Using Multimedia and Cooperative Learning for Online Teaching of Signal Processing Techniques in Communications

Amir Asif
Department of Computer Science
York University, 4700 Keele Street
North York, ON M3J 1P3, Canada
Phone No.: (416) 736-2100 Extension 70128
Fax No.: (416) 736-5872
Email: asif@cs.yorku.ca
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Abstract

The paper describes how multimedia technology and cooperative learning are used to teach an online course at the junior level covering signal processing techniques in communications. Students study online presentations enhanced by multimedia animations and perception quizzes, discuss problems using an asynchronous conferencing system, and meet weekly on campus for a cooperative laboratory session based on Matlab simulations. A locally developed course management system (CMS) is used to study the online portion of the course. Comparative study performed between two different sections of students indicates higher student achievement and a more positive attitude towards learning enhanced with online and cooperative pedagogies.
1 Introduction

Advances in the educational technology made possible by the World Wide Web and multimedia support on the personal computers provide an opportunity to enhance learning in university education. Several universities including [1]-[6] have used the Web at different levels of education for both onsite and offsite students. A catalog of online educational programs is available at [7]. In this paper, we describe the experiences accumulated in teaching a junior level course covering signal processing techniques in communications. The course material was supplemented by online learning technologies including multimedia presentations, flash/java animations, perception quizzes, asynchronous question and answer (Q&A) board, and cooperative projects based on Matlab\(^1\). Making course material available online allows flexibility and round the clock access to the learners. Integrating online activities with face-to-face interaction enables application of the multimedia and other web-based features to improve pedagogy without eliminating social interaction. Introduction of structured, team-based activities has substantial positive impact on the overall performance of students. To emphasize that our philosophy of online and cooperative learning is indeed productive, we include an informal study that compares the scores of the current students with a former batch that took the course in a more traditional lecturing mode. The study shows promising results.

The manuscript is organized as follows. In section 2, we present some of the unique features of the course management system (CMS), an interface used to access the curriculum. Section 3 describes the course content and the course delivery model along with a list of simulation projects. Section 4 enlists a representative collection of learning objects. Words underlined in the manuscript are links to the learning objects in the Web document maintained at [8] or in the pdf file [9], if electronic access is available. Finally, in section 6 we conclude the paper.

2 Course Management System

A course management system (CMS) is the entry to the online features of the course and is crucial to the successful implementation of the course delivery models. In the delivery of signal processing techniques in communications, we used a web-based CMS developed locally by the Department with core functionality written in XML/RPC, Dynamic HTML, and JavaScript. The notable features of the CMS include an entry page designed to support community building by providing general announcements, a Java-based text chat serving as a virtual cafe or hallway, a facility to support electronic voting on community issues, and links to online conferences dealing with a variety of student concerns. The CMS connects to a personalized page (referred to as ispace shown in fig. 1)

\(^1\)Matlab is a trademark of Mathworks.
that provides access to the online presentations of the registered courses, a scheduling calendar with the time-table of courses, and one's personal file space on the university server. Email and announcement servers can also be accessed from the ispace. Clicking on one of the registered courses takes the student to a syllabus page (fig. 2) of that course containing weekly multimedia presentations, learning objectives, online conferences, cooperative projects, and descriptions of assignments and sample exams along with selected solutions. The syllabus page also includes a link to one’s team page listing all class members of the student’s team. The team page provides access to team conferences used to discuss questions related to projects within a team.

3 Course Overview

The objective of the course is to develop a mathematical and physical understanding of digital communication systems from the information source through the transmitter, channel, receiver, and the information sink. Emphasis is to cover signal processing techniques used in source and channel coding, modulation and demodulation, detection of signal in the presence of noise, and spread spectrum techniques. A course specification document, was developed that describes the content of the course in terms of the objectives, projects, and learning objects on a weekly basis. The course outline given below summarizes the specification document.

2. Source Coding I: Lossless Codes (Huffman, Arithmetic, and Dictionary Codes).
3. Source Coding II: Lossy Codes (Vector Quantization, Predictive and Transform Coding).
4. Shannon Bounds, Quantization, and Baseband Transmission: (PAM, PCM, PWM, PPM, DPCM).
7. Error Performance Analysis of M-ary schemes discussed in (6).
8. Channel Coding I: Linear Block and Cyclic Codes.
9. Channel Coding II: Convolutional Codes.
11. Application of Convolutional Codes to Compact Disc (CD).
13. Spread Spectrum (SS) Modulation: Direct Sequence and Frequency Hopping SS.

The pre-requisite for the course is an understanding in signals and systems, probability, and random Variables. The text selected for the course is the Sklar text on Digital Communications [10].

**Delivery Model:** A course delivery model is a combination of logistical, technological, and pedagogical features. To enable scalability, the Department developed a set of course delivery models consisting of appropriate combinations of learning methods and technologies. An expanded list of delivery models is included in [11]. Signal Processing techniques in Communications uses the Presentational Cooperative (PC) model, which requires study of web presentations and the related sections from the text every week prior to coming to the optional face-to-face session that lasts for another 1.5 hours each week. This model replaces the lecture with web presentations designed to explain the material in text through multimedia and interactive elements, such as pdf files, animations, streaming video, and other URL links. The cooperative activities are designed in such a way...
that these can be completed off-campus with minimal hardware and software requirements. At this
time, most of the students work in the university laboratory in teams of 3 to 6. An asynchronous
online conference is provided for students to interact with each other.

**Perception Quiz:** To ensure that the learners are studying the material on time, we ask them to
write a weekly online quiz based on Questionmark’s perception. The quiz facility records the per-
formance of each learner, which can be used to judge where the sticky spots exist for the learners.
These can be addressed separately in either the face-to-face session for on-campus students or the
Q&A board for off-campus students. An example of perception quiz is available at [8].

**Cooperative Learning:** The cooperative activity, [3], determines the style of the course and
ensures that the students understand the underlying concepts through programming. Many useful
ideas for labs are appearing in new books, such as [3], dedicated to Matlab simulations in Digital
Communications. A representative list of Matlab projects developed for the course includes
1. Review of Matlab: Introduced as a review with some elementary exercises.
2. Computer Generation of Random Variables: Generate random variables with any given distri-
bution from a random variable with uniform distribution on (0,1).
4. Quantization: Simulate both uniform and nonuniform quantizers using Lloyd’s algorithms.
5. Matched Filtering: Design optimum receivers for transmitting binary information through
a channel corrupted with additive White Gaussian Noise (AWGN). Both signal correlator and
matched filter implementations are considered and error performance analysis is performed.
6. Phase Shift Keying (PSK): Monte-Carlo simulations of an $M$-ary PSK communication system.
   Error performance analysis is performed by plotting the symbol error-rate versus SNR for AWGN.
7. Frequency Shift Keying (FSK): Same as (6) but for an $M$-ary FSK communication system.
   Performance is observed for different values of $M$ and compared with corresponding $M$-ary PSK.
8. PSK modulation with Convolutional Codes: [3]: Monte-Carlo simulations for a binary commu-
nication system that uses convolutional encoding with PSK. Quantify improvement over (6).
9. FSK modulation with Convolutional codes: Same as (8) but with FSK modulation. Performance
   is compared with (7) and (8).
10. Direct Sequence Spread Spectrum Communications (DSSS): [3]: Demonstrate the effectiveness
    of DSSS in suppressing jamming interference. Error performance analysis is performed.
11. Frequency Hopping Spread Spectrum (FHSS) Communications: Repeat (10) for FHSS and
    compare the two systems in terms of symbol error-rates.

In designing simulation exercises for the class, the goal has been to ensure that these are readily
transportable to different platforms including workstations, personal computers and MacIntosh’s.
The software needed is the student version of Matlab from MathWorks. On-campus students work
in supervised groups but for distant students, the simulations can be performed independently.

**Feedback:** To answer queries from the students or provide feedback to the learners, we have designed a moderated question and answer (Q&A) board. Each group has a separate Q&A board for internal discussions within the group and a class Q&A board for general discussions. The instructor monitors the Q&A boards and answers important concerns and questions. We also maintain a list of frequently asked questions (FAQs), which the learners can explore as desired.

**Assignments:** The assignments are accessed online. Similarly, students submit their individual solutions through the web. The solutions for the assignments are also provided online. Since students work on a variety of exercises, it is important to give them a single place to turn for a summary of their scores and current standings relative to that of others in the class. This facility allows students to review their performance in assignments, examinations, and quizzes.

4 Learning Objects

Interactive multimedia enables the web presentations to be dynamic and presents information in a nonlinear format that is more attuned to the way the students think. A series of multimedia animations, referred to as learning objects, were developed to explain the intrinsic details involved in complex algorithms. We found Macromedia Flash to be an excellent software that allowed stepwise analysis of each operation. The student can go back and forth at his own pace while studying a simulation. A sample of the Macromedia Flash animations include Convolution, Huffman code, Lempel Ziv encoder and decoder, Arithmetic encoder and decoder, and Viterbi algorithm. These can be accessed online by visiting [8]. There are several hosts of java-based learning objects including [14] available on the web. Some of these URLs were made accessible to the students.

**Latex to HTML Formula Translator:** A major hiccup in preparing technical presentations for the Web is the unavailability of an appropriate software that presents complex mathematical expressions in an intelligible manner. A Latex to HTML formula translator was developed within the Department. Mathematical expressions were first written in Latex and then translated to HTML using the translator. In certain cases, some effort was required after the translation in HTML to format the spacing and other minor details in the expressions.

5 Evaluation of the Online Experience

The online version of the course was offered in the Fall semester of 2001 and overall grades were compared with an earlier batch of students that took the course with the same instructor using the conventional lecturing approach. Informal feedback was also collected through a questionnaire.
Figure 3: Comparison of percentage marks of students taught with lecturing and online modes. The table on the left contains the statistical comparison while the figure on the right is the box-whisker plot.

Since the study was developed as an afterthought so it may have certain statistical flaws. In future, more scientifically unbiased studies will be reported. In the lecture mode, the instructor introduced a pre-selected list of topics (as announced in the course outline distributed at the start of the semester) from the text and explained the important concepts in a face-to-face environment. The lectures were followed by weekly assignments consisting of conceptual questions and few simulations. The final grades were based on the performance of the students in the assignments and on the score received in the mid-semester and final exams. The number of students registered was close to 40.

A recent class of 45 students used the collaborative project-based approach. The students had advance access to the course content in multimedia format as discussed in the manuscript. The final grades of the students were determined by their performance in the weekly quizzes, cooperative activities, and a final exam. In each case, the same text was used. The assignments and exams were obviously different but kept at a similar level of difficulty.

Qualitative feedback received from the students strongly favors the cooperative activities performed in the class. In their view, the multimedia content especially the learning objects and perception quizzes greatly enhanced the quality of delivery of the course. Placing material online provided round the clock accessibility and added flexibility to the schedule of the students. Fig. 3 illustrates the spread of the cumulative percentage score achieved by the students in the two sections using a box and whisker like plot. In each case, the line within the rectangle is the mean score. The rectangle shows the spread of the marks within one standard deviation (std) of the mean. For convenience of reference, we also include the mean, maximum, minimum, and standard deviation of the scores. In terms of the mean score, there is a 10% improvement in the performance of the class with the online approach. The maximum and minimum values have also improved considerably. A similar improvement in the marks was also observed separately in the assignments and the final exams. We attribute the improvement to collaborative learning supported by multimedia delivery.

6 Summary

The paper described how cooperative learning and multimedia technology were integrated to face-to-face delivery for a junior level course teaching signal processing techniques in communications. In
our study, the delivery of the courses was shown to be significantly improved by adding cooperative projects and online presentations. The pedagogical content as described in this manuscript was particularly liked by the students and is a step forward towards distant learning.

References


[6] Simon Fraser University (Surrey Campus), Information Technology and Interactive Arts. Available http://www.surrey.sfu.ca/


