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Asynchronous Electronic Lectures in Web-based education

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Web lectures are becoming increasingly popular in delivering course content. Here Dr. Bruislovsky provides a framework for comparison of various Web lectures, as well as systems for authoring and delivery of Web lectures.

Electronic lectures

Since the early days of universities a traditional oral lecture has been a keystone of higher education. Nowadays many universities and colleges are trying to preserve a lecture as an element of Web-based education replacing real lectures by *electronic lectures*. These can be classified into two major groups: synchronous and asynchronous lectures. Synchronous lectures provide a distance access to a real lecture theatre. Asynchronous lectures are recorded and can be viewed at any time. A number of advanced suites of tools support both synchronous and asynchronous lectures: a synchronously presented lecture can also be recorded, enhanced, and turned into an asynchronous lecture (mStar, KMi Stadium).

Web-based asynchronous electronic lectures sometimes are referred to as “lectures on demand”, “just in time lectures”, or simply Web lectures. Increasingly, Web lectures have become a popular method of presenting course material on the Web. Many faculty consider it the best substitute for classroom lectures claiming that neither textbooks, nor handouts can adequately replace an up-to-date lecture done by a leading researcher or professional. Distance students appreciate that Web lectures provide them with the "feeling of the classroom". Course developers find that a Web lecture is often the easiest way to place some course content on the Web. Content providers consider Web lectures as an eligible courseware element that can be stored, “owned”, and distributed. Some research found that Web lectures are at least as efficient as regular lectures (LaRose & Gregg, 1997). Web lectures constitute an active research and development area in Web-based education. Many examples of Web lectures are now available on the Internet (Bidarra & Peters, 1999). A number of authoring and delivery systems for Web lectures have also been developed.

What is a full-fledged Web lecture?

Web lecture is an example of *electronic presentation*- a way to represent sequential material such as a lecture or a slide show. A professionally done Web lecture has all attributes of a good electronic presentation. One of the features of a good electronic presentation is a complete set of sequential navigation tools. The presentation should have a distinct “top” node with some introduction and a link to the first node. All nodes (we call them “slides”) should contain “next” and “previous” navigation links as well as a link to the top node. A table of contents that provides direct navigation to any slide should be also provided.

A full-fledged asynchronous electronic lecture is a sequence of authored slides with audio/video narration and sequential navigation tools. This kind of electronic lecture was originally developed for an older CDROM-based technology (Dannenberg, 1999), but its Web implementation (Web lectures) now dominates.

Web lectures: what can be different?

Current technologies for producing Web lectures differ significantly in two aspects – the *content structuring* level and the *media level*. A high-quality "archival" Web lecture should allow fine-grained sequential and random access to the lecture content. First, the video/audio stream has to be divided into the smallest meaningful chunks, which usually correspond to a line or a piece of a slide. Chunking is important for slide synchronization, random access to lecture parts, and retrievability. Synchronization means that each audio or video chunk has to be associated with a corresponding portion of the slide presentation. With *slide-level* synchronization a chunk of narration is associated with the whole slide. With *line-level* synchronization a chunk is associated with each line (or a fragment) of the slide. Random access means that each chunk and slide (or slide line) can be individually addressable via a table of contents. A table of contents can be either a simple list of slide numbers or titles, or a timeline. A timeline shows the users both a title of each slide and a relative length of its narration. Retrievability means that the user can retrieve lecture chunks satisfying some criteria, for example, containing some keywords. To be retrievable by request, each chunk must be indexed with keywords or domain concepts. This is very important because it enables students having problems with later lectures or exercises to retrieve a helpful piece of teacher's explanation. Finally, an author may be willing to provide annotation, i.e., associate comments, references, and links to additional resources with any chunk of material. Annotations also can be used to find a relevant lecture piece with full-text search. In a basic form, a simple Web lecture provides no line-level synchronization, and no indexing.

Currently very few systems like MANIC, CALAT, and JITL support line-level chunking and synchronization. Fewer support indexing and search. Reliable chunking, synchronization and indexing, therefore, requires several hours of manual work for one hour of lecturing. Special advanced synchronized recording software used in AOF, Sync-o-Matic 3000, WLS, mStar, and Classroom 2000 can to some extent solve the problem of synchronization. The software records the time when the presenter changes each slide or slide line and uses this data to change the slide or to highlight a new line when re-playing the presentation. Synchronized recording technology can also be used to build a table of contents, although, it does not solve the indexing problem nor support retrievability.

The three media levels in existing Web lecture systems are recorded audio, recorded video, and high-quality video. The difference between recorded audio and recorded video reflects the bandwidth capability the clients. Audio is generally used to serve students with low-bandwidth Web connections. With streamlined video technologies and higher bandwidth connections emerging, recorded video will become more and more common. High-quality video requires special recording equipment, preferably a studio with a *blue screen* and several hours of processing time for a one hour of lectures.

Existing Web lecture systems also differ in the variety of supported "extras" – the features that are not necessary for the main Web functionality of Web lectures, but are useful for lecture authors and students. Two popular features that can extend the power of a Web lecture are whiteboard and attachments. Whiteboard component in a Web lecture system lets the teacher write and draw during the lecture (over the prepared slides or in a separate space) and records the whiteboard content for the future presentation in a Web lecture. The ability to add various attachments (such as extra graphic, sound, video, or external Web page) enables the lecture author to show content that does not fit standard "slides+narration" formula. A traditional way of adding attachments is manual linking of multimedia files and URLs to the table of contents of a Web lecture (JITL). Contempoary lecture recording software makes it possible to record any URL brought by a teacher during the lecture and auto-attach it to the proper place in the table of contents Classroom 2000. Naturally, a recorded URL can point to a third party Web page, as well as any multimedia file that a teacher has placed on a course site.

Name	Primary references	Developed in	Media	Structuring	Advanced features
JITL	(Dannenberg, 1999)	Carnegie Mellon University	Processed Video	Line-level chunking, synchronization and search	Advanced video
Stanford Online (ADEPT)	(Harris & DiPaolo, 1996; Stanford Online, 1999)	Stanford University	Processed Video	Slide-level chunking and synchronization	
mStar	(Synnes et al., 1998)	University of Luleå (Sweden)	Video	Time synchronization	Broadcast and replay; Editing and indexing
KMi Stadium	(Scott & Eisenstadt, 1998)	Open University (UK)	Video	Several kinds of synchronization	Broadcast and replay
Sync-O-Matic 3000	(Severance, 1999)	Michigan State University	Video	Time synchronization	
AOF	(Bacher & Ottmann, 1996)	University of Freiburg (Germany)	Video	Time synchronization	Whiteboard recording
Classroom 2000	(Abowd, 1999)	Georgia Institute of Technology	Video	Time synchronization	Whiteboard recording, timeline
WLS	(Klevans, 1997; Vouk, Klevans & Bitzer, 1999)	North Carolina State University	Audio Video	Time synchronization	
MANIC	(Stern et al., 1997; Stern, 1997)	University of Massachusetts	Audio	Line-level chunking	Adaptivity
CA309	(Smeaton & Crimmons, 1997)	University of Dublin (Ireland)	Audio	Slide-level chunking and search	Advanced searching
VW	(Barbieri & Mehringer, 1997)	Cornell University	Audio	Manual slide-level chunking	
CALAT	(Nakabayashi et al., 1996)	NTT (Japan)	Audio	Line-level chunking	Adaptive sequencing

Table 1. Characteristics of some existing Web lecture systems

Matching the goals with the technology

The developers of Web lecture technologies are driven by three reasonably different goals. For some developers (Classroom 2000), Web lectures support regular "classroom" students by recording "what happened in the classroom". Because these students can re-play a lecture at their own pace, they can spend less time taking notes and more time focused on understanding the content of the lecture. For other developers (Stanford Online, Sync-O-Matic 3000, AOF), the goal is "on-the-fly" authoring, i.e., providing a "fast copy" of a real lecture for students (mainly distance learners) who can't be in the classroom. Yet other developers (JITL, VW) aim to provide archival material aimed specially for distance education. While the goal audience (classroom students only, distance students only or both) may influence different features of Web lectures, any existing Web-lecture systems can serve all three kinds of audiences.

There is an obvious relationship between the goals of developing Web-lectures and the level of used technology. Web-lectures made as a record for classroom students can use audio or low-quality video without fine grained chunking and random access (a teacher is available to solve problems!). On-the-fly authoring, the goal of which is to provide a copy of a classroom lecture for a distance audience as soon as possible can afford only 2-3 hours of processing for one hour of lecturing. Both of these contexts allow a minimum amount of manual content processing and video processing. Both can benefit from recording-time automation that can provide time synchronization, whiteboard recording, and auto-attachment of URLs. An archival Web lecture specially prepared for asynchronous distance education requires the highest level of content structuring as well as high quality video. At present, it requires many hours of processing for one hour of lecture. An archival Web lecture also needs advanced search capabilities. Whiteboard functionality, however, is hardly necessary because course developers can prepare all required graphics or animations in advance.

Choose your level

To compare Web-based education systems, use the following three levels of advancement in each component: Base, State-of-the-art and Research.

Base level: A present a base level Web lecture is a sequence of static slides with a separate audio or video narration file for each slide or video. Some evaluation (LaRose & Gregg, 1997) claims that the outcomes of base level Web lectures are equivalent to

ordinary face-to-face lectures. Base level Web lectures can be developed with COTS tools such as Microsoft Power Point with its "Web assistant" or TopClass assistant. Systems offering no more than the Base level features may survive on the market if they are well supported, inexpensive, reliable, or because customers do not demand more sophistication.

State-of-the-art level: The requirement for state-of-the-art lectures is in-slide synchronization with audio and video. It can be either authored synchronization, as in MANIC, CALAT, JITL, or recorded time synchronization. Authored synchronization allows a line-level access to the material, but it is much more expensive. Slides or sometimes lines, are indexed or annotated to allow keyword or full-text search. State-of-the-art lectures are usually developed with special authoring tools or technologies. Few systems will be State-of-the-art for all components. Commercial products have some, but not all, State-of-the-art features.

Research level: Research teams working on Web lectures are trying to extend Web lecture technologies in the following directions: developing more powerful authoring tools, adding advanced options for finding relevant audio/video chunks (CA309), and adding adaptivity to user knowledge to systems with Web lectures (MANIC, CALAT). These features, often incorporating advanced elements of artificial intelligence, are not yet available in commercial systems.

It's important to remember that the progress in WWW-related technology is so fast that many techniques, which were State-of-the-art last year now only qualify as Base level. When features are incorporated into several commercial systems, they redefine a new Base level. So the development cycle is that Research level capacities move into the State-of-the-art, while State-of-the-art features are rapidly incorporated into commercial systems.

This development in video processing, software tools, and bandwidth availability will make Web lectures an ever-increasing strategic part of the online curriculum.

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