Moving freely while staying on track — Smart Glasses to Support Lecturers

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Abstract: This paper explores the use of smart glasses as a supporting tool for lecturers. Typical constraints of lecture rooms, like fixed lecture stands and projection surfaces, impose limits on a lecturer's interaction with the audience. Wearable devices like smart glasses could allow the lecturer to move freely, keep continuous eye-contact to facilitate attention, while providing unobtrusive access to time information and lecture notes. Following a human-centered design process (HCD) the development and evaluation of a working prototype is presented. Results of the HCD process show the potential and feasibility of the proposed design solution, but also highlight the limitations of the current technology.

Keywords: face-to-face teaching, lectures, wearables, smart glasses, Google Glass

1 Introduction

The physical room of a face-to-face lecture is still very important in education. However, in many lectures, the lecturer uses a data projector to visualize content. While convenient, the use of a computer on a fixed lecture stand requires the lecturer to stay in one place or frequently return to it, e.g., to advance the slides or look at lecture notes to stay on track (e.g., using the Presenter Display in PowerPoint or Keynote). Using the lectern "hides" most of the lecturer while looking down on the notes breaks eye contact with the audience. Although remotes allow advancing slides from any location, they do not provide lecture notes. Smartphone apps like Apple's Keynote iOS App do provide this information, but require the lecturer to look down on the small screen and thereby also breaking contact with the audience.

Time keeping is another challenge — considering topics in a lecture can take longer than expected if the students have questions or topics can be skipped, if the students already know about it. While clocks are in plain sight in many lecture rooms, they do not provide direct feedback when, e.g., half of the time is up, or when there are only five minutes left. The lecturers have to remember to look at the clock, calculate the remaining time and match the remaining content with the remaining time. Again, a presentation view of Keynote or PowerPoint can provide this information, but again only at the lectern.

Given these constraints of the lecture room, we look at ways to improve its infrastructure

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in order to increase presence and eye contact with the students. We want to enable the lecturer to move freely and keep in contact with the audience to facilitate attention, while having unobtrusive access to lecture notes to stay on track and on time.

For this purpose, wearable devices like smart glasses seem very well suited. They are carried by the lecturer who can move freely. Smart Glasses, like Google Glass [St13], could display information about the presentation in real-time within the field of view of the lecturer (cf. Fig 1) while maintaining eye-contact with the audience.

But is this really the case? To address this question, we ask:

1. Can lecturers be supported by smart glasses like Google Glass?
2. What are the strengths and weaknesses of smart glasses in a lecture setting?

The study follows an ISO 9241-210 human-centered design process (HCD, [Pr11]), which was used to develop a working prototype. Steps in the process include understanding and specifying the context of use, specifying the user requirements, developing a prototype, and conducting multiple formative evaluations and a main summative evaluation of the prototype.

Fig 1: Google Glass Explorer Edition

When dealing with the use of smart glasses in face-to-face higher education, it is important to keep in mind that Google Glass does not replace the infrastructure already in place. It augments it and provides the lecturer with more freedom and possibilities to interact more directly with the audience.

2 Technical Background and Related Works

Smart glasses are a subcategory of head-mounted displays (HMDs). HMDs have been a topic of research since the late 1960s [Su68]. In recent years, commercially available and less expensive devices have become available with different characteristics. Important differences between models are whether the screen is projected on one eye (e.g. Google

Glass) or both eyes (e.g. Epson Moverio series), and whether the image is projected in the line of sight (e.g. Epson Moverio series) or above the line of sight (e.g. Google Glass). For use in lecture settings — with focus on eye contact with the audience — Google Glass seems to be the best choice. Google Glass Explorer Edition [Go17a] (cf. Fig 1) projects the image on a prism in front of the right eye (with a display resolution of 640 x 360 pixels) and seems relatively unobtrusive. Its unobtrusiveness should make it well suited for keeping eye contact. Even when looking at the projected image, the lecturer is oriented towards the audience and does not need to return to the lectern.

Studies with smart glasses have already been conducted in different application domains, for example regarding use cases and usability challenges in the healthcare domain [MWH15] or exploring the use of smart glasses in the museum [Ma16]. These two settings exemplify main potentials of smart glasses: interacting freely with a mobile computer, e.g. hands-free in sterile environments, and displaying information in mobile contexts, including by means of augmented reality (AR).

The mentioned potentials are also highly relevant in the education domain, for example regarding the potential usage of Google Glass for training future scientists in laboratory work [Hu15]. The authors' findings show the potential of smart glasses when it comes to situated access to information — hands-free if needed — but also point out technical and usability limitations. One important limitation shown by previous studies is user input via speech recognition (e.g., [We14]). In an educational setting, different students can be speaking at the same time, which results in errors in speech recognition. The authors propose the use of head gestures as an alternative.

A study in the context of higher education by [EME16] also explored the use of Google Glass in a face-to-face lecture setting, with an application displaying live results from an audience response system. The study addresses some issues with Google Glass including lecturers wearing eyeglasses, interfering light sources in the environment, limits to the amount of information presented, difficulties with input controls, the necessity of habituation to the device, excessive heat generation, short battery life, and unstable internet connection. Conscious of these limitations, the authors nevertheless concluded for audience response systems that Glass has benefits in face-to-face lectures and increases interaction with the audience.

Looking at the prior work, smart glasses like Google Glass do seem to have potential in educational settings. However, they also come with limitations. The questions remain: Can smart glasses support lecturers? What are their strengths and weaknesses of smart glasses in this context?

3 Analysis

As first step in the HCD process, interviews with the target audience were conducted to assess design features and possible concerns, followed by a context analysis.

3.1 Interviews

To understand and specify the context of use, six interviews were conducted with lecturers and research assistants at a university. All interviewees had prior experience with Google Glass, ranging from short tryouts to thorough testing and app development. Questions assessed lecturing habits, Google Glass, and ideas to support lectures with Google Glass.

Results regarding lecturing habits showed that the interviewees used MS PowerPoint or Apple Keynote, some in combination with remotes. No one used additional smartphone applications. Lecture notes were usually used for scientific presentation, not for lectures. However, they were open to trying out lecture notes if they would work with Google Glass.

The hardware itself was seen critically — with low display resolution, battery life and heat generation being the main issues. However, its potential was regarded as high enough to be willing to try a lecture app on Google Glass, although not yet in real lectures.

While Google Glass was preferred for visual feedback during a lecture, most preferred using a different device as input controls. Neither speech control nor head movements were seen as suitable in the context, and the touchpad at the side of Google Glass was seen as acceptable. However, regularly “scratching” one’s head to interact with the Google Glass touchpad was seen as a distraction. Given lecturers stand exposed in front of an audience, some worried that they could look ridiculous when interacting with Glass.

Desired information on Glass varied between the different participants and included (in no particular order) lecture notes, current slide, next slide, current time, countdown time, and titles of next slides. Other, more advanced features — like taking pictures, streaming video, or web searches — were seen as interesting, but not regarded as crucial for a first prototype nor used regularly in lectures.

3.2 Context Analysis

Preliminary informal tests with Google Glass revealed differences in display readability depending on the kind of room. Readability was better in flat seminar rooms as the image was usually seen against the background of a white wall. Lecture halls with rising rows of seats constitute a "noisy" background, thus reducing readability.

3.3 Conclusions from Analysis

Given the heterogeneity in desired information, even within the small sample size, a modular layout supporting different information types is needed. Given the "noisy" background, especially in lecture halls, high contrast and clearly distinguishable colors are required. For controls, speech and head tracking is unsuitable for a presentation context. Either the touch pad of Glass has to be used, or the input has to be done via other devices like handheld remotes or smart watches.

4 User Interface Concept

How can the relevant information be presented for the lecturer on smart glasses? We look first at design guidelines and then present our prototype concept.

The Google Glass platform offers two different types of user interface patterns [Go17b]. The "timeline" pattern offers a consistent appearance for the home screens and settings of Google Glass. The "immersion" interface pattern is suitable for stand-alone applications that need to deviate from standard Google Glass applications, e.g. by implementing a custom user interface.

Given the use case — a specialized user interface for lecture support — the immersion type was chosen. The main screen of our user interface consists of three different areas. A three-row layout provides the heterogeneous target audience the flexibility to configure the layout to their preferences or the situational characteristics of the room by allowing for many different combinations of content modules. At the same time, it provides some structure to reduce information overload.

The main area in the center should handle information-heavy content, especially content modules displaying slides and notes. Two bars at the top and bottom are intended for additional information that does not take up much space, e.g., content modules displaying slide headings, timers or clocks. If areas are not used the other design elements scale up to use the otherwise unused space.

Fig. 2 shows an early mockup of the user interface. In this instance, the configured layout is comprised of six content modules:

- The top bar accommodates a module (1) showing heading of the current and the following three slides. It is modeled after announcement systems in public transport systems.
- In the center, the current slide (2) is shown on the left side, complemented with the matching presenter notes (3) on the right.
- The bar at the bottom contains three modules. The module on the left shows the time passed since the presentation was started (4). In the middle, a progress bar (5) displays the ratio of displayed to upcoming slides. The module on the right displays the current time of day (6).

A formative evaluation of the user interface concept revealed issues with readability regarding the module in the top bar. Headings were frequently too long to display them for all four slides. Possible approaches for a solution included: scaling down font size, shortening headings or displaying fewer headings. However, each of these solutions poses new questions that needed further research. Thus, the particular module was removed in this first prototype.

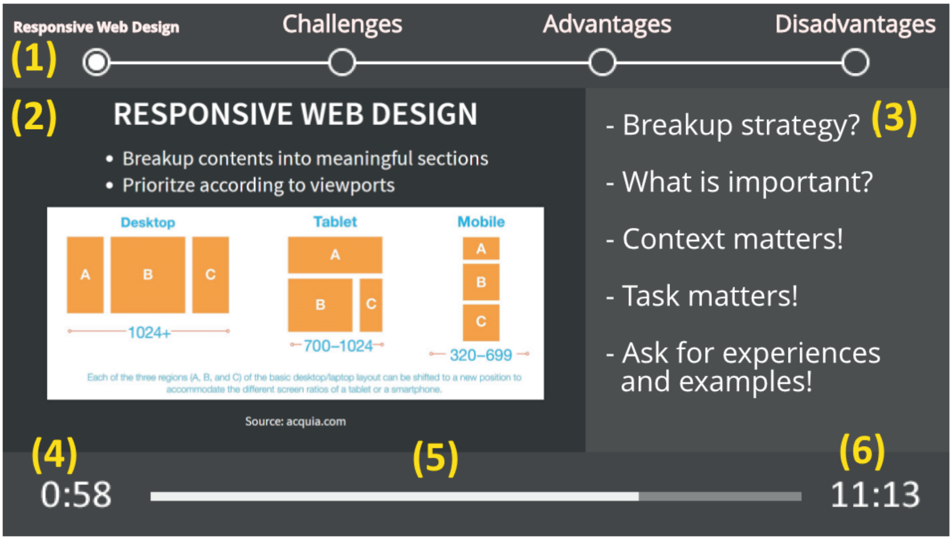

Fig. 2: Early user interface concept of the presentation view

The resulting user interface concept addresses both the heterogeneity of the user group and provides some structure to avoid information overload.

5 Backend System for Google Glass

A Google Glass application alone is not sufficient to realize the envisioned scenario. A backend system must be in place to control and deliver the lecture slides to the device. To keep development simple in this prototyping stage, the HTML presentation framework reveal.js [Re17] was chosen for presenting the slides. The use of HTML based presentations allows a clear separation between content and visual styling, enabling the use of different design templates on different devices. The devices were connected via WebSocket protocol by using the multiplexing plugin of reveal.js. The multiplexing plugin uses a Socket.io [So17] server and the publish-subscribe pattern to synchronize application events, e.g. display next slide, across connected devices. The developed system potentially allows for multiple devices being connected at the same time (including student notebooks and the like), but our focus is on a single lecturer.

The Google Glass App itself has been implemented using the Glass Development Kit

(GDK) with Android API level 19. The app consists, among others, of the following Android activities**:** In order to connect to the web-based presentation system, the app starts with the providing users with a Quick Response (QR) code. After successful connection, the *PresentationActivity* shows the previously chosen layout or a standard layout. The user can now navigate the slides of the loaded presentation by swiping horizontally on the touchpad. For this slide navigation, the interaction model from the Google Glass Timeline was adapted. Thus, a swipe from front to back moves the slide to the left, vice versa a swipe from back to the front moves the viewport to the right. Following the Google Glass design principles two other gestures have also been implemented: First, swiping down stops the App and brings the user back to the timeline. Second, a tap on the touchpad opens the *MenuActivity* of the app.

The menu is a substantial part of this application, as configuration and individualization of the user interface are very important both intra- and interindividually: First, as outlined above, the layout may be customized depending on user and physical context. Second, due to the current low availability of Google Glass, there might not be one device for every lecturer and switching layout profiles might be a regular task. To address these issues, possible solutions like configuration by a connected smartphone, the use of a web service or manual configuration were discussed. To keep the prototype simple, we opted for a manual approach. Settings relevant for a single presentation should be transferred via scanning of the QR code. More enduring settings, like the presentation layout, are configured in the menu.

Three different layouts were implemented for the summative evaluation of the prototype. One is shown in Fig. 3 primarily using the center region for displaying current and upcoming slides. The available slots in the top and bottom bar are not used, except for a timer in the bottom right displaying the elapsed time of the presentation.

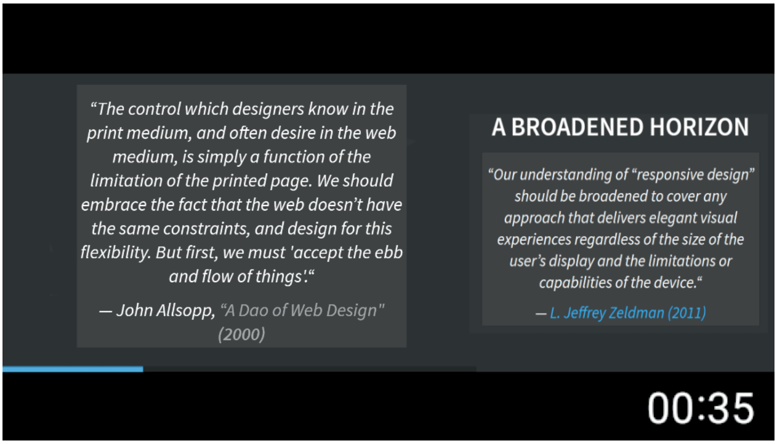

Fig. 3: One of the implemented layouts, showing current slide in the left, next slide on the right.

The thin progress bar starting on the left center region is conveniently embedded in the

HTML presentation layout thus not taking any more limited display space. In the second layout option, the right main region showed the current display notes instead of previewing the next slide. The third layout variation makes use of dynamic column resizing by just showing the current slide in the center and adding a clock to the bottom bar. The color scheme of the slides is independent from the original layout template of the slide, allowing for high contrast.

This backend system provides the necessary infrastructure to allow lecturers to present with Google Glass and should be well-suited for a prototype test.

6 Summative Evaluation

To assess the quality of the developed prototype, a summative evaluation was conducted.

6.1 Method

The prototype was evaluated with six participants, four of which also participated in the user analysis. A structured system exploration with think aloud (cf. [SBS94]), followed by an interview was used. The evaluation was conducted in an open-space multimedia lab. Participants were asked to familiarize themselves with the touchpad and app navigation and try out different layouts with different color schemes (white on black and vice versa).

6.2 Results

Results of the summative evaluation include the following:

Display quality: Participants answers varied regarding the specific elements of the interface. Headers were readable, and the slide layout and the images were recognizable. Regarding the amount of text, beyond a few bullet points the text became hard to impossible to read. However, participants were able to recognize the specific slide even without being able to read the text and they were content with this information. The presenter notes were readable if they were concise. Similarly, the timer was easily readable. Varifocals pose a problem given the prism of Google Glass lies in the area of far-away objects of the varifocal glasses. Bright, direct light was also an issue, impairing readability.

Layout: While four participants were content with the layout, suggested improvements include additional variations, e.g. resizing modules or displaying only one module and clearly visible dividing lines between modules. The proportions of the modules were seen as well-chosen, especially the division of the central area into unequal slots.

Interaction: The touchpad was seen as the best way to interact with Google Glass on its own. However, two participants felt it was odd and distracting to touch their head regularly for navigation, echoing the concerns of the analysis. Additionally, users got confused about the direction of the swipe movements. As mentioned above and following Google Glass conventions, to move from right to left (advance a slide) a swipe from front to back on the touchpad was chosen. Intuitively, users preferred it the other way around. Myo (armband for gesture interaction, [My17]) and smart watches were suggested as alternative control devices. Most would prefer to use the keyboard or a remote to control the slides. The optional head nudge feature was enabled to be able to switch off the display momentarily, which led to two participants switching off their display by accidental nodding.

Acceptance by students: Concerns were raised regarding acceptance by students. In addition to the scratch gesture of advancing slides, looking at the display was considered as quite noticeable and as potentially distracting for the audience.

Technical issues: While the delay between touch event and feedback on the projected slides was seen as acceptable, some network connection dropouts occurred.

Overall assessment: Participants did not see the technology as suitable for day-to-day lectures yet, but were open to additional tests and improvements and curious to see how the technology evolves.

6.3 Discussion

Overall, the summative evaluation did show the potential of Glass, but also highlighted important critical issues.

On the technological side, the current state of Google Glass poses hardware issues that may disrupt lecturers in their presentations. Among these are heat generation and corresponding sluggishness of the system, displaying text close to the border of the display, and unstable Internet connection, replicating some of the findings of [EME16].

The evaluation also highlighted some usability issues and minor errors that should be fixed in a next iteration. Users could be asked for their preferred swipe direction for navigating through the slides. The default control should be switched in accordance with the more intuitive movement. The metaphor of pushing the next slide to the students in front of the lecturer (moving the finger from back to front) vs. getting the slide back (moving from front to back) might be used to explain the slide controls. Variable color schemes and font sizes might solve some of the issues with readability. To deal with limited resolution automated scrolling concept might be a direction worth to explore.

Independent from the application, some users experienced headaches after wearing Google Glass for a few minutes. The causes were not explored in this study. Although one could argue that users might adapt to the small display over time, this issue has to kept in mind.

Regarding the range of features, the evaluation supported the outcomes of the initial user and task analysis, and lead to suggestions for improvement. Suggestions for content types can be easily implemented as the modular architecture allows to integrate new layouts or new content modules without developing a whole new application.

7 Conclusion and Future Work

In the present paper, we described a human-centered design process to assess whether lecturers can be supported with Google Glass and to identify the strengths and weaknesses of Google Glass in the lecture setting.

Our analysis did show the heterogeneity of users and their differing expectations, which was addressed in the modular user interface concept and backend system. Different modules can be used to personalize the graphical user interface. The backend system allows the flexible presentation of the content and allows for further adaptations and functions, e.g. providing the slides to students. The summative evaluation did test the developed prototype and provided empirical data on the success of the HCD.

Overall, results show that Google Glass has the potential to support lecturers. The participants were willing to try out the Google Glass App further, albeit only after further improvements have been made. However, the HCD process also revealed the difficulty of implementing a lecturer support system using smart glasses. Issues include major weaknesses of current technology (stability, heat, etc.) but also concerning unobtrusive interaction. Glass is useful to display information unobtrusively, but not for interacting unobtrusively with the device. Smartwatches might provide an alternative and less obtrusive way to control presentations. Also, smart glasses need to address the heterogeneity of the users. Lecturers differ in the kind of information they need and how it should be presented, thus care should be taken to maintain the customization and personalization features of the app.

The architecture used in the prototype is already capable to deliver the same content in different layouts/designs to the devices involved, e.g. one version intended for projecting onto canvas and a high contrast version to display on Google Glass. Ideally, this relieves lecturers from investing additional time into reformatting their slides for Google Glass. However, an integration of Google Glass with an authoring tool would give users more control over slide design and layout customizations. Developments will likely focus on integration with desktop presentation tools like Microsoft PowerPoint or Apple Keynote, as many users are familiar with them and have already invested lots of time and effort in their lectures using these applications.

An advantage of the proposed web-based solution is its expandability. This service can provide additional options to improve student interaction. For example, lecturers might allow access to a copy of their presentation on the personal devices of the students, e.g. smartphones or laptops. This would enable students to go a slide back in case they have questions about the lecture. Incorporating smartphones or laptops opens up more use cases for students worth exploring, like annotating lecture slides, sharing content or take part in audience response activities. However, these are beyond the scope of this paper.

A major unknown at the moment is the perception of such a solution from the perspective of the students. In analysis and evaluation, lecturers were concerned about the impression they make on their students when using Google Glass. Thus, tests in actual lecture settings should include student evaluations.

Overall, the potentials of Google Glass are enticing. However, the technical hurdles – mostly related to the smart glass system itself – are currently too high for practical use. With the continued development of smart glasses these issues might soon be solved. We have also identified other areas in which more progress is needed and have identified ways to deliver and display content. Thus, contributing to the goal of allowing the lecturers to move more freely while staying on track and in close interaction with the students.

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