

Creating Simple and Effective Prerecorded Web-Based Lectures

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Abstract

Recent advances in computer hardware and software can enable individual instructors to easily create and deliver prerecorded lectures via the World Wide Web. Through the use of new video and audio compression techniques, an entire semester of lectures can be stored on less than 2 gigabytes of disk space and delivered over the Internet on demand. A methodology for quickly generating effective lectures at relatively low video frame rates is described, and examples of the technique are provided on the Web.

I. Introduction

In recent years, the need to expand instruction beyond the traditional classroom has led to the rapid growth of supplemental teaching methods such as videotaped lectures, classes via satellite broadcast, and Internet delivery of lectures. In particular, the World Wide Web is receiving growing attention as a preferred medium for asynchronous delivery of course materials and prerecorded lectures to remote students. Universities throughout the country are developing courses (and entire curriculums) specifically for Web presentation.

However, the development of Web-based classes can be hampered by limitations of time and economics. Many instructors take a “presentation-style” approach to lecture notes, spending many hours of painstaking effort to create elaborate HTML documents incorporating graphics, slides, and text for each lecture. Others attempt to duplicate the style of videotape by recording the instructor in a standard classroom setting, but this technique requires the assistance of additional personnel and is expensive in terms of disk space and bandwidth. Ideally, an instructor should be able to individually record and present a Web-based lecture with the same speed and convenience of a standard classroom lecture, but without the delay of generating elaborate graphics or the requirement of excessive amounts of disk storage.

In this paper I will describe a methodology for recording an effective lecture in the privacy of one’s home or office, using inexpensive hardware and software on a personal computer. These Web-based lectures can be created without excessive preparation or effort beyond the requirements of typical classroom lectures. By limiting frame rates to 1 frame per second (fps) and employing new compression techniques, a fifty minute lecture with video and high-quality audio can be stored on 30 to 50 megabytes of disk space, or less than 2 gigabytes for an entire semester of lectures.

II. Effective Lecture Techniques

When creating a multimedia presentation for delivery on the World Wide Web, let's consider what elements make a typical classroom lecture an effective learning experience for students and a preferred teaching method for faculty. A classroom provides an easy-to-use drawing medium (e.g. a whiteboard or blackboard) that allows an instructor to quickly generate simple but effective graphics and text while simultaneously speaking to students. In situations where more detailed graphics are required, overhead projectors are used to supplement the written material on the whiteboard. Due to the dynamic (and sometimes nonlinear) method in which information is presented, students are effectively forced to take notes in order to organize the lecture into a meaningful set of facts that can be easily referenced and studied.

Most lecturers would probably agree that student notetaking significantly enhances the learning experience when compared to passively listening to a lecture, as previous research has confirmed¹⁻⁷. Yet many instructors create Web-based class notes and lectures that imitate the style of a formal presentation, i.e. various elaborate slides, graphics, and video clips coupled with voice narration. An obvious temptation for the student is to passively listen to the lecture and print out relevant material as it appears on the computer screen. In effect, these instructors spend an enormous amount of time creating lectures that may be considerably less effective than a standard classroom lecture.

One possible solution for both the instructor and student might be to record the professor's classroom lecture for Web broadcast. This method is already used for videotape and satellite delivery on many campuses, and generally requires little additional preparation by the instructor. However, recording a classroom lecture requires studio facilities and the services of a camera operator, and the disk space and bandwidth requirements of an hour-long lecture at 15 to 30 fps are on the order of gigabytes and hundreds of kilobauds, respectively. Lowering the frame rate or reducing the video resolution can reduce these requirements, but the resulting poorer quality may make the lecture very difficult or unpleasant to watch.

The ideal Web-based recorded lecture should use relatively little disk space and bandwidth, provide acceptable resolution, and require relatively little time and effort for the instructor to create. Instead of imitating the style of a formal presentation or a videotaped lecture, a better solution is to duplicate the effects of the classroom whiteboard and overhead projector. Although an instructor's lecture style can animate the classroom and help motivate interest in the subject, relatively little technical information is communicated through body language. Instead, students focus their attention on the whiteboard and overhead projector while listening to the instructor. Only when the instructor points to some item of interest do most students actively pay attention to body language.

Fortunately, recordings of whiteboards and overhead transparencies do not require the high frame rate of a typical videotaped presentation. The written information on a whiteboard changes relatively slowly, and the image on a transparency usually remains fixed for tens of seconds while the instructor speaks and points. As long as voice-quality audio and some sort of pointing mechanism are provided, a very effective lecture can be created with the computer equivalent of a whiteboard and overhead projector at low video frame rates. However, these

equivalent computer media should remain easy for the instructor to use and inexpensive to implement.

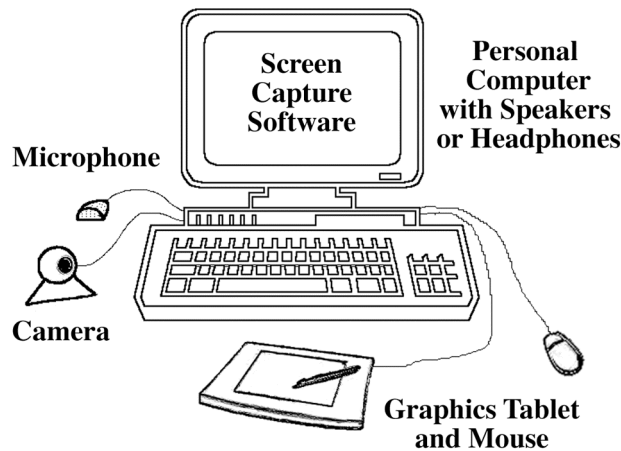


Figure 1. A multimedia computer configured for recording a lecture.

III. Recording A Lecture Directly on a Computer

The development of inexpensive hardware and software for multimedia presentations has now made it possible for an instructor to record a lecture using a personal computer without the need for a studio or camera operator. Figure 1 shows a block diagram of a basic setup for a multimedia recording. The heart of the setup is a continuous screen capture program with an adjustable recording “window”. Inside this window, the actions and output of any programs running on the computer are displayed and saved. A low cost camera, microphone, and graphics tablet (in conjunction with the keyboard and mouse) serve as input devices during the recording session. The graphics tablet with its pen-based input gives the recording the flexibility of a classroom lecture by allowing the instructor to create notes and graphics with relative ease. In addition to handwritten notes, the lecture can be supplemented with complex graphics, animations, slides, terminal windows, video clips, or any other suitable output that can be displayed on the computer screen.

Figure 2 demonstrates one possible screen layout for a lecture. The video window is set to 640 by 480 pixels in size (i.e. minimum VGA screen dimensions). The top portion of the window shows a title bar and a grayscale video image of the instructor’s face. (Despite the minimal information conveyed by the face alone, preliminary feedback indicated that viewers preferred seeing it on the screen. The students’ desire to see the professor’s face could not be ignored.) A software package suitable for painting, drawing, and image manipulation is used to generate the whiteboard “canvas”. The canvas is large enough to hold dozens of screens of drawings, with only a portion of the full canvas area visible on the screen at any given time. As the lecture progresses, the mouse and keyboard are used to scroll through the canvas while words, equations, and figures are written using the graphics pen. Screen windows from other programs can be opened in the background and positioned in the same capture area as the whiteboard. By bringing these windows to the foreground, various Microsoft PowerPoint⁸ slides (figure 3), terminal windows (figure 4), typed text, video clips, or animations can be integrated into the

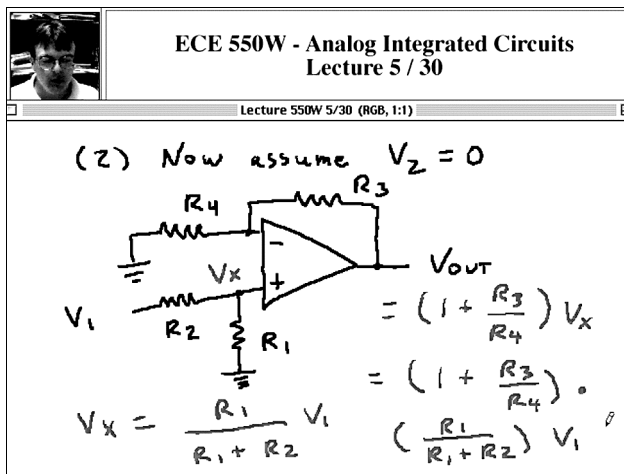


Figure 2. Sample screen shot showing the "virtual whiteboard" in a recorded lecture.

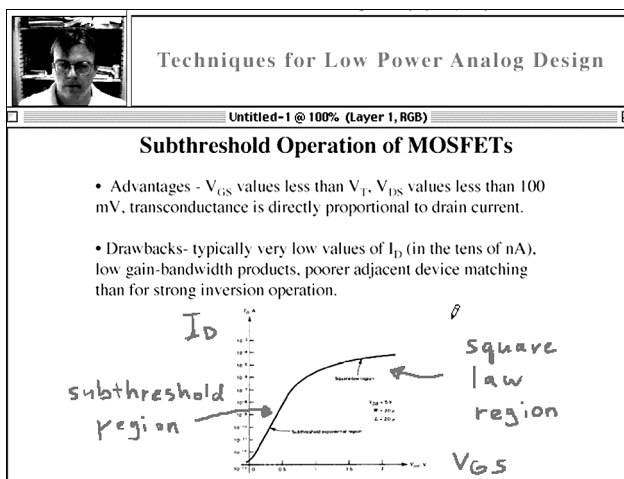


Figure 3. A lecture screen incorporating graphics and text from a PowerPoint slide.

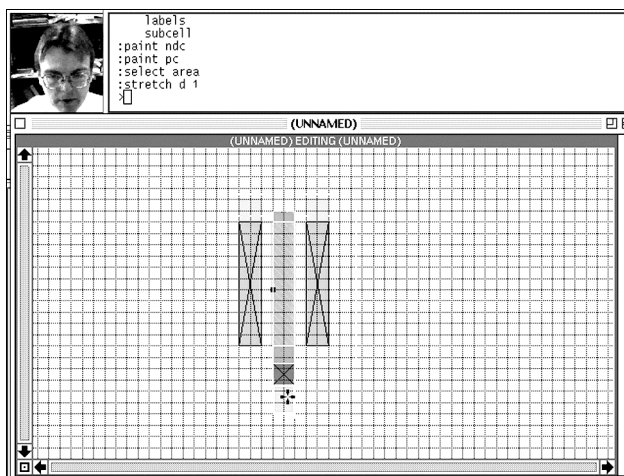


Figure 4. A demonstration of a UNIX-based CAD software package using an X-window terminal.

lecture with relative ease. Because of the dynamic lecture format that this technique encourages, students are more inclined to take notes as they watch and listen, just as in an actual classroom.

IV. Examples of Computer-Recorded Lectures

Samples of this lecture technique can be viewed on the World Wide Web at <http://www.ece.arizona.edu/~holman/lecture.html>. To create these lectures, I used the following hardware and software components:

- a Macintosh G3 desktop computer with external speakers and microphone ⁹,
- QuickTime Pro multimedia authoring / editing software ⁹,
- a 4" by 6" Wacom graphics tablet ¹⁰,
- a QuickCam video camera ¹¹,
- Cameraman screen capture software ¹², and
- Adobe Photoshop LE to generate the virtual whiteboard ¹³.

It should be emphasized that all of these software and hardware accessories, or their equivalents, are also available for the Windows 95/98/NT platform. The total cost for the necessary hardware and software accessories should range from \$400 to \$1000 per workstation.

Recording a lecture was a straightforward process once the computer was properly configured. A video frame rate of 1 fps was chosen as the best compromise between file size and learning effectiveness. Working from standard lecture notes, I quickly sketched out preliminary equations and drawings to save time and effort during the actual recording session. During the lecture, a different pen color was used to either write new information or annotate and underline existing material, with the pen-shaped cursor serving as a pointer. In case of errors or mistakes, I simply backed up to the proper point on the whiteboard, made corrections, and continued talking and writing as before. After finishing the recording, the Cameraman and QuickTime Pro software packages were used to edit the lecture and remove any sections with errors. Finally, the audio and video were compressed with QuickTime Pro, resulting in a file size of approximately 0.4 to 1.0 megabytes per minute, depending on the complexity of the graphics used in the lecture. Compression was by far the most time-consuming part of the process and generally required one to two minutes per minute of lecture. Fortunately, the compression process does not require attention once begun and can be performed overnight.

Thanks to new algorithms available in QuickTime Pro (e.g. the Sorenson video compressor or the QuickTime graphics compressor), a compressed fifty-minute lecture with a 640 by 480 pixel screen is typically only 30 to 50 megabytes in size. An entire semester (45 lectures) would require less than 2 gigabytes of total disk space. Given that multi-gigabyte hard drives and 2-gigabyte removable disk cartridges are now common and inexpensive, any engineering department can afford to create and store an entire curriculum of classes using this method.

People often think of Web-based classes in terms of outreach to off-campus and nontraditional students, but this format also holds promise for allowing faculty members to easily “amplify” their teaching efforts with traditional students. How many instructors wish that their department could afford the resources and personnel to teach additional electives in their area of interest? With a minimal investment of computer hardware, software, and faculty time, an engineering department can expand its curriculum and course offerings beyond the limits normally imposed

by the available number of instructors. In addition, the small size of the files would make it possible to distribute an entire course, including lectures and supporting materials, on three or four inexpensive compact discs.

One final point should be made about bandwidth considerations. Despite the relatively small size and bandwidth requirements of these files, even 56 kilobaud modems cannot transmit data over phone lines quickly enough to "stream" a lecture in real time as it downloads. In these cases, a student must wait until the entire lecture downloads before viewing it, or download it on-campus for later viewing. Data rates over Ethernet connections are considerably higher, so remote students at business sites, in campus computer labs, or in Ethernet-wired dormitories can view the lectures with ease. Future advances in high-bandwidth residential Internet connections (e.g. cable modems) should improve the situation for off-campus students.

V. Conclusion

Plans are currently underway to offer a Web version of an ECE graduate course utilizing this lecture technique starting Fall Semester 1999. Initial response to the virtual whiteboard recording method by both faculty and students has been very promising. The entire set-up, recording, and editing process for a single 50-minute lecture typically requires less than two hours. In particular, faculty members find the translation of standard classroom notes and slides to the virtual whiteboard medium to be straightforward and intuitive. Students have commented favorably on the effectiveness of the QuickTime movie format, which allows them to pause or replay any portion of the lecture as desired. Although a recorded Web lecture cannot replace an interactive classroom experience, students appear to find the effectiveness of this technique comparable to that of a videotaped lecture. A more formal survey of student and faculty attitudes and recommendations concerning this lecture format will be made in the coming months.

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