via tele-lectures from a remote location, can provide an appropriate visual and contextual realism, as it adequately allows for natural and spontaneous interaction between the lecturer and the students [3].

Teaching with Tablet PCs has recently attracted attention as a potential tool for educational use and a "Classroom Presenter" system has been developed [4] for delivering computer science courses. Surveys of this system [4] indicate that students pay more attention and gain a better understanding of the course material. Their system was further extended for collaboration and active learning within the classroom, where students could submit digital ink-based material to the lecturer, within a Tablet PC-based classroom, to display on the projector [5]. Signal processing education relies strongly on keeping up to date with technologies constantly being generated by new research in the field [6].

This paper describes the methodology and technology used in developing an interactive whiteboard DSP teaching laboratory that was established at the School of Electrical Engineering and Telecommunications, University of New South Wales, to aid teaching. Significant features of this laboratory are the mixed modes of delivery, which include the broadcast of a lecturer's desktop onto student monitors to demonstrate a lesson or simulation, for example a MATLAB-based signal processing laboratory. The lecturer can select a student's monitor or their own console and project it onto the whiteboard for annotation and explanation. Students can use the electronic whiteboard to interact with the lecturer and their peers during tutorial discussion sessions in the laboratory. These interactions are saved as pdf files at the conclusion of the session and distributed to all students by email for their future reference.

Another key feature of the laboratory is that solutions to tutorial problems are provided via electronic capture of the lecturer's handwritten explanation on blank slides

together with audio commentary, prepared outside the classroom using the Tablet PC, and these can be accessed by all students in and outside the laboratory.

2. ELECTRONIC WHITEBOARD BASED TEACHING LABORATORY DESIGN

2.1. Virtual Teaching Laboratory (VTL) Design

In 2003, we reported the design and operation of a VTL [3] at our school for multiple site/two-site mode configurations, allowing students to receive fully interactive, real time lectures delivered from a remote international location. We presented 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 [3]. 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.

2.2. Signal Processing Teaching Laboratory (SPTL) Design

Using the above experience gained in designing a VTL, we then designed a teaching laboratory for signal processing education. The design incorporates a wall-mounted SMART Board, which serves as an interactive electronic whiteboard and is networked with 30 student workstations.

A significant feature of this laboratory is the use of SMART Technology based "SynchronEyes" software that broadcasts a lecturer's desktop onto student monitors to demonstrate a lesson or simulation, in addition to displaying the lecturer's desktop on the electronic whiteboard. This permits the lecturer to write directly onto the whiteboard using an electronic pen, such that all students can see the annotations on their monitors. This is a useful feature to have when the lecturer is demonstrating and explaining MATLAB simulation results, particularly in large lab classes. Alternatively, the lecturer can select a student's monitor and project it onto the whiteboard for annotation and explanation.

A sample screenshot taken from the Signal Processing course is shown in Figure 1. Here the lecturer uses "attention marks" (in this case a red circle) to draw the student's attention to a specific item.

We have used this laboratory very intensively for teaching the laboratory component of signal processing courses in both undergraduate and postgraduate programs. Interaction between the students and the lecturer/tutors has been extremely positive when compared with our experience of previous signal processing courses, which have been taught in similar laboratories without an interactive electronic whiteboard.

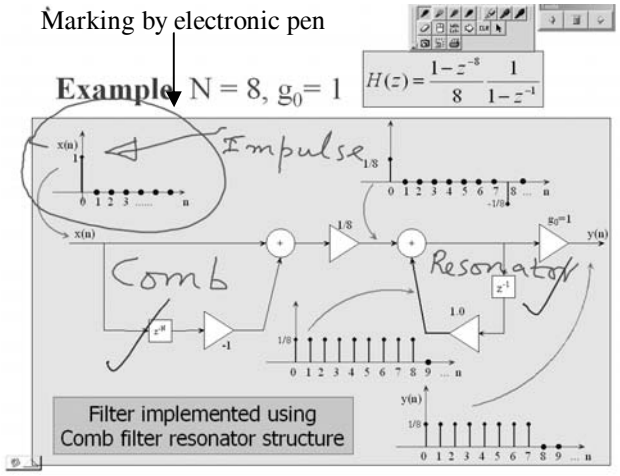

Figure 1. Screen capture of an example PowerPoint slide on the electronic whiteboard.

2.3. Interactive Tutorial Sessions in the SPTL

It was not our original intention to use the SPTL for tutorial discussions. When it was first attempted, we discovered that the students started to use the electronic whiteboard more often to interact with the lecturer and their peers during such sessions in the SPTL laboratory. The discussion annotations on the electronic whiteboard were automatically captured and saved (see right column on Figure 2), with new blank sheets for being opened for the various discussions.

It was also possible to switch between the saved annotated sheets by simply touching the relevant icon. At the conclusion of the tutorial sessions, these interactions were saved as pdf files and were emailed to all students for future reference. During the sessions, interaction via the electronic whiteboard became very productive and student attention and participation rose quickly as they appropriated it for technical discussion purposes. The increase in attention was attributed to the fact that students did not need to maintain their own set of notes at the same time as participating in the tutorial discussions.

Figure 2 shows a snapshot of a live tutorial discussion session in which several students have contributed to each of the seven sheets (see right column).

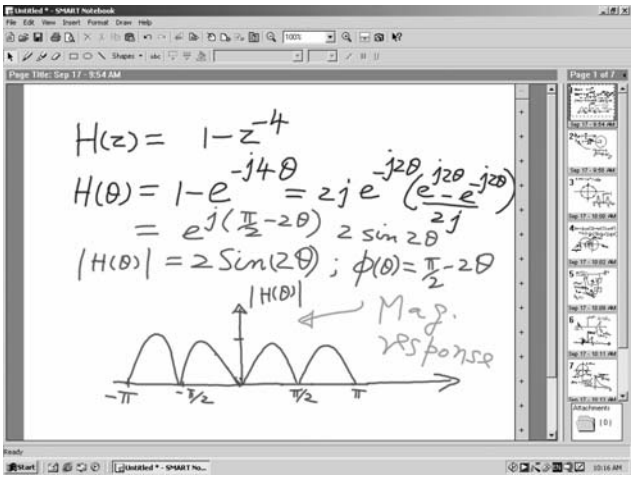

Figure 2. A snapshot of an example tutorial discussion session using the SPTL electronic whiteboard.

2.3. The Tablet PC as a Digital Whiteboard

Tablet PCs have recently attracted attention as a useful tool for educational sessions [4], [5]. We first employed a tablet PC in a first year class of 250 students in April 2003 as a presentation device, replacing a laptop and whiteboard in the lecture theatre. We are now regularly using Tablet PCs for teaching signal processing courses, in particular postgraduate classes. In our experience, the Tablet PC provides another form of interactive electronic whiteboard teaching in a classroom environment. We found that there are many advantages to the use of a Tablet PC in place of a laptop:

- The lecture can be prepared as normal using PowerPoint slides and annotated during the lecture, or alternatively the lecture can be conducted entirely using an electronic pen without preparing material in advance;
- The lecturer tends to maintain more constant eye contact with the class. There is no need for the lecturer to turn to the board, as occurs when using a laser pointer in conjunction with a laptop;
- There is easy access to multiple pens with various widths and colors, and the lecturer can easily revisit previously discussed material during the class;
- It is easy to switch to applications, such as the simulation of a digital filter using MATLAB, and display the results and then use the digital pen to draw attention to a specific item, for example by encircling it;
- Important discussions can be posted to class web sites and/or emailed to students after classes.
- Labor-intensive PowerPoint animations in lecture notes can be avoided, as the Tablet PC allows annotation with natural handwriting.

Student feedback regarding the use of Tablet PC-based lectures has been extremely positive. This is due to the fact that the Tablet PC supports high quality handwriting annotation in combination with more natural lecturer-student interaction, thus allowing students to pay more attention to the lectures.

2.3. Tutorial Solutions using a Tablet PC with Audio Commentary

We have also used "HyperCam" software to capture text annotations on the Tablet PC screen and audio (lecturer's voice), saving them as a standard and easily edited AVI file. "HyperCam" allows us to define the precise area of the screen that we want to capture, unlike camcorders that record the entire screen. The AVI files can be useful as teaching tools, for students to download and review any illustrative material at their convenience in and out of the class environment. Since no video is recorded, the AVI files are reasonably small in size. However, further compression can be obtained by inserting the AVI file into a read-only PowerPoint slide.

We have utilized this capability to provide self-paced solutions for selected tutorials, where AVI files comprising the lecturer's interactive handwritten explanation on blank slides along with audio commentary were made available to students. The files were prepared outside the classroom using the Tablet PC, however at a fraction of the preparation time required to produce the same material via more traditional electronic media. We have developed approximately 200 multiple choice questions, including many thought provoking questions, for our undergraduate course entitled "Digital Signal Processing" covering the major topics in digital signal processing, and for a selected subset of these we have rapidly generated AVI files as explained above. A sample snapshot of a recorded AVI file (audio + screen capture) is shown in Figure 3.

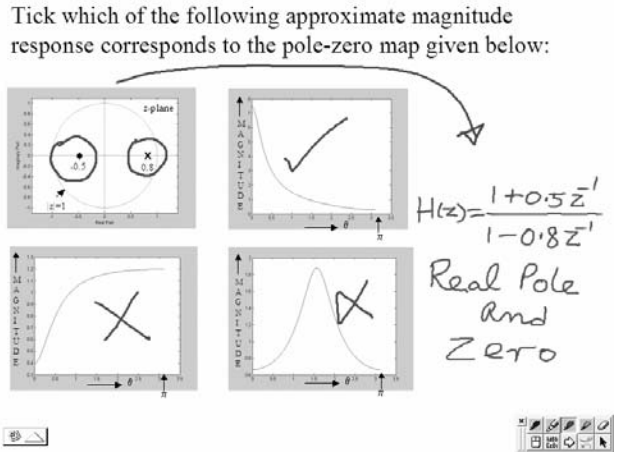

Figure 3. Snapshot of the final frame of an AVI file

In the recording of Fig. 3, the lecturer highlights that the pole and zero are real, and rules out incorrect options in a specific order. The AVI files were well received by the students and their comments regarding this approach showed that they liked this explanation, and that the AVI files helped their understanding.

3. EVALUATION

The postgraduate course 'Speech and Audio Processing' was offered to 40 postgraduate students using the mixed-mode delivery. The course was delivered in 3-hour lecture/laboratory/tutorials weekly over 14 weeks during session 1, 2004. A major objective of this project was to evaluate the experiences of the staff and students. At the completion of the course, a survey was conducted among the students to gauge their responses. The survey comprised questions covering the technology, including the electronic whiteboard, the pedagogy, the learning process, interaction with the lecturer, and the ability to concentrate on the lecture material.

The students were asked about the naturalness of the mixed-mode delivery of this postgraduate course and they were in full agreement of this mode of delivery. Highlights of student responses include (percent agree):

- The use of colorful PowerPoint slides and colored electronic pens is important in helping to maintain concentration (98%)
- During the tutorial sessions, student interaction via the electronic whiteboard became very productive and student attention was very high (96%)
- Annotations of discussions captured on the electronic whiteboard in the tutorial class were extremely useful for future reference (100%)
- Providing AVI files using a Tablet PC for tutorial solutions enhanced student learning (100%)

A WebCT-based student survey was conducted on 45 students at the conclusion of a separate undergraduate signal processing course, to compare their responses to traditional style and Tablet PC-based AVI Quiz solutions. 80% of students responded that they actually used the AVI files during their self-directed study.

Lecturers who used the Tablet PC for this project were extremely positive about the production of the AVI files for student tutorial solutions. In addition, they preferred a Tablet PC to a laptop in a class environment, due to the facility for annotation with natural handwriting.

As a final note, a Tablet PC was used in a similar manner for the presentation of a signal processing paper at a recent international conference, and was very well received by the audience, who appreciated the presenter's improved ability to maintain eye contact with them while referring to the visual presentation material.

4. CONCLUSION

We have developed an electronic whiteboard-based Digital Signal Processing Teaching Laboratory and have demonstrated that the "SynchronEyes" software facilitates improved interaction between the lecturer and students via their monitors and the whiteboard. The SPTL laboratory was also employed for interactive tutorial sessions, where a key advantage of the system was that the interaction between students and lecturers catered for an increased understanding of the material taught, compared with traditional methods of teaching. Following interactive tutorial sessions, annotated discussions captured on the electronic whiteboard were saved as pdf files and conveniently made available to all students for future reference. The capture of AVI files for handwriting and audio annotation of tutorial solutions has been found to enhance self-paced student learning. The Tablet PC as an electronic whiteboard in the lecture environment has also been observed to provide many advantages for lecturers when compared with the more traditional use of a laptop. The integrated teaching laboratory system we have demonstrated has opened up new avenues for teaching, and students readily agree that it enhances their learning.

5. ACKNOWLEDGMENTS

This project was funded by the Faculty of Engineering Innovation in Teaching Methods and Technology (ITMT'04) Grant Scheme and the Educational Technology Grant Scheme (EDTech'04) of the School of Electrical Engineering and Telecommunications, The University of New South Wales, Sydney, Australia.

6. REFERENCES

[1] Abdallah, C. *et. al*, "Interactive DSP course development Teaching Environment", in *Proc. IEEE ICASSP*, May 1997, pp. 2249-2252.

[2] Faggion, P., An, J., and Ambikairajah, E., "Online Java signal processing education", in *Proc. ICICS*, 2001.

[3] Ambikairajah, E., Epps, J., Celler, B G., Sheng, M. "Evaluation of a virtual teaching laboratory for signal processing education", in *Proc. IEEE ICASSP* (Hong Kong), vol. III, pp. 757-760, 2003.

[4] Anderson, R., *et al*., "Experiences with a Tablet PC Based Lecture Presentation System in Computer Science Courses" in *Proc SIGCSE* (Norfolk, Virginia), March 2004.

[5] Simon, B., *et al*. "Preliminary Experiences with a Tablet PC Based System to Support Active Learning in Computer Science Courses" in *Proc SIGCSE* (Norfolk, Virginia), March 2004.

[6] Deller, J., and Wang, Y., "Highlights of Signal Processing Education", *IEEE Sig. Proc. Magazine,* pp. 20–22, 1999.