Sliders Versus Storyboards – Investigating Interaction Design for Mobile Video Browsing

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Abstract. We present a comparative study of two different interfaces for mobile video browsing on tablet devices following two basic concepts - storyboard designs representing a video's content in a grid-like arrangement of static images extracted from the file, and slider interfaces enabling users to interactively skim a video's content at random speed and direction along the timeline. Our results confirm the usefulness and usability of both designs but do not suggest a clear benefit of either of them in the direct comparison, recommending – among other identified design issues – an interface integrating both concepts.

Keywords: Mobile interfaces, Mobile video browsing, Interactive multimedia.

1 Introduction

The increasing availability of videos on mobile devices also results in a growing need for better search and browsing functionality – not just in video archives but within single files as well. Confirming predictions of earlier studies [1], users these days want to interactively skim video content, for example, to find parts of particular relevance or skip ones of minor interest. Especially in situations when the searched information is unknown or hard to describe by queries and when watching videos for fun, users often rely on personal, interactive skimming of video content in addition to query-based retrieval. Yet, browsing videos is traditionally a difficult problem due to the transient nature of the continuous signal. In contrast to static information, such as text and images, videos are time-dependent, i.e., only a fraction of their content is displayed at a time. Most common approaches for video browsing therefore usually follow one of two principles: they either give people more interactive control over the timeline or dissolve a video's transient nature by representing the dynamic signal via a static one. Maybe the most omnipresent example for the latter approach are so-called storyboards, where thumbnails of still images extracted from the video are used for a time-sorted, grid-like static representation of the content that is easy to browse by humans. Examples enabling users to manipulate a video's timeline in order to flexibly browse its content include simple fast forward or slow motion (e.g., to quickly skim a video and to investigate a particular area of interest in detail, respectively) and, maybe most important, slider interfaces that represent a video's timeline and allow users to interactively and flexibly "scroll" though its content by providing

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real-time feedback when dragging the slider's thumb. Applying such approaches to mobile devices, such as smartphones and tablets, introduces a whole set of additional problems, mostly due to their form factor and resulting limited screen estate. Motivated by the ultimate goal to create better browsing interfaces for such mobiles, we present a comparative study between two interface designs for video browsing on tablets – one featuring a storyboard, and one with extended and optimized timeline sliders. Our research aims at identifying advantages and disadvantages of each concept, verifying their usefulness for mobile interface design, and gaining knowledge about how to best integrate them into common video players, considering search and browsing performance as well as usability and personal user preferences. After discussing related work (Section 2), we introduce two interface designs (Section 3) that are evaluated in a comparative study providing answers to aforementioned questions (Section 4) and identifying general design issues and alleys for potential future research (Section 5).

2 Related Work

Video browsing is an important and relevant topic that has gained lots of attention for desktop computing. In the following, we will mostly discuss related work for mobile computing and focus on browsing via interactive exploration, in particular via storyboards and slider interfaces. For excellent general reviews we refer to [2] and [3].

Interfaces using static representations of video content (i.e., thumbnails created from extracted video frames) have been introduced and researched in various incarnations. Examples include different arrangements of such thumbnails, such as film stripes [4] – nowadays often used when browsing video archives – and storyboards [5], i.e., matrix-like structures with thumbnails temporally sorted line-by-line from top left to bottom right – nowadays often used to represent the content of long, single video files. Special cases such as comic-book-style visualizations [6] and 3D representations [7] exist as well. Other researchers investigated the benefit of replacing still images with "moving" thumbnails, i.e., small clips extracted from the video [4], [8]. Related work on mobile devices mostly focused on investigating optimum thumbnail sizes for small screens [9], still versus moving thumbnails [10], and interaction techniques such as paged versus continuous scrolling [11]. Related results, for example, with respect to optimum thumbnail sizes have been considered in our interface designs presented in the next section.

To the best of our knowledge, there is no comparative evaluation of storyboards with interactive timeline-based video browsing using slider interfaces yet. Considering the latter, we can however observe a trend of integrating storyboard-like visualizations into the browsing process, for example, by visualizing related thumbnails on top of the slider's thumb while dragging – as done in the popular YouTube online video platform (cf. Fig. 1). However, especially with small screen sizes on mobile devices, moving the slider even just one pixel can result in a relatively large jump in the file, thus not enabling users to explore content in detail. Several researchers have addressed this *granularity problem* with different interface designs. Examples from mobile video browsing include circular and elastic interfaces [12] as well as the

ZoomSlider [13] where skimming a video is done by left/right gestures on the screen and browsing granularity depends on the gesture's vertical location. While this enables users to flexibly navigate a file at different levels of granularity, it introduces another problem, namely that content is often covered by the user's fingers. [14] addresses this issue with an interface design optimized for smartphone-sized screens that can be operated with one hand. Accidental content hiding is reduced to a minimum by placing the thumbnails to the left of the screen and browsing them via gestures made on the right side. Yet, the solution does not account for the aforementioned granularity problem. [15] addresses both issues with a video browsing interface for tablets that can be operated with one's thumbs when holding the device in both hands. The right side features a thumbnail-enhanced slider for video browsing, while the left side of the screen enables users to activate different functions, including an option to modify the right thumbnail-slider's scale. Their idea of using such "vertical" sliders to make them easier to reach and limit accidental information hiding served as inspiration for the enhances slider interface we introduce in the next section.

3 Interface Designs

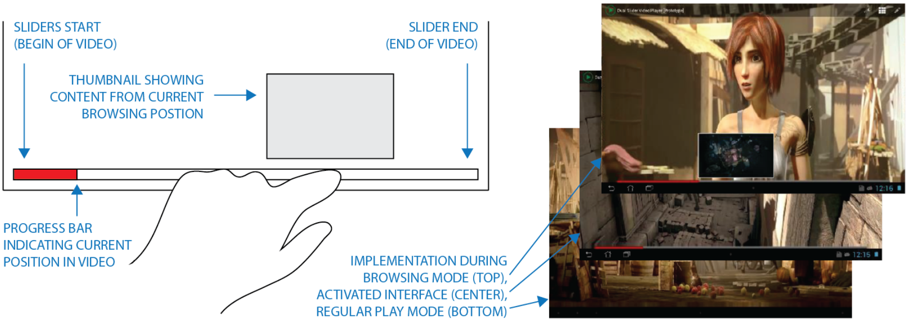

Fig. 1. State of the art video browsing interface implementation

Motivated by the state of the art and as starting point for our research, we implemented an ***initial player interface*** based on the popular YouTube design (cf. Fig. 1). It features a slider at the bottom, representing the length of the video, with a thumb that enables users to quickly access all positions along this timeline. The interface is hidden during normal playback but becomes visible as soon as a user touches the screen. To provide real-time feedback during browsing, a thumbnail image representing the corresponding content is displayed on top of the slider's thumb while it is dragged. Informal testing confirmed obvious advantages such as flexibility, familiarity, and the fact that location feedback with respect to the whole video file is provided. Yet, we also saw that the design suffers from the granularity problem mentioned in Section 2, and the single thumbnail providing only limited content information. In order to deal with these two issues, we introduce two alternative designs that we evaluate in a comparative study in the next section – one storyboard-based, in order to deal with the latter problem, and a modified, enhanced slider interface addressing the granularity issue while also providing more content information during browsing.

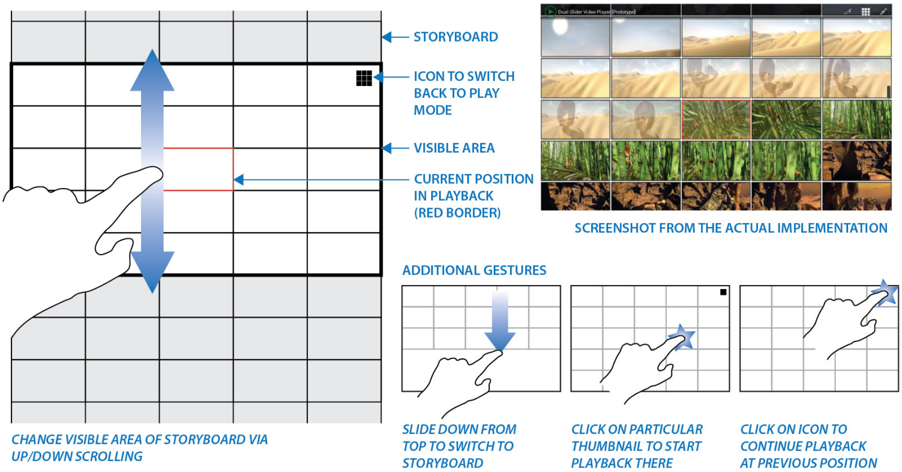

Fig. 2. Storyboard design implementation

Our ***storyboard design*** extends the initial player interface by featuring a separate storyboard with a 5x5 grid layout that can extend to the top and bottom beyond the screen, as illustrated in Figure 2. Scrolling to parts of the video before or after the currently visible area is done via up and down gestures, respectively. In order to illustrate the location of the currently visible part within the whole video, a scrollbar-style icon is added to the right side of the screen. Informal user tests with colleagues and students otherwise not involved in this project were used to confirm its usability and identify potential issues. *Potential advantages* of such a design include that it provides detailed content information that is easy to skim due to its static character. The layout is usually considered intuitive and easy to understand following common interaction designs that people are familiar with. *Potential disadvantages* are that the additional display of content also enforces additional interaction (up/down scrolling) and the need to switch between two separate screen layouts for playback and browsing. For example, in our concrete implementation, switching from player to storyboard view is done either by clicking on a related icon at the top of the screen (in pause mode) or by a down gesture starting at the top of the screen (in pause and playback mode). It is also not clear how accurately and easily people can spot relevant parts despite the intuitive layout and how well they are able to handle it in a real-world situation. For example, direct interaction is usually considered more intuitive, but might result in people covering relevant parts of the content with their fingers during operation.

Slider interfaces are usually placed at the horizontal side of the screen (top or bottom, cf. Fig. 1), thus minimizing the risk of covering relevant content during browsing. Yet, when comfortably holding the device with two hands, it still requires people to release one hand from the device during operation. Partly inspired by [15] we therefore decided to place the slider in our enhanced ***slider interface design*** vertically on the left (cf. Fig. 3). While this makes the interface easier to reach, it even increases the already existing granularity problem due to the screen's aspect ratio (height < width). We aim at coping with this issue by introducing a second slider bar on the right side of the screen for more fine granular navigation. It only represents a fraction of the whole video and displays additional content information in the form of a vertical filmstrip. A small indicator is added to the left slider to illustrate which part of the video is represented by the currently visible filmstrip. Initially, the visible part on the right matches the current video position, but it can be modified by related up and down scrolling gestures. *Potential advantages*, again identified with informal studies, include better visualization of more content during browsing compared to the standard interface (Fig. 1) plus support of higher and lower granularity levels. The left side can be used to get a quick overview of the file or find a larger region of interest (e.g., a particular scene), whereas the right side can be used for more detailed skimming (e.g., to find a specific event in that scene). In addition, the interface can be operated easily while naturally holding the device in two hands. *Potential disadvantages* include a less familiar design with timelines that are placed vertically instead of the usual horizontal arrangement. For example, in the informal studies, we asked what mapping people considered more intuitive – having the video start at the top or at the bottom of the vertical slider. While the majority agreed on starting at the top (mostly due to being used to read from top to bottom), a noticeable number seemed to prefer a reversed design. Common reasons included that "it starts at the same position then as the familiar horizontal design" and that "it resembles filling a glass" when playback is progressing. In the tested version, we decided to place the start at the top of the screen. Similarly to the standard interface, the control elements are hidden during regular playback but appear as soon as a user touches the screen.

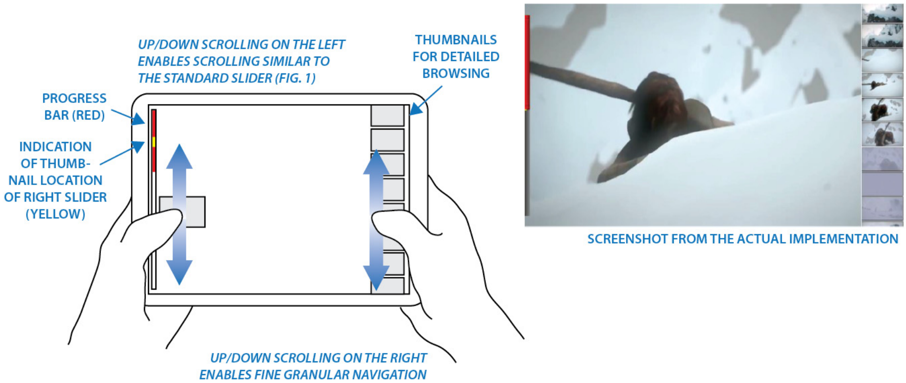

Fig. 3. Enhanced slider interface implementation

4 Comparative Study

In order to verify the presumed advantages and disadvantages described above and to gain further insight with respect to usability, performance, and general interface design for mobile video browsing we compared the storyboard and slider interfaces in a controlled experiment. 24 students volunteered as test subjects (17 male / 7 female, ages 18-27 years with an average of 21.3). 19 were right handed, three left handed, and two had no preference. None of them were involved in any of the informal pre-studies or had any other knowledge of our project. Not all owned a tablet, but all were familiar with them or related touch interaction, for example, via mobile phones or devices owned by friends and family members. No noteworthy difference could be observed in the tests considering age, handedness, gender, experience, or pre-knowledge of the movies used.

4.1 Study Design

Two movies with a length of about 15 minutes were used for the experiment[1]. In a within-subject design, each participant tested both interfaces. Interface order as well as association of the two movies to the two designs was counterbalanced, leading to four setups, each used by six of the 24 subjects. Inspired by the Video Browser Showdown competition [16], users had to perform tasks resembling a Known Item Search (KIS) where they are presented a clip of five seconds from the movie and had to find a frame from that clip using one of the two interfaces. Clips were extracted from the video roughly every two minutes and presented to the subjects in randomized order with the restriction that a following clip cannot be within the same 1/5th portion of the file to avoid targets being too close to each other. For each interface, there were nine tasks of which the first was a training assignment and not considered in the statistical evaluation. The last four of the remaining eight tasks also contained some rough location information indicating that the clip can be found in the first, second, third, fourth, or final fifth of the file in order to simulate situations such as "I remember it was roughly at the beginning of the file." Users were encouraged to solve the tasks as quickly as possible.

During the actual tests, users were seated on a chair and held the device freely in their hand or on their lap. Clips of the tasks were played on a separate computer screen. After reading a printed tutorial containing screen shots with explanations about the tested interfaces, subjects started to do the nine tasks for the first interface (one training, four standard KIS task, and four KIS tasks with rough location information), followed by the nine tasks for the second one. Afterward, a related questionnaire was filled out and an informal interview and discussion took place. The whole procedure took about 20 minutes per person.

In addition to the questionnaire and informal interview, other qualitative data was gathered via observation of the otherwise neutral executor of the experiment who also

[1] *Tears of Steel* and *Sintel* from the Blender Foundation, cf. `http://archive.blender.org/features-gallery/movies/index.html`

noted comments made during the tests. Quantitative data, such as interactions and time to solve a task, was logged directly on the device. For the tests, we used an Asus Transformer Pad (TF300T) with 10.1-inch screen size (1280x800 pixels resolution) running Android version 4.1. The implementation was optimized for speed using the OpenGL ES 2.0 library. Thumbnails were extracted from the video and generated on the fly, enabling real-time usage of random video files, but resulting in a slight delay during very fast scrolling operations in the storyboard layout. We did not get the impression that this delay had any negative effect on the results, nor could we observe any related issues in the logged data. Yet, it might have had a small impact on the subjective user ratings (cf. below).

4.2 Results

Holding the Device. One of the major advantages we expected for the enhanced slider interface compared to the storyboard design was that people can operate it with their thumbs while comfortably holding the device in both hands. However, analyzing heat maps created from the logged data (indicating which areas people touched during the tests) and observational notes from the neutral observer showed that only one user constantly held the device like this, but all others had it in their non-dominant hand most of the time and used the dominant one for interaction. Only nine subjects operated the slider on the right, which provided a more elaborate and detailed view of the content, with their thumb. One switched midway from thumb to finger operation. This observation is independent of the order in which the interfaces were tested (five of those nine started with the storyboard design). Despite this unexpected behavior, several users explicitly commented positively about the design and placement of the sliders, characterizing them as “easy to reach”, “good positioned”, and “more handy” than the storyboard. Only one subject made explicit negative comments on the rather uncommon vertical placement.

General Usage and Operation. The storyboard design was mostly used as intended. After switching to storyboard view, subjects used up and down scrolling gestures (mostly with their dominant hand) and visually skimmed the thumbnails in search for content from the played clip. Yet, in 35% of the tasks, users solely relied on the original player’s slider bar (Fig. 1) and did not use the storyboard at all. For 17% of the tasks, people exclusively relied on the storyboard, whereas for the rest, subjects used a combination of both (mostly slider first, then switch to storyboard). Surprisingly few participants made comments about how their interactions occluded content and thus interrupted their search process. For the slider interface, in about 65% of the cases subjects did indeed use the interface as intended, i.e., in a mixed approach where the left slider was used to roughly find an area of interest and the right one to further explore this area and find the concrete target. Yet, like with the storyboard design, in almost 35% of the cases people solely used the left slider. These observations for both interface designs indicate the initially identified advantages of the standard slider interface (cf. comments on the related informal studies for the initial player interface at the beginning of Section 3). They further show that people appreciate and need advanced browsing functionality but if and only if it is needed (it should be noted that not all tasks were solvable with the left/bottom slider due to the aforementioned granularity problem).

Search Time. For the slider interface, obviously, the cases where people were able to solely rely on the coarse slider on the left screen side to solve the tasks resulted in a much lower search time than the ones where it was necessary to use the more detailed view provided by the right slider. Average times for a single task were 22.73 seconds for the first case (left slider) versus 54.87 seconds for the second (both sliders used). Observations for the storyboard design are comparable (23.33 sec average search time for exclusive slider usage versus 63.73 seconds for a mixed approach). Average search time for the 17% of the cases where people solely relied on the storyboard was in between (39.72 sec).

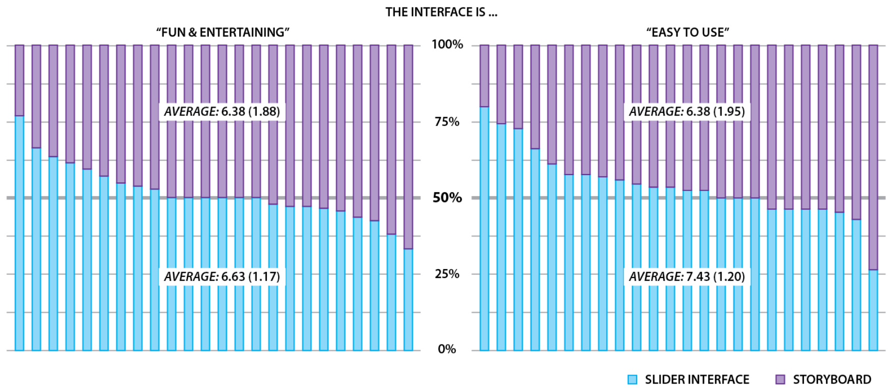

Fig. 4. User ratings for the two tested designs sorted by user with decreasing preference for slider interface design. Values are normalized per user (i.e., 50% corresponds to an identical rating for both designs). Averages (and standard deviation in brackets) are absolute values between 0 (= totally disagree) and 10 (= totally agree).

User Preference and Ratings. When analyzing our observation notes and the logged interaction data we were not able to identify any particular preference or context that might speak in favor of one of the two tested designs over the other. This is generally confirmed by the user ratings. Although people expressed some preferences, in most cases opinions about both designs did not differ by much. In particular, when asked to rate experience ("fun and entertaining") on a scale from 0 (= "totally disagree") to 10 (= "totally agree"), users gave an average rating of 6.63 for the storyboard design versus 6.38 for the slider interface. Figure 4, left, shows the normalized preference on a per user base, illustrating that nine subject had a slight preference for the storyboard, nine for the sliders, and six did not see a difference. Considering usefulness ("easy to use") we observe a slight preference towards the slider design (14 users, cf. Fig. 4, right, versus three neutral ones and seven with a preference for storyboards). This is reflected in the average ratings (7.43 in preference of sliders versus 6.38 for storyboards) but in most cases the differences are only minor (e.g., lower than 10% in 18 of 24 cases). Yet, they are also evident when subjects were asked to directly compare both designs: 14 preferred the slider interface, two were neutral, and only eight preferred the storyboard. When prompted to justify their preference, many subjects indicated the necessary switch between two layouts as a major negative issue of the storyboards. In contrast to this, a fewer, but non-negligible amount of subjects made opposed comments, i.e., expressed appreciation for the storyboard noting that the thumbnails from the slider interfaces were occluding the player window. Although they generally did not consider the slight delay in thumbnail generation for very fast scrolling operations to be a major issue, some users explicitly commented negatively on it, so it might have had a slight influence on the ratings as well. Many people explicitly praised the clearness and clarity of the storyboard design, mentioning its detailed overview. Positive statements often mentioned in relation to the slider interface characterized it as “fast”, “easy to use”, and “intuitive”.

Perceived Search Time. As said above, comparing the average search times per task for the two interfaces, we can observe similar trends and comparable performance for both designs. Likewise, if we compare them on a per user base, 13 were faster with the storyboards, whereas 11 were slightly faster with the slider interface. Yet, when being asked about which interface they assumed to have performed better with, two subjects said that they cannot tell, four assumed they did equally well with both, five suggested a better performance with the storyboard, and 13 thought they were faster with the slider interface. However, in both of the latter cases, users’ opinions were frequently wrong compared to their actual performance (3 of 5 for the storyboard, 6 of 13 for the slider interface). Apparently, the slight preference for the slider design expressed in the qualitative ratings and statements discussed above also affected the perceived performance (and vice versa).

4.3 Discussion

Because all but one single task (which contained a scene similar to the target clip elsewhere in the file) have been solved correctly, we can conclude that both interface designs are useful, intuitive, and easy to operate even without any significant training time. No differences in both performance and usage could be identified between the first four and last four tasks (which included additional location information).

Users generally liked the designs, frequently characterizing both options, for example, as “cool”, “nice”, and visually appealing. Yet, preferences for either of the designs were mixed with different users making contradictory statements to each other. These comments are confirmed by the user ratings and other observations discussed above. No direct relation between performance and user characteristic (e.g., gender, experience) could be identified, thus suggesting that differences are mostly due to personal preference, individual taste, and habits.

Maybe the biggest surprise for us was that few subjects used the slider design in the way we intended, i.e., holding it comfortably with two hands using their thumbs for operation, although they were purposely seated on a chair during the test where they could not put down the device on, for example, a table resembling a more "relaxed" situation (e.g., when sitting in an armchair or on a couch at home). It is unclear if this is due to a still existing laboratory atmosphere during the experiment and its limited duration or if we just overestimated the wish of users to hold devices in a more comfortable way during browsing.

5 Conclusions and Future Work

In contrast to most related work, which either aims at exclusively optimizing and evaluating either storyboard designs or slider interfaces, our research targeted a direct comparison between these two concepts. Yet, the comparative study could neither reveal a clear advantage of one approach over the other, nor identify concrete situations in which either of them should be preferred. It appears that both have their merits thus suggesting a seamless integration of both for optimum interface design. In particular, we draw the following conclusions for the general design of better mobile video browsing interfaces from our observations:

First, we saw that people still rely on the rather simple, but intuitive and easy to operate standard slider interface if search tasks allow for it, suggesting that advanced techniques should only complement such existing designs and need to be seamlessly integrated into the browsing process. While this seems obvious and in line with general interface guidelines, looking at many of the proposed designs introducing new, complex (and useful!) features but neglecting existing yet powerful and established approaches, it also seems noteworthy and important to highlight.

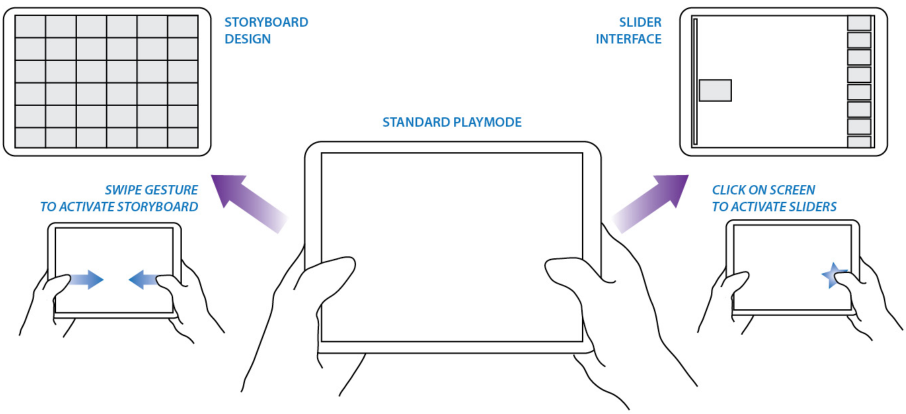

Fig. 5. Proposed design, seamlessly integrating both interaction concepts

Second, this observation also emphasizes the importance of a "smooth", seamless integration of more complex and advanced techniques with the simpler but established and powerful ones. Considering the concretely tested two designs, a combination of both approaches could of course easily be done. In fact, some users even suggested this or asked why we are not just integrating both designs into one. And our observations suggest that such an integration not only could but also actually should be done. Figure 5 illustrates this idea, providing an interface where users could start using simple browsing actions (standard timeline sliders) first, then switch to more advanced ones depending on context, situation, and personal preference (again following commonly accepted design guidelines from other domains, such as Sheiderman's Visual Information-Seeking Mantra [17]).

The proposed design (Fig. 5) also fulfills our design goal of creating an interface that can be operated easily and comfortable when holding the device in two hands, which we assumed to be the most common and preferred way. Yet, as a third and final general conclusion our experiments showed that such intuitive and seemingly reasonable assumptions do not necessarily hold in practice. Although some users commented positively on this, the actual usage data does not clearly verify it and might even suggest different, less expected behavior.

One major aspect for future work is therefore a more detailed investigation of the latter issue, for example, via a long-term study under more realistic conditions (e.g., using the system at home versus in temporary restricted and artificial lab settings). In addition, our experiment was purposely designed to focus on user experience and testing if and how well users can operate the proposed designs, even at the risk of not being able to gain conclusive results considering actual search performance. A more detailed study focusing explicitly on that issue and, for example, aiming at identifying situations and contexts in which one browsing approach might be superior to another would be important. This includes the evaluation of other search tasks than KIS. Finally, further developments of both the actual data visualization (e.g., content-dependent storyboards) and interaction (e.g., different gestures for scrolling) seem like important and interesting options with potential for better mobile video browsing interfaces as well.

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