Social navigation in Web Lectures
A Study of virtPresenter

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ABSTRACT

Social Navigation is an emerging approach to enhance online learning content. With social navigation, users can be guided through large volumes of learning material by visual cues, which integrate the browsing history of past users. This allows users to easily identify the most important content fragments, which attracted more attention from similar users. Social navigation in classical hypermedia such as hypertext has shown to increase learners' motivation and helped users to discover most valuable information. This paper presents our attempt to extend the benefits of social navigation beyond its traditional scope. We developed a footprint-based social navigation approach for time-based continuous media, a popular kind of educational content in lecture recording systems. We implemented this approach in the web lecture system virtPresenter and evaluated it in a two-semester long classroom study. The results show that the social navigation cues significantly affect user lecture navigation causing users to pay more attention to the material previously explored by other users. The user subjective feedback on the usefulness of the social navigation cues and related navigation components was significantly positive.

Keywords: Intelligent User Interface, Information Filtering, Lecture Recording, Social Navigation, Web Lectures

1. INTRODUCTION

Web lectures play an increasingly important role in the elearning portfolio of many universities. While this kind of media comes with a number of benefits such as a multimedia learning experience and relatively low production costs per learning unit (Mertens, 2007), educational applications of time-based media require efficient navigation approaches. Without efficient navigation, the advantages of web lectures can not be leveraged to their full extend. Unfortunately, entertainment-oriented interfaces, the currently dominating application of time based media, offer only very primitive playback interfaces. For songs and movies, fine grained navigation (such as navigating to distinct passages) is not very important since people typically want to replay the whole song or movie. However, the use of a web lecture as a fully-fledged educational tool demands elaborated search and navigation tools. While the navigation problem for web lectures has already been tackled by a number of approaches like those described in (Hürst, 2004), (Ziewer, 2006), (Mertens, 2007) an intrinsic property of time based media still poses a considerable problem when every day use of web lectures is concerned. The main challenge for all navigational tools for web lectures is helping the user to locate the most useful parts of a long lecture, those that can help to solve a problem or to answer a question. In case of static text, relevant fragments can frequently be located by skimming and scanning, which are essential skills for understanding texts that allow readers to get a rough idea of a text's content at a glance (Leane, 2002). However, video and audio documents can not be easily skimmed or scanned. This problem motivated one of the popular navigational tools for Web lectures - accelerated replay of a recorded lecture's audio track. This technique is supported by interfaces described in (He et al., 2000) and (Hürst et al., 2004). Other approaches include filtering out speech pauses (Li et al., 2000) or allowing users to skip predefined brief intervals of a recording (Moses et al., 2002). While these approaches enable users to browse the content more effectively, they still do not free the users from actually having to watch unneccesary passages of the recordings albeit in an accelerated fashion.

An alternative approach is the provision of elaborated search tools for finding relevant content. Such systems as BMRC Lecture Browser (Rowe et al., 2001), eClass (Brotherton, 2001) or E-Learning Navigator (Dorai et al., 2001) have served as testbeds for the use of audio transcripts as a basis for full text search in recorded lectures. (Hürst, 2004) describes a number of different interfaces for search result retrieval from transcript-based full text search in lecture transcripts. Given the fact that Word Error Rates for automatic speech recognition can be as high as 45% for recorded lectures due to the acoustic qualities of lecture halls and standard recording equipment (Munteanu et al., 2006), automatic transcripts of recorded lectures do, however, not provide a usable basis for scanning and skimming in all cases. Understanding the transcribed text is aggravated by the lack of structural elements such as headlines or paragraphs in automatically generated transcripts. Another shortcoming of search-focused access interfaces is the lack of browsing support and at-a-glance understanding of Web lecture content.

The most popular, although technically challenging approach is providing a slide based overview of the lecture and connecting lecture slides to the passages in the recording in which they had been shown. This approach supports both efficient browsing and at-a-glance content assessment. Slide-based overviews help users to locate potentially interesting parts of a recording more easily. Yet, it is still a challenge to assess how far the lecture actually covered the topic of the slide and whether the respective part of the recording is relevant to their current learning goal. The reason for this is that the lecturer might have chosen to just briefly touch the topic or the discussion of the topic might be at a level inappropriate to the students' current needs.

This paper explores a very different approach to help users of web lectures. It is based on the ideas of social navigation. Social navigation is an approach originally developed for navigating link-based information spaces like the World Wide Web (Wexelblat & Mayes, 1999). The idea behind the approach is that traces of one user's interaction with a web site might help another user to decide what link to follow next. The social navigation approach has been already explored in e-Learning context by a few projects such as EDUCO (Kurhila et al., 2002), Knowledge Sea II (Farzan & Brusilovsky, 2005), and AnnotatED (Farzan & Brusilovsky, 2008a). While all existing social navigation approaches deal with link-based hypertext, we believe that social navigation is also a promising way for helping users to find information in continuous media such as web lectures. This way users can take advantage of the knowledge about the video's contents gathered by others instead of having to process the whole video themselves. The challenge addressed in this paper is to adapt the ideas of social navigation developed for hypertext to the time based continuous nature of web lectures. This paper presents our attempt to develop a navigation interface for web lectures enhanced with social navigation support. The interface has been implemented as a component of the *virtPresenter* web lecture system (Mertens et al., 2004). We ran a two-semester long classroom study of the social navigation interface in a graduate class on interactive systems design (INFSCI 2470 – Interactive Systems Design) at the University of Pittsburgh. The results of this study are also presented in this paper.

The paper is organized as follows: section 2 gives a brief overview of related work. Section 3 describes the web lecture interface used and the integration of social navigation in this interface. Section 4 covers technical details of the underlying web lecture system in order to illustrate how usage data was gathered during the evaluation of the system. A discussion of the conclusions that can be drawn from this data is given in section 5. In section 6, results from surveys taken in both terms where the interface was employed are presented. The paper concludes with an overall discussion of the results obtained with the social navigation interface and provides perspectives for future research on social navigation in web lectures.

2. RELATED WORK AND TERMINOLOGY

Social Navigation

Social navigation (Dieberger et al., 2000) is a specific kind of *social information access*, a stream of research that explores methods for organizing users' past interaction with an information system (known as explicit and implicit *feedback*), in order to provide better access to information for future users of the system (Brusilovsky, 2008). *Social navigation* in its early forms attempted to visualize the aggregated or individual actions of community users. The motivation behind this work was that these "footprints" can help community users to navigate through information space. The ideas of social navigation are frequently traced back to the pioneering *Read Wear and Edit Wear* system (Hill et al., 1992). This system visualized the history of authors' and readers' interactions with a document enabling new users to quickly locate the most viewed or edited parts of the document. Different social information access techniques are typically categorized by three aspects: (1) which kind of past user behavior it collects; (2) how these traces are processed to form "community wisdom"; and (3) how this information is used to enhance user information access.

Existing social navigation projects focused mostly on exploring the first two dimensions – i.e, attempted to build social navigation based on different kinds of past user behavior and on different ways to process this behavior. The most popular kind of user behavior used for social navigation is user browsing. This kind of social navigation is sometimes called as *traffic-based* navigation. Starting with pioneer systems Juggler (Dieberger, 1997) and Footprints (Wexelblat & Mayes, 1999), traffic-based social navigation has been used in a number of projects (Brusilovsky, Chavan & Farzan, 2004; Dieberger & Guzdial, 2003; Mertens, Farzan & Brusilovsky, 2006). More recent projects attempted to increase the reliability of social navigation by using user annotation behavior (Farzan & Brusilovsky, 2008a), bookmarking (Farzan & Brusilovsky, 2008b), and ratings (Farzan & Brusilovsky, 2006). An attempt has also been made on using the results of user search behavior for social navigation support (Coyle et al., 2008; Farzan et al., 2007). However, existing social navigation techniques are still quite similar in this third aspect: they assist the user by adapting links used for navigation. This approach is limited in its applicability – it works with link-based hypertext media, but it can't support continuous time-based media such as web lectures.

3. SOCIAL NAVIGATION COMPONENTS IN THE VIRTPRESENTER LECTURE VIEWER INTERFACE

The social navigation interface for web lectures used in this study is based on the virtPresenter lecture viewer interface described in (Mertens et al., 2004). The standard interface already features a number of hypermedia navigation elements such as backtracking, bookmarks, structural elements, full text search and individual footprints. The social navigation in the interface is build on the top of these navigation elements using the popular social navigation concept of social footprints. This section is divided in two parts, the first of which introduces the standard navigation interface and its hypermedia navigation concept. The second part of the section describes how social navigation is integrated in this navigation concept.

NAVIGATION INTERFACE OF VIRTPRESENTER

As mentioned above, social navigation was originally devised as a navigation aid for the World Wide Web and thus classical text- and picture-based hypermedia. One way to realize social navigation for a web lecture is to enhance an already existing hypermedia navigation concept for web lectures. According to the definition in (Bieber, 2000), fully fledged hypermedia systems feature backtracking, bookmarks, structural elements, full text search and footprints as navigation aids. To the authors' knowledge, virtPresenter is the only system that features a full hypermedia navigation concept. The concept is described in detail in (Mertens et al., 2004), this section provides only a brief description.

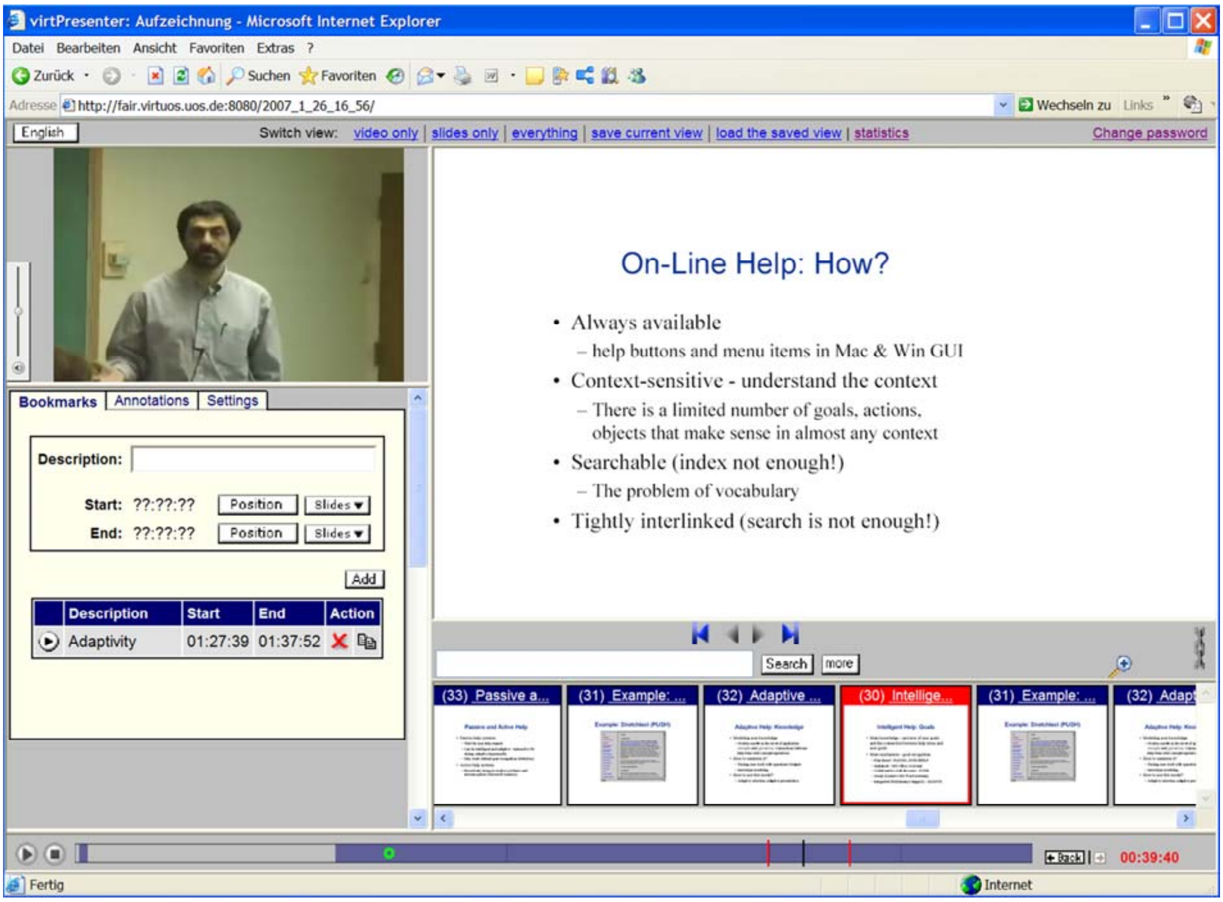


Fig 1: virtPresenter user interface in a web browser

Fig. 1 shows the virtPresenter lecture viewer interface in a web browser. Fig. 2 highlights virtPresenters navigation components in detail. Important areas are magnified for illustration purposes. Neither the magnification nor the connector shapes are part of the interface.

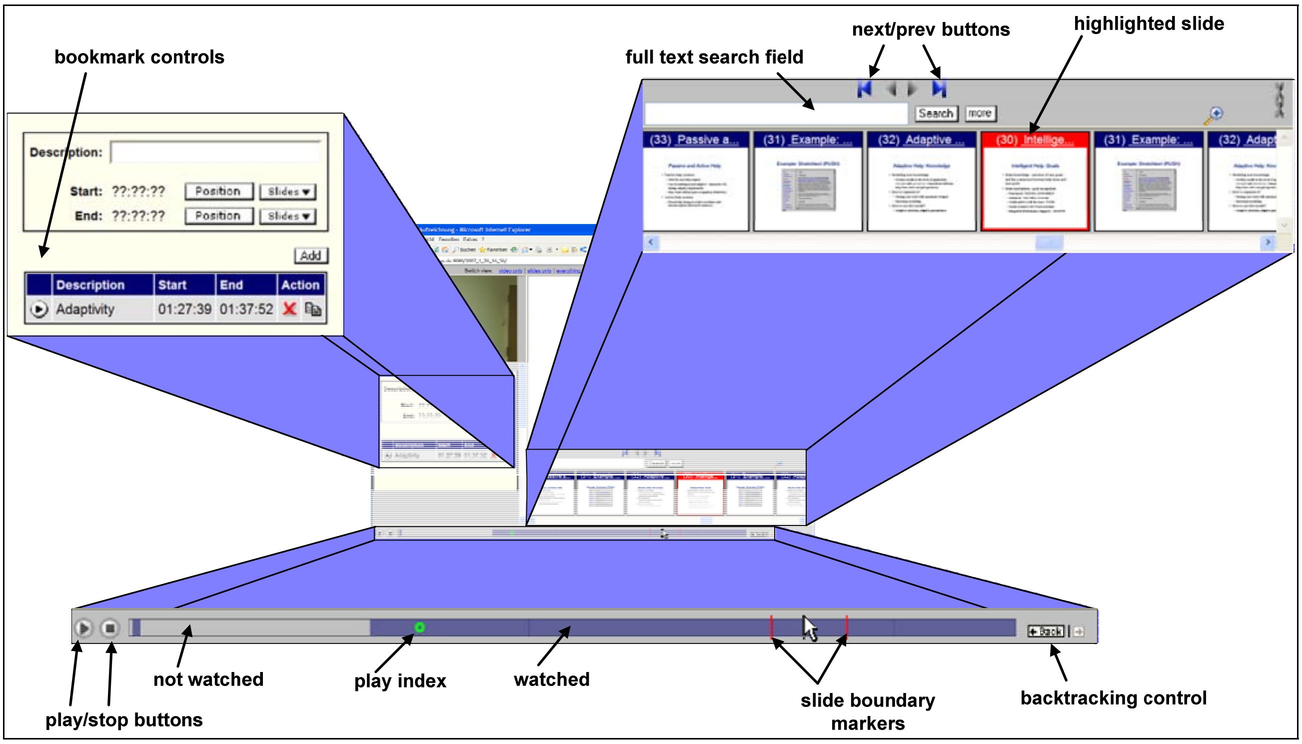


Fig. 2: Overview of navigation features in virtPresenter

All hypermedia navigation elements are adapted to web lectures in that their design takes into account the partially time based characteristics of web lectures. Bookmarks can be defined with a start point and an optional end point in the lecture's timeline. Full text search is realized by searching the text on the slides in the slide overview. The slides in the slide overview are linked to respective passages in the timeline. Structural elements are realized by both next / previous navigation arrows and clickable slide items. The next / previous navigation arrows allow stepping to the next or previous slide or animation step respectively. Clickable slide items allow navigating directly to the point in the recording's time when the slide element clicked on appeared on screen during the lecture (Mertens et al., 2006). If the mouse is clicked into the timeline, a preview feature highlights that slide's boundaries in the timeline and also highlights the slide in the thumbnail overview. Backtracking allows undoing any navigation action by starting replay at the play position left with that navigation action (minus three seconds to facilitate user orientation). Footprints are realized as a time based feature. In the timeline, every part of the lecture watched by the user is marked by blue coloring. This way, users can easily discern which parts of the recording they have watched and which part is new to them. All other navigation facilities (bookmarks, full text search, structural elements and backtracking) are linked to this footprint component in order to connect footprints to all these navigation facilities (Mertens et al., 2009).

SOCIAL NAVIGATION COMPONENT OF VIRTPRESENTER

The social navigation component of virtPresenter is based on the footprint feature integrated into virtPresenter's timeline. It is closely connected to this footprint feature and is linked to all other navigation features in the same way as the footprint feature. Fig. 3 shows how the social navigation component is integrated in virtPresenter's interface. The component shows how frequently each part of the video has been played by the rest of the class. This information is visualized as a graph, which is situated directly over the individual footprint component.

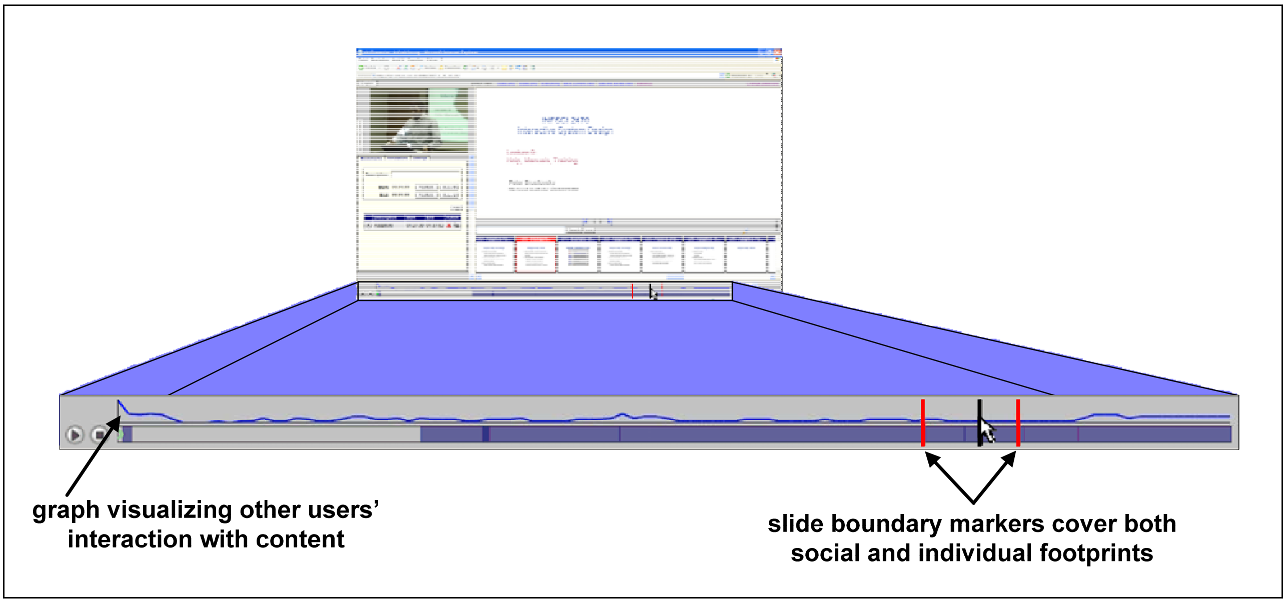


Fig. 3: integration of social navigation in virtPresenter

The component is integrated in the overall navigation concept in the same way as the individual footprint component. Slide boundary markers and preview markers used by other navigation features such as bookmarks and backtracking are enlarged to cover both the social footprints generated by other users and individual footprints generated by the current user. This way, social navigation information enhances all other navigation features of the interface.

4. THE IMPLEMENTATION OF SOCIAL NAVIGATION IN VIRTPRESENTER

In order to provide users with other users' footprints, viewing data from all users has to be gathered and redistributed among users. In the original virtPresenter user interface, individual footprints were stored on the user's computer using their web browser's cookie mechanism. To make this data available for other users, the mechanism was changed to server side storage of footprints. Server side user authentication was added to discern users so that each user can retrieve his or her own footprints as well as social footprints gathered from other users. An additional advantage of this server-based solution is that students can access their personal data such as footprints or bookmarks on different computers (Mertens et al., 2007). In order to compute social footprints, the total length of the recording is divided into a number of timesteps. For each timestep, a social footprint value is computed. The values computed are visualized as the graph depicted in Fig 3. Social footprints are computed on a per user basis. Equation 1 shows how this computation is realized in detail.

$$f_j(t) = \sum_{i=1}^{m} u_i(t) - u_j(t)$$

Equation 1: Computation of social navigation function for user *j* at time *t*

The interaction of the current user is denoted as u_j, t denotes a timestep. The function $u_i(t)$ delivers the number of times user i had accessed timestep t of the recording. Hence, the function $f_j(t)$ sums up all accesses by all users at timestep t excluding user j.

Using this function, information about what the current user has watched is not displayed in the social footprint component. This way, users can easily spot differences between their own viewing history displayed in the individual footprints and the accumulated viewing history of all other users. The individual footprints are stored on the server as 3-tuples {CreationTime, StartIndexInVideo, EndIndexInVideo}. CreationTime denotes the time and date at which the footprint was created. StartIndexInVideo and EndIndexInVideo denote the time indeces in the video where replay was started and stopped respectively by the user. In the interface this data is used to draw the footprint bar as overlapping rectangles. The footprint bar is drawn in SVG (Scalable Vector Graphics). SVG is a vector graphics format that can be dynamically modified on the client computer. The format also supports transparency. Hence, the rectangles can be drawn as semitransparent shapes. This way, passages that have been watched by the individual user more often can be recognized by a darker color shading. SVG is also used to visualize the slides, the interactive slide boundary markers (Mertens et al., 2007) and the social navigation graph. The social navigation graph component is constructed dynamically out of the server side database whenever a user loads the interface for a recorded lecture. The accumulated data used for social navigation is stored in a table as one data set, i.e. one entry per recorded lecture per week. This way, viewing statistics can be retrieved for every single week the recording was online. This way footprints can be shown for week 1, week 2, …week n.

However, due to the fact that only a relatively small number of users (n = 24) participated in the study presented in this paper, this feature was disabled. Instead, only the accumulated viewing statistics for all weeks were displayed. The data sets used to construct the social navigation graph are also stored in a database and are updated periodically with the data stored for the individual footprints of all users. They are organized as 100 segments per recording and viewing data is stored for each segment. When a user watches a recording, an SVG element is automatically generated from the corresponding data.

5. THE CLASSROOM STUDY

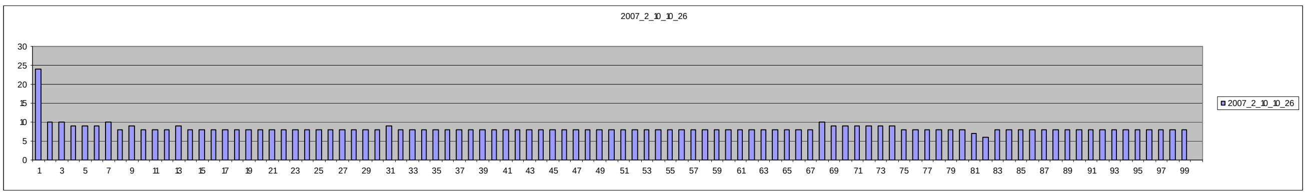
The system described in this paper was evaluated in a classroom study in the context of a graduate course on Interactive System Design held at the University of Pittsburgh. The system has been used in two consecutive sections of this class, one in the Spring and one in the Fall semester. All lectures of this course were recorded and made available to the students using virtPresenter with social interface. Students were required to attend only 10 out of 14 lectures. Regargless of their attendance, students were encouraged to play the recordings at home. All student interactions with virtPresenter were logged.

To increase the users' engagement with the system, one lecture of each semester was delivered exclusively through virtPresenter. Frequent quizzes based on the lecture content were given in class to provide additional motivation.

At the end of the class the students were asked to fill-in a non-mandatory questionnaire. In total, 16 students filled the questionnaire in the Spring term and 8 in the Fall term.

THE LOG ANALYSIS

As described in the preceding section, virtPresenter logs viewing statistics in order to process and present them to the users in the form of social navigation support. In our study we also used this log data to analyze viewing behavior of the students. Fig. 4 depicts usage data gathered from two lecture sessions. The peaks at the first intervals result from the fact that the video often is loaded before the application is fully initialized. They thus present an artifact and were ignored in the analysis.



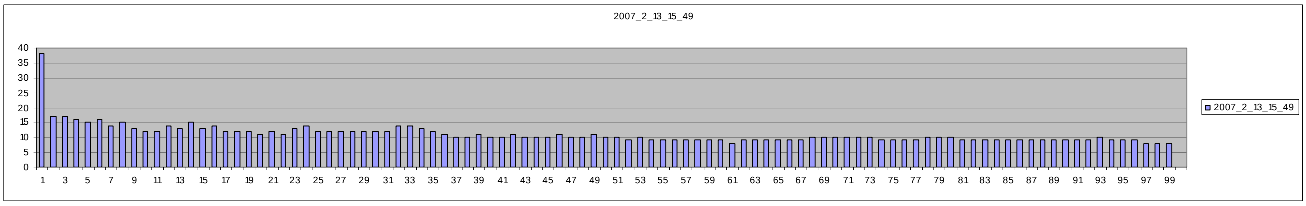


Fig. 4: Usage data gathered for two lecture sessions

As a basis for the analysis of the students' viewing behavior presented in this paper, we selected data gathered from each individual student (as used to show the student's personal footprint). In contrast to the accumulated social data, individual data is stored with a much higher temporal resolution, both with respect to what passages of the lecture had been watched as well as to when the individual student has watched the passage in question. In order to measure the effectiveness of social navigation, social navigation data was only updated once per day. This way, when two or more users watched a lecture at the same day, they did so without knowing that another user had watched that very lecture. Furthermore, they did not know which parts of the lecture others had watched. Consequently, accesses that take place on the same day are not affected by social navigation data gathered during that day.

This way, access rates can be computed for each day without previous accesses on the same day having effects on later accesses during that day. If a segment does not have any accesses from previous days, it can thus be regarded as not being affected by social navigation. Of course, this condition only holds until one day after the segments has been accessed for the first time. For the first day on which the segment has been accessed, all accesses can thus be regarded as not affected by social navigation. All accesses of the segment in consecutive day will be affected by social navigation. This way, access behavior under two different conditions can be easily distinguished and compared. This organization allowed us to easily evaluate the following hypotheses:

H0: Users access logs will be the same under both conditions, i.e. displaying social navigation information does not affect user behavior.

H1: Users access logs will be different under the two conditions, i.e. displaying social navigation affects user behavior.

In order to measure the user behavior, we compared the distribution of hits on intervals marked as viewed before and on intervals marked as not viewed before. The distribution of hits for intervals marked as viewed before is computed as the number of hits on all intervals viewed before a certain date divided by the number of total hits for this date. Respectively, the distribution of hits for intervals not marked as viewed before is computed as the number of hits on all intervals not viewed before a certain date divided by the number of total hits for this date. Since all hits during a specific day are *not* displayed in the social navigation interface until the next day, all hits on the same date are independent from each other. Thus multiple hits on the same date can be counted without causing interferences. On the first access day of a recording, social navigation is not displayed. Hence, the first access date was excluded from the analysis. Additionally, access dates on which less than 5 % of the recording had been marked as visited before were excluded because they had been identified as an artifact resulting from an initial manual quality check. All recordings had been subject to this manual check before they were made available to the students. In order to have a reasonable number of users to measure the effect of social navigation, lectures that had been accessed by less than 10 different users have also been excluded. Table 1 shows the data collected for the recordings fitting these criteria.

Recording ID	2007_1_ 21_22_58	2007_1_ 26_16_38	2007_1_ 26_16_56	2007_2_ 10_10_26	2007_2_ 13_15_49	2007_2_ 14_9_37	2007_2_ 8_9_39

Percentage of hits on intervals marked as viewed before	0.042	1.0	0.69	1.0	0.99	1.0	0.23
Percentage of hits on intervals not marked as viewed before	0.96	0.0	0.31	0.0	0.01	0.0	0.77
Number of users	12	24	11	19	24	16	13

Table 1: Recordings with more than 10 viewers, initial threshold 5%

The means of the distribution values shown in Table 1 are 0.71 for the condition "marked as viewed before" and 0.29 for the condition "not marked as viewed before". This means that lecture segments marked in the social navigation interface as viewed before attracted at average a much higher attention of the users. However, a single tailed paired t-test yields a result of 0.11, which means that this difference is not statistically significant.

A careful analysis of the data hinted that the 5% cut-off threshold is too low. We though that from a student prospect, a lecture recording where just a small portion of content is marked as visited before may not look like really being thoughtfully watched in the past, but rather like randomly sampled. We speculated that in this situation, the users might not consider the social footprints as reliable. To explore this hypothesis, we decided to increase the threshold for access dates from 5 % to 15 %. The resulting data is shown in Table 2. For the recording above the 15% threshold the means of the distribution values are 0.82 for the condition "marked as viewed before" and 0.18 for the condition "not marked as viewed before".

A single tailed paired student t-test yields a result of 0.03, which means that there is a statistically significant difference between the two conditions, falsifying H0. These results allows us to conclude that social navigation footprints significantly affect user behavior causing them to focus more on content, which is indicated as previously viewed by other users. However, this impact does not reach significance until the fraction of previously viewed content reaches some reasonable threshold. In our case, the coverage of 15 % was found to be a critical mass for social navigation to affect the distribution of hit rates.

Recording ID	2007_1_ 26_16_38	2007_1_ 26_16_56	2007_2_ 10_10_26	2007_2_ 13_15_49	2007_2_ 14_9_37	2007_2_ 8_9_39
Percentage of hits on intervals marked as viewed before	1.0	0.69	1.0	0.99	1.0	0.23
Percentage of hits on intervals not marked as viewed before	0.0	0.31	0.0	0.01	0.0	0.77
Number of users	24	11	19	24	16	13

Table 2: Recordings with more than 10 viewers, initial threshold 15%

THE SUBJECTIVE FEEDBACK ANALYSIS

To analyse the users' subjective opinion about the system we analyzed their answers with the end-of-the-class non-mandatory questionnaire. The questions of the questionnaire were grouped in four categories: web lectures in general, virtPresenter (without social navigation features), virtPresenter's social navigation features and specific interface features.

Category	Explanation	Label
general	Usefulness of recorded lecture	g1
	Usefulness of watching recorded lectures in concept clarification	g2
	Usefulness of watching recorded lecture in increase of interest	g3
virtPresenter	Usefulness of system	v1
	Usefulness of time based navigation	v2
	Usefulness of slide based navigation	v3
	Usefulness of backtracking	v4
SNS	Usefulness of footprints on the timeline	s1
	Usefulness of knowing about passages visited by other in locating interesting passages	s2
	Usefulness of knowing about passages visited by other in locating relevant passages to assignments	s3
Interface	Usefulness of showing slide boundries	i1
	Usefulness of showing the target of navigation on mouseover	i2
	Usefulness of visualizing activity of other on a curve	i3

Table 3: Items in questionnaire grouped by category

Table 3 shows the questionnaire's items grouped by category along with the original question number and its symbolic label. In the questionnaire, students could answer the questions by checking boxes on the Likert 1-5 scale (1: strongly agree; 2: agree; 3: no strong opinion; 4: disagree; 5 :strongly disagree). They were also able to mark a specific feature as not noticed (marked as 6 in the figures and tables).

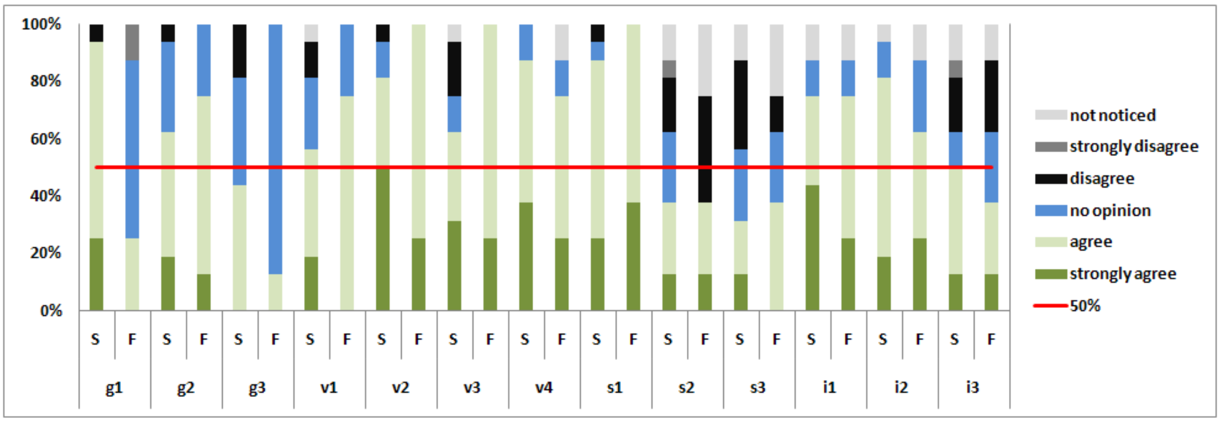


Fig 4: A summary of user answers to the questionnaire (S - spring term, F - fall term)

The overview of student answers (Fig. 4) shows that some features were regarded by users quite positively, while others caused clear disagreement. This figure, however, does not allow us to judge whether the user opinion of a specific feature was significantly positive or negative and whether this attitude was significant. To assess the overall attitude, we calculated the average rating by averaging numeric values of ratings (see Fig. 6 and Table 4). Note that lower numbers indicated a more positive opinion. The figure allows to distinguish a clearly positive opinion (value less than 2), a generally positive opinion (value less than 2.5), non-negative (value less than 3), and rather negative opinion (value above 3). This allows us to easily single out two features regarded by students most positively:

the time-based navigation (v2) and the social navigation (s1). In addition, to assess the significance of the attitude, the student's answers were assessed by t-tested to evaluate two hypotheses:

H0: Students did not agree (operationalized as mean >= 3)

H1: Students did agree (operationalized as mean < 3).

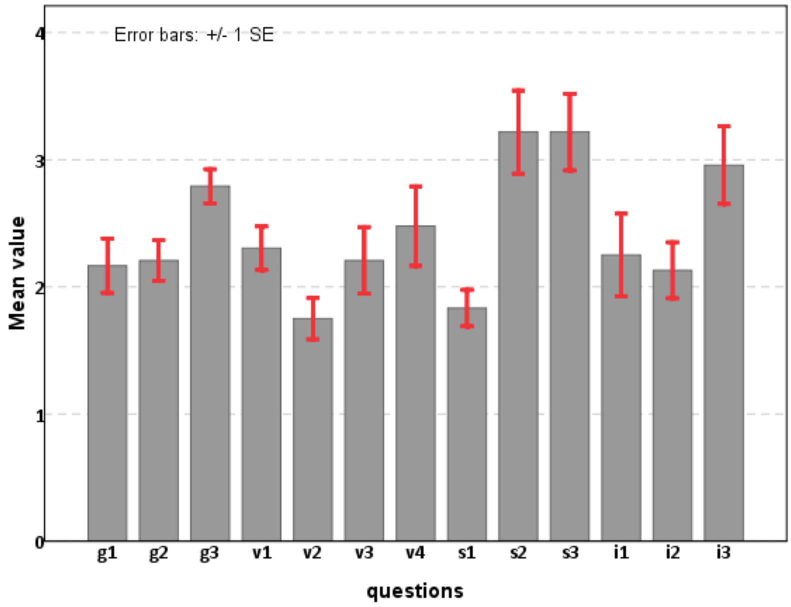


Fig. 6: The average value of user answer showing the general attitude

Question	Mean	Std Error	df	2-tailed p-value
g1	**2.17**	.214	23	**.001**
g2	**2.21**	.159	23	**.000**
g3	2.79	.134	23	.135
v1	**2.30**	.171	22	**.001**
v2	**1.75**	.162	23	**.000**
v3	2.21	.262	23	**.006**
v4	2.48	.314	22	.110
s1	**1.83**	.143	23	**.000**
s2	3.22	.326	22	.512
s3	3.22	.301	22	.478
i1	2.25	.326	23	.031
i2	**2.13**	.221	22	**.001**
i3	2.96	.305	22	.888

Table 4: Mean values and T-test results for questionnaire answers. Significant data are shown in bold

Table 4 shows the results of this significance analysis. Significant results were found for questions g1, g2, v1, v2, v3, s1 and i2, which all featured student positive opinion. The degrees of freedom (*df)* vary since some questions were not answered by all participants.

Focusing on significant results, we can report that the students found the recording useful in general (g1) and in concept clarification (g2). It also shows that the students found virtPresenter useful as a whole (v1) and positively assessed both time-based navigation (v2) and slide-based navigation (v3). Interesting is that the time-based navigation was regarded much more positively than slide based navigation emerging as the most valued feature of the system. The students did, however, not ignore the slide based overview. Instead, they used it to improve contextual orientation when using time based navigation (i2). Most important for the goal of our paper is that the users provide a strong positive feedback on the usefulness of the footprints on the timeline (s1) making it one of the most appreciated features of the system and second only to time-based navigation itself.

6. CONCLUSION AND FURTHER WORK

In this paper we presented our attempt to expand the ideas of social navigation to web lectures, an important case of time-based continuous media. We equipped a web lecture system virtPresenter with a continuous version of footprint-based social navigation and evaluated it in a two-semester long classroom study. The results of this study were analyzed using both objective and subjective data: i.e., the user access log and the answers to the end-of-the-term questionnaire.

The analysis of user logs has shown that continuous footprint-based social navigation support can significantly affect user navigation and can influence user navigation encouraging them to pay special attention to lecture fragments viewed by other users. This result is in agreement with the impact of social navigation found in discrete link-based media. We discovered, however, that fraction of previously viewed content should reach some threshold (in our study – 15%) to affect future users. We speculate that below this threshold the lecture is not considered as viewed thoughtfully and the users do not consider footprint as reliable. These hypotheses, however, should be assessed by further studies.

The questionnaire-analysis has shown that the students regarded most important features of the system (including time-based, slide-based, and social navigation) very positively.

The results of this work have motivated further work on social navigation for web lectures. A newer version of the social navigation approach for web lectures has been developed and tested at the University of Pittsburgh. The re-designed footprint-based navigation support has been included in the production version of virtPresenter, which is now available for many lectures at the University of Osnabrück. Currently, we are running an extensive evaluation of the new system using 90 individual lectures with about 600 available episodes. We already collected data of thousands of students from different disciplines who used the social navigation functionality within the virtPresenter system. With the help of this data it has become possible to automatically generate a visible structure in otherwise unstructured time based media. Our future plans focus on including more semantic information about the user and the user's intention while working with the media content in order to improve the significance of the visual representation. In addition, we plan to explore the use of bookmarks in social navigation.

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