

Hypermedia Navigation Concepts for Lecture Recordings

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Abstract: This paper introduces a complete hypermedia navigation concept for lecture recordings, along with virtPresenter, a prototype software tool for automatic generation of hypermedia user interfaces for lecture recordings. A special focus is on how navigation concepts of hypertext have to be modified in order to work with continuous media.

Introduction

During the last years, lecture recordings have emerged as a fast and convenient way to produce eLearning content. Most systems record PowerPoint presentations together with a synchronized audio or video stream and automatically generate a web-presentation of the recording (Lauer & Ottmann 02).

If offered in addition to a conventional lecture, lecture recordings are mainly used as a supplementary means for repetition and self-study, much like a script or textbook (Zupancic & Hürst 02). Since the students have actually attended that very lecture, they only want to access those parts of it they have not understood (Bell et. al. 01) or some specific details they need to complete their course assignments. This scenario demands complete indexing of the recorded material (Bell et. al. 01) as well as direct addressability of the content at a very fine-grained level^[1] (Brusilovsky 00). Indexing and direct addressability combined allow finding and retrieving arbitrary positions within the recorded materials according to the users' search criteria: users enter a query; matching positions in the content are found and can then be accessed directly. Unfortunately query-based search alone often ends in a dead end when users do not know how to form the right query (Manber et al. 97) or when the required keywords can not be found. Consistent use of content based metadata as proposed by (Einhorn et al. 03) could in part solve this problem. The detailed level of granularity required though, would severely inhibit the automation of the production process, one of the mayor points in the Authoring on the Fly paradigm described in (Bacher et. al. 97).

^[1] A complete index has to point accurately into the film. An index that says "The item you are looking for can be found somewhere between minute 42 and 51" is not really helpful.

How Do People Search Electronic Media?

Human search in electronic media can often be done by navigating as opposed to querying (Jul & Furnas 97). In fact (Olston & Chi 03) state that information retrieval in multimedia environments actually is a combination of search and browsing in most cases. Browsing is particularly important for searching in non-textual media, like voice-streams or films, as these media pose severe difficulties for indexing (Cox et al. 98). (Dunlop & Rijsbergen 93) have used a mixture of text-search and browsing as a theoretical framework to implement search algorithms for pictures. In the field of lecture recordings, names like the Cornell Lecture Browser (Mukhopadhyay & Smith 98) and BMRC Lecture Browser (Rowe et al. 01) strongly suggest the importance of browsing. (Hürst et al. 00) emphasize the importance of browsing for filtering results of query-based searches in lecture recordings and introduce a software tool that offers random visible scrolling for navigation.

Browsing in electronic media though differs from watching a linear stream of information, in that it requires a linked structure of documents that can guide the user from topic to topic. Hypermedia offer such a structure combined with a convenient way of following the respective links and thus facilitate browsing in an information space (Nielsen 90a). This could be the reason why recent overviews call for a linked structure of the presentation (Brusilovsky 00) or at least for a fully linked thumbnail overview of the slides (Lauer & Ottmann 02), which are both significant steps towards transforming recorded lectures into hypermedia documents.

Lecture Recordings as Hypermedia

According to the strict definition of hypermedia (see (Tolhurst 95) for an overview of definitions) the linking described above is in itself sufficient to make a recording qualify as a hypermedia document. More recent definitions of hypermedia like the one by (Bieber 00) however, include a number of navigational features such as backtracking, bookmarks and structural features that reflect the relation of one hypermedia node to another. This might mainly be due to the fact that these features play an important role in coping with confusion and disorientation, problems that often arise in hypermedia environments (Carmel 92).

Following this reasoning, we have decided to design a learner-interface for lecture recordings that incorporates all of the navigational features found in current hypertext systems. Adapting these features from static as opposed to continuous media involves a number of technical and conceptual problems. The technical aspects of linking and authoring user-interaction in time-based media are discussed in greater detail by (Hardman et al. 00). The conceptual challenges in adapting navigation interfaces and functionality will become clear, when we examine hypermedia navigation in the next section.

Navigation in Hypermedia

Modern hypertext browsers offer a variety of means that facilitate navigation and orientation in hypertext documents. Backtrack and history lists, bookmarks and footprints (also called breadcrumbs) provide the user with an individualized interaction history (Nielsen 90b). This contextual orientation, along with the structure of the respective hypertext document, helps users to focus on their search goals and simplifies navigation within otherwise confusing hypertext environments (Carmel 92).

Applying these navigational concepts to lecture recordings raises a number of difficulties, since these concepts are largely based on the static and visual nature of hypertext and picture augmented hypertext. In order to analyze these problems, the next subsection investigates why hypertext navigation works for text and pictures and why it does not work for audio and video. The closing part of this section will give an overview of the purpose of hypertext navigation facilities. This analysis provides a working basis for applying the underlying concepts to navigation in lecture recordings as described in the next section.

Foundations of Navigating in Static Hypermedia

Navigation facilities in static hypermedia rely heavily on how humans perceive static visual content. The following observations might seem trivial at first glance, but the lack of the described features in time-dependent media presents the main obstacle for hypermedia-navigation in lecture recordings:

- **Readers can assess visually static media at a glance.** The impact of this fact on searching and browsing in text and pictures has been investigated by (de Bruijn & Spence 00). In hypertext navigation, this at-a-glance orientation enables users to rapidly identify undesired steps in backtracking or to discern similarly titled bookmarks from one another. It also allows to “scroll by sight”, as readers get instant visual feedback when navigating at a line-to-line level.

- **Reading speed is determined by the reader alone.** When reading a book or a newspaper, the reader alone decides when to turn a page or when to move on to the next paragraph. The same holds true for static hypermedia. The timing of each move from node to node is determined by user actions and not by the medium itself. As a consequence, **hypertext nodes are clearly delimited.** This lets links and footprints denote a self-contained part of the document, which in turn gives each link or footprint a distinct meaning. In audio- or video-based media, a link might point to a specific position in a stream, but as the stream plays on, many other nodes could be traversed without the transition being noticed by the user. Depending on its implementation, a footprint might mark a section as viewed even though the user has just briefly visited it, or it might not mark a node as completed even though the user has already seen the important parts of it.
- **The structure of the document is visualized by document elements like headings or highlighted text.** For online content, these visualizing features are even more important than for conventional, non-electronic text, as readers tend to use these elements for quick orientation (Morkes & Nielsen 97). In the field of recorded instructional presentations, (Gupta et al. 00) have conducted a user study that shows the importance of meaningful slide titles. They also advise authors to keep slides focused to one key-point in order to facilitate navigation within the recording. This alone, however, hardly compensates for the lack of fast accessibility to the document structure, especially when a document's low-level structure, like highlighted text or bullet lists is concerned.

Navigation Facilities in Hypermedia

The navigation facilities described below are common in any of today's internet-browsers. A closer look at each of these features will give an insight into their purpose. The general description of the following hypermedia navigation features is mostly taken from (Bieber 00):

- **Full text search** is rated as one of the most important search features in hypertext by (Morkes & Nielsen 97). It allows direct access to arbitrary parts of a document without having to scan through the document's structure. Full text search is especially helpful for keyword search within large documents.
- **Bookmarks** provide an easy way of customizing hypermedia documents according to the needs of individual users. Users have the option to set bookmarks at any node within a hypermedia document. Later these bookmarks can be used to revisit marked nodes at a mouse click.
- **Backtracking** has proven to be very helpful whenever users get lost (Nielsen 90b). By clicking the backtrack button, users can get back to where they left off before following a misleading link or starting down the wrong path. History lists offer the possibility to go back several steps at once. Forward buttons allow undoing backtracking actions that went too far.
- **Breadcrumbs or footprints** are any types of visual indicators showing that a node has been visited or that a link has been traversed (Parmar 93). Footprints allow for an easy distinction between parts of a document that have already been visited and those that are new to the user.
- **Structural elements** of hypertext documents often coincide with the structural elements the document would have if it were a non-hyper text document. Headings that indicate a new section in a text often also indicate a new node in the corresponding hypertext document. Well edited hypertext documents often provide linked tables of content, as well as "next", "top" and "previous" navigation links that are also recommended for lecture recordings by (Brusilovsky 00).

In hypertext browsing these features are often used in conjunction with each other. This fact poses an additional constraint for the adaptation of the navigation facilities described above to continuous media like lecture recordings, in that each feature has to be implemented with the whole interface in mind.

Navigation in Lecture Recordings

Throughout this section we will first summarize what means of navigation most lecture recording systems offer to students. Additionally we will discuss ways to improve existing navigation features so that the access to small pieces of information becomes possible. The second part of the section introduces the student interface of virtPresenter, a PowerPoint based lecture recording tool. The student interface incorporates all of the hypermedia navigation facilities discussed above.

A special focus of this subsection is on how most of these features had to be modified in order to be applicable to lecture recordings.

Time and Slide Based Navigation

Modern lecture recording systems offer two categories of navigation: Time based navigation and slide based navigation. (Fig. 1) may serve as an example to illustrate interfaces for these navigation methods.

In the first two subsections we will briefly describe how both kinds of navigation work. In the last subsection we will examine the key problem of conventional slide based navigation and discuss two possibilities to improve its efficiency.

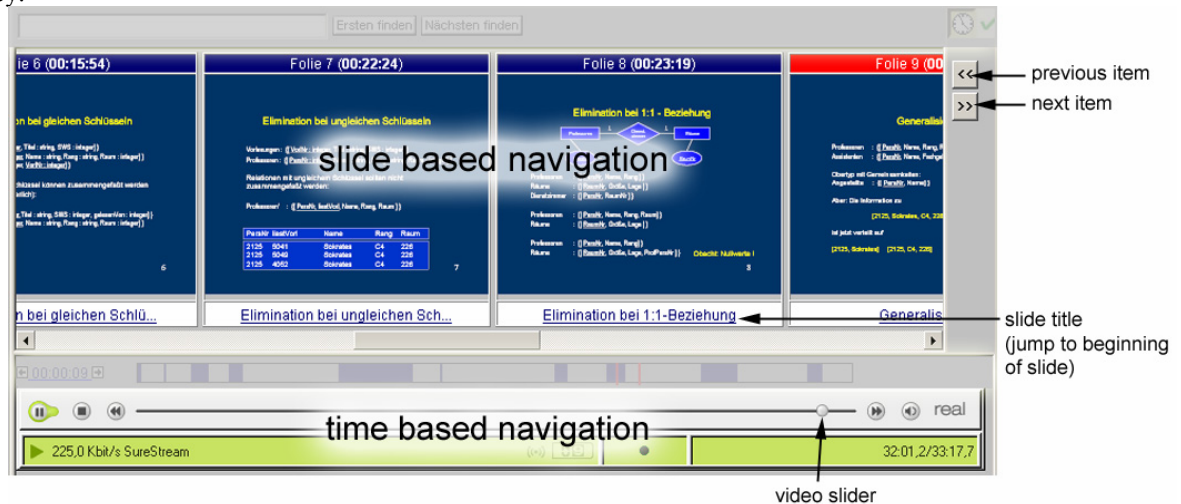


Figure 1: Time based and slide based navigation interfaces in recorded lectures

Time Based Navigation

In time based navigation students can drag a marker on a timeline to potentially access any time index in the recording.^[1] Using this slider widget they can quickly scan through the whole recording. In random visible scrolling, the system state is continually updated during the drag operation (Hürst & Müller 99). This way, the user constantly gets visual feedback and is able to find the desired video sequence.

(He et al. 00) propose accelerated replay of recorded presentation as a navigation technique. This technique would allow lectures to be viewed at up to twice their speed, without losing information.

Basic Slide Based Navigation

In slide based navigation the time index of every slide is kept in a link which the student can select in order to jump to the beginning of the slide discussion in the recording. Normally the anchor of such a link is the slide's title or a thumbnail image of the slide. A set of slides is either displayed as a directory of slide titles or visually as a sequence of thumbnail images. Unlike dragging the video slider, clicking a slide link is a content driven way to retrieve a desired piece of information in a recording.

Advanced Slide Based Navigation

Although slide based navigation offers a way to establish a link between content and time, the information chunks that can be directly accessed via these links are much too big. In a common scenario where a slide is discussed for several minutes, jumping to the beginning of a slide and then scanning with the video slider can be a slow and tedious task. As a consequence a finer granularity of directly accessible information chunks is needed to support students in their efforts to retrieve a certain piece of information fast. The key to increase the "information resolution" is to regard a slide item (instead of the slide itself) as the smallest addressable chunk of information. Accordingly the slide consists of a sequence of slide items. The discussion of each slide item begins at a certain time

[1] In most existing systems the video slider has an associated time resolution that is dependent on the width of the widget and the duration of the video. The more (horizontal) pixels are available for the widget and the shorter the duration of the video the higher the time resolution. As a consequence not every time index is accessible via the slider. (Hürst & Stiegeler 02) and (Richter et al. 99) describe zooming slider interfaces as an approach tackling this problem in the context of AOF and Classroom 2000 (now called eClass) respectively.

index in the recording which can be directly accessed by the student. virtPresenter uses animated slide items to determine this time index. We are currently working at the automatic linking of these slide elements. One possibility of how students can get access to the individual items on a slide is via a simple "previous item - next item" navigation mechanism (Brusilovsky 00), as implemented in MANIC (Schapira et al. 01) and AOF (Hürst et al. 01). For a given slide students can "semantically scroll" back and forth through the sequence of slide items by hitting the appropriate button for every slide item they want to skip. Although compared to time based scanning this solution can lead to a decrease in search time, it still does not offer direct access to arbitrary slide elements. Therefore we are working on a solution to make slide items accessible by clicking on the portion of the thumbnail slide where the requested information is displayed.

Hypermedia Navigation in Lecture Recordings

This section discusses how full text search-, backtracking-, bookmark- and breadcrumb-functions must be shaped to meet the specific requirements of hypermedia lecture recordings. It then describes a prototype implementation of these navigation facilities in the virtPresenter interface. A closer look at each navigation facility will reveal that many aspects have already been implemented in other systems, even though not all in the same system.

Full Text Search

The student must be able to initiate a full text search within the scope of all textual slide items and the whole set of slides. When presenting the search result it is not enough to highlight the part of the text that matches the search string, but it should also be possible to jump directly to the part of the lecture in which the text item is discussed. A simple click on the text item could accomplish this. Although a full text search is implemented in AOF, Lecturnity (Lauer & Ottmann 02), the BMRC Lecture Browser and MANIC, none of these systems offers the possibility to jump directly to the time index in question.

To facilitate spotting search results, virtPresenter uses motion instead of highlighting, as motion is the most effective way to attract the eye's attention (Egeth & Yantis 97). In the current implementation, search results are shrinking to their normal size while flying into position.

Backtracking

Backtracking should allow to undo every kind of navigation interaction and to jump back exactly to the point in the recording that was playing before the interaction. The replay should begin several seconds earlier to make orientation easier for the student. Moreover it is desirable to store not only one backtracking point but every backtracking point that has been created during the session. This history of backtracking points should be browsable by the student via an easy back/forward navigation mechanism.

MANIC is the only system that supports backtracking but only to the beginning of a textual or graphical item of a slide. Backtracking is not explicitly implemented in MANIC, but users can hit the browsers backtrack button, as MANIC documents basically are hypertext with associated sound files.

In the virtPresenter user-interface, for every navigating action (activating a bookmark, pulling the slider, clicking a slide title or hitting the next item – previous item buttons) a time index is added to the list of backtracking points. This time index indicates the point minus two seconds where the stream was playing before the navigating action was executed.

Bookmarks

Users should be able to set bookmarks at any time while they are watching the recording. By using bookmarks, points of personal interest can be marked and become directly accessible for future use. (Fig. 2) shows how bookmarks are displayed in the virtPresenter interface.

	description	start time	end time	
▶	entity relationship diagrams	00:03:44	00:10:31	delete
▶	database query examples	00:30:48	00:32:41	delete
▶	end of theoretical part	00:16:21	--	delete

Figure 2: Bookmarks in virtPresenter

Apart from bookmarks that link to a certain time index in the recording we propose a second type of marker that can be used with benefit in hypermedia lecture recording: sequence marks. Unlike bookmarks, **sequence marks** also define an end time and are thus capable of representing self-defined subsets of the lecture. By using sequence marks students can "cut out" all the relevant parts of the lecture and only have to revisit these important intervals when dealing with the same lecture again. Therefore sequence marks are a means to economize the learning process especially when the time that has passed between two visits is very long.

Both bookmarks and sequence marks should offer the possibility to be labeled with meaningful titles so that they can be recognized by the student in the future. They should also be exportable so that students can share them with other participants of the lecture. In the current version of virtPresenter, sequence marks are realized as cookies so they can be used without any log-in mechanism.

In MANIC there is the possibility to set bookmarks but only at the beginning of a new text item, this again being a result of MANIC's document structure. In DLH students can set markers, so called tags, with a remote control during the live presentation (Mühlhäuser & Trompler 02). These tags can even be shared among the students. However, there does not seem to be a way to insert tags when viewing the recorded presentation. (Miyahara et al. 02) have implemented a bookmarks only system that can be used to collect and manage clips that belong to different recordings.

Footprints

In lecture recordings students should always be able to find out which parts of the lecture are new to them and which parts they have already visited.

In eTeach's slide directory a slide title is crossed out once the slide has been visited by the student (Moses et al 02). Although this representation of the breadcrumb idea is quite helpful, a more detailed representation with a higher time resolution would be desirable. After all it is a big difference whether the student has only seen some seconds of a slide discussion or has watched it to the end.

Therefore virtPresenter introduces a **graphical component** that is capable of visualizing exactly and intuitively which parts of the lecture have already been seen by the student. This component is of exactly the same width as the video slider and starts at the same horizontal position. Hence every possible slider position corresponds to a position on this "progress bar" and both positions have the same x-coordinate. The **progress bar** is illustrated in (Fig. 3).

Whenever the movie is running, we can record the periods of time that have passed without navigation actions like stopping or jumping and continually update the progress bar to visually reflect changes. As a consequence the progress bar that is empty at first becomes more and more filled as the student watches new time intervals during his work. The screen location of video slider and progress bar makes it easy for students to jump to parts of the lecture they have not visited yet: they simply have to move the video slider to an x-position where the progress bar is still empty.

Though the progress bar as described above is very useful for finding new parts in the lecture it still fails to inform the students which parts of a given slide discussion they have already seen. That is why we show interval markers (red vertical lines) on top of the progress bar whenever the mouse moves over a slide title or over an animated part of the slide. These interval markers indicate the start and end time of a slide discussion on the progress bar's time scale. As a consequence every empty bar interval between the slide interval markers signals a new part of the slide discussion whereas every filled interval indicates a part that has already been visited.

In the current version of virtPresenter the progress bar is not persistent over different sessions, because this part of session management has not yet been implemented.

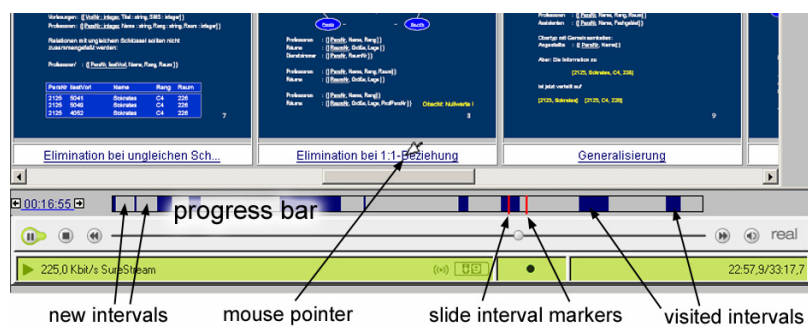


Figure 3: the progress bar visualizes visited parts of the film

Structural Elements

The “next item”-“previous item” navigation discussed in the paragraph about advanced slide based navigation surely is the first idea that comes to mind when thinking about structural elements in lecture recordings. Another structural element that is planned to be realized in virtPresenter is linking every animated slide element in the navigation view to the film. This is especially useful in combination with full text search and footprints. Items retrieved by full text search can be directly accessed and footprints can be associated with parts of the lecture at a very fine granularity. Linking every animated slide element is closely related to an approach presented by (Graca Pimentel et al. 00) for the Classroom 2000 project. In Classroom 2000 handwritten annotations by the lecturer are automatically captured and linked to the respective position in the recording. Handwritten annotations, however, can not as easily be searched by a full-text query as PowerPoint text elements.

Conclusion and Further Work

This paper has analyzed the differences between hypertext documents and lecture recordings with regard to hypermedia navigation features. Based on this analysis a hypermedia navigation concept for lecture recordings has been developed and a prototype implementation of this concept has been presented.

Many, but not all of the navigation features proposed can already be found in existing systems. There is, however, no system uniting all of these features. In hypertext, though, navigation features work as a coherent concept in which each feature supports the use of others. Following this reasoning the virtPresenter student interface was developed, integrating all navigation features found in hypertext browsers.

Whereas some of the navigation features presented have already been employed successfully in recorded lectures at Osnabrück University, user-testing the concept as a whole is planned for the near future.

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