Best Practices for Eye Tracking of Television and Video User Experiences

Noor F. Ali-Hasan
Microsoft
1065 La Avenida Street
Mountain View, CA 94043
+1 (650) 693-1925

Elizabeth J. Harrington
Microsoft
1065 La Avenida Street
Mountain View, CA 94043
+1 (650) 693-2705

Joel B. Richman
Microsoft
One Microsoft Way
Redmond, WA 98052
+1 (425) 421-5221

{noor.ali-hasan, beth.harrington, joel.richman}@microsoft.com

ABSTRACT
Eye tracking is a usability tool that employs a device that measures on-screen eye fixations and movements to determine how users visually interact with an interface. In this paper, we present best practices for planning and moderating eye tracking sessions as well as offer details regarding the technical configuration used during our studies. We found that eye tracking is pivotal in determining complex usability issues that would be difficult to uncover with traditional observational and think-aloud techniques.

Categories and Subject Descriptors
H.5.2 [**INFORMATION INTERFACES AND PRESENTATION**]: User Interfaces – *evaluation/methodology, user-centered design, graphical user interfaces (GUI)*

General Terms
Measurement, Design, Experimentation, Human Factors, Verification

Keywords
eye tracking, Tobii, usability, user research, television, TV, interactive TV, video, multimedia

1. INTRODUCTION
Interactive television and video applications are more popular than ever. Digital Video Recorders (DVRs), once a novelty, are becoming a staple product in the homes of media enthusiasts [8]. Moreover, the emergence of non-traditional television devices such as the Apple TV[1] and VUDU[2], is changing the interactive television user experience. No longer are consumers limited to passive recording of broadcast television – these new technologies aim to deliver on-demand video content, striving to combine the capability of an internet-enabled PC with the simplicity of a television appliance.

[1] http://www.apple.com/appletv/

[2] http://www.vudu.com/

uxTV'08, October 22–24, 2008, Silicon Valley, California, USA.

Ensuring a positive user experience for these types of devices and interaction models is critical to consumer acceptance. The advancement of new interactive technology often demands a progression in the tools and metrics employed to capture usability issues, and this topic is no different. In our experience, usability and ethnographic studies are standard practice for conducting user research of interactive television applications. On the other hand, more advanced usability methods such as eye tracking are uncommon in the television space, despite its popularity in testing the design of Internet websites and computer applications [2] [4] [7].

Based on our experiences conducting four eye tracking studies examining three interactive television interfaces, we present best practices for conducting eye tracking studies of television and video interfaces. First, we review related work in the field of eye tracking in usability research. Next, we review our methods and offer guidance for the technical setup of the eye tracker in a living room setting, planning a television eye tracking study, moderating the sessions, and analyzing the data. Finally, we offer conclusions and future directions.

2. RELATED WORK
Eye tracking systems allow usability professionals to capture user eye movement patterns to collect objective behavioral data that cannot be captured by verbal protocol or observing user actions [2]. Observing eye scan and fixation patterns can provide valuable insight into how the user processes a user interface. For example, longer eye fixations can imply that the user is spending more time processing the fixated feature [6]. Similarly, the pattern of eye movements can indicate the efficiency of visual search and the salience of user interface elements [3].

Eye tracking has been effectively used in testing the design of internet web pages [2] [4] [7] to provide valuable insight into how users perceive and operate the interface. However, eye tracking has been used in little research on television or video user interfaces (i.e., "ten-foot": *a user interface intended to be viewed on a television screen and operated using a remote control*). Indeed, Chabane et al. [1] indicated the scarcity of eye tracking studies on video interfaces. Several studies have explored the presentation of on-screen information overlaying television programs [9] [10]. In addition, Obrist et al used eye tracking to better understand the usability issues elderly users experience when using interactive TV products [11]. Pelssers and Berte used eye tracking to assess the effectiveness of interactive television advertising [12]. Sperring and Strandvall used eye tracking in evaluating an interactive TV quiz show [14]. Nonetheless, the research literature offers little guidance for conducting eye tracking studies of television and video interfaces. In this paper,

we present best practices for planning and moderating eye tracking sessions as well as details regarding the technical configuration used during our studies.

3. RESEARCH METHODS

Over the course of one year, we conducted four eye tracking studies, covering three television interfaces: Microsoft Mediaroom, Microsoft Windows Media Center, and an exploratory prototype of a next-generation user interface (hereafter referred to as "the prototype"). A combined total of 25 participants took part in the four studies. In each of the studies, participants completed a variety of core television watching tasks, such as finding a program to watch, using the EPG, scheduling programs to record, viewing program information, playing recorded programs, using search, renting video-on-demand movies, and setting parental controls. The specific goals of each study differed but at a high level, all four studies aimed at identifying usability issues with the interfaces and evaluating the effectiveness of the visual and interaction design of each product.

4. TECHNICAL SETUP

Recent technological advances have reduced the physical size and intrusiveness of eye tracking equipment. No longer are users required to maintain unnatural viewing positions to ensure accurate gaze tracking [2]. Modern remote systems, such as the Tobii eye tracking system[1], utilize infrared illumination and unobtrusive cameras to determine where the participant is looking on a surface. This method provides a more natural viewing environment, which is conducive to more natural interactions.

All four of the studies were conducted in a standard usability lab consisting of two rooms: a participant room and an observation room where the moderator instructed and observed participants. The first eye tracking study used a Tobii computer monitor eye tracker (model 1750)[2], with Tobii ClearView software. This eye tracking setup supported a viewing distance of approximately two feet, which did not represent a natural television viewing experience. The following three studies were conducted in a usability lab that resembled a living room, where participants interacted with the interactive television device on a large TV set from the comfort of a couch. These studies used a standalone Tobii X120 Eye Tracker, with Tobii Studio software. This standalone eye tracking setup allowed for a relatively natural TV watching environment, with participants sitting approximately 10 feet away from the screen – while accurately capturing the users' eye movements.

The Tobii X120 was connected to a Dell desktop computer with an Intel Core™2 Quad CPU @ 2.66 GHz with 3.25 GB of RAM. An Osprey 230 video card[3] captured video from the eye tracking computer. The video display for this computer was split with one part going to a Longview[4] connection, which enabled simultaneous display on both the participant and observer sides of the usability lab, and a second part that fed into a separate desktop computer to record with the Ovo Logger software[5]. The device being tested during each study was also connected to an audio/video splitter that simultaneously displayed on both a Sharp 48" LCD TV set as well as the Dell computer for video capture.

All of the devices were operated by infrared (IR)-based remote controls. During testing, it became apparent that the remote controls experienced significant interference with the Tobii eye tracker, which also used IR to capture the user's eye position. To reduce interference and enable more consistent operation of the remote controls, each of IR receivers were placed on the table directly in front of the participant during their respective studies. This repositioning greatly reduced the amount of interference during study sessions.

5. RESEARCH QUESTIONS

In conducting the studies, we found that eye tracking is a valuable research tool for discovering usability issues that could not be answered with traditional observational methods. However, we also learned that not all research questions could be answered with eye tracking.

The research questions that eye tracking could provide answers for tended to be specific inquiries about visual feedback and affordances: *"Do users notice a specific element, and if not, why?"* For instance, in traditional usability studies with Windows Media Center, participants rarely seem to notice a tip that appears near the bottom of the screen when the user quickly navigates the TV Guide: *"Tip: Channel + to Jump 12 Hours"* (see Figure 1). We were curious to discover if it was an issue with visibility or understandability. Through eye tracking, we found that users rarely used the 12-hour skip feature because their eyes are fixated in the upper right, reading the currently displayed time and not noticing the tip at the bottom of the screen.

Figure 1. Windows Media Center's *Jump 12 Hours* Tip is not noticed by users because they fixate in the upper right-hand corner of the screen, near the currently-selected time.

On the other hand, we were unable to answer more general research questions – such as whether the transparency of the Mediaroom interface interfered with users' usage of various features (see Figure 2). It was simply too difficult to gauge how transparency impacted the users' perception and comprehension of the interface using the eye tracking methodology.

[1] http://www.tobii.com/

[2] Tobii no longer makes this model, replacing it with the T60 and T120 models.

[3] http://www.viewcast.com/pages.asp?page=osprey-230

[4] http://www.avocent.com/LongView.aspx

[5] http://www.ovostudios.com/

Figure 2. Mediaroom EPG

Another limitation we encountered across our studies was the inability to track eye position when the participant looked at the remote controls. In order to track eye gaze patterns and fixations of the remote controls used in each of our studies, a second eye tracker would have been necessary. We were able to identify instances when our participants shifted their attention from the television to the remote control. However, without the ability to look at specific gaze direction data, we are unable to identify the relevant parts of the remote control. We were, therefore, unable to make recommendations regarding remote control design based on eye tracking data.

6. MODERATION TECHNIQUES

The sessions were largely conducted in the same manner as traditional usability studies. The standard verbal protocol ("think-aloud") usability testing method, where users are asked to verbalize to the moderator their current thoughts and feelings [13], was used in all four studies. The use of the think-aloud protocol is typically discouraged in traditional, eye tracking studies, as its use may interfere with automated analysis methods [5]. However, since automated analysis methods were not used to analyze the data, the use of the think-aloud protocol did not interfere with our results. For example, if a researcher was timing how long users looked at various screen elements, different participants verbalizing about different elements of the user interface would tend to obscure the timing data.

Participants were asked questions following each task to confirm their eye tracking data. The follow-up questions were necessary since eye tracking data may not always represent what the user actually "saw." For instance, a participant may notice a visual element through their peripheral vision, which would not be tracked through the eye tracker. Moreover, a participant may fixate on a visual cue but not comprehend its meaning. In asking follow-up questions, care must be taken to ask the questions at the appropriate time in a session. Inquiring about a visual element too early in a session may not give the participant enough time to notice it on his or her own. Moreover, if too much time passes between when a participant is exposed to a visual element and when a researcher inquires about it, the participant may not remember the element.

7. DATA ANALYSIS METHODS

Due to the nature of eye tracking user interfaces over video content, traditional automated and aggregated eye tracking analysis methods (such as heat maps) could not be generated for the television interfaces tested. Instead, we relied on a more time-consuming qualitative analysis method: watching videos of each session. While watching each session, we looked for recurring patterns of usage behavior, paying special attention to participants' eye fixations and saccades. Moreover, additional factors guided our analysis including participants' comments while performing the tasks, their responses to follow-up questions, and their task-completion rates.

8. CONCLUSIONS AND FUTURE WORK

Eye tracking can be a valuable usability method for evaluating interactive television and video user experiences. In this paper, we have described the technical setup of conducting TV eye tracking studies and offered best practices for asking appropriate research questions, moderating sessions, and analyzing eye tracking data.

We plan to regularly conduct eye tracking studies to evaluate changes to visual designs of our interactive television products. Future work may also include conducting eye tracking studies of remote controls. Such studies would allow us to make recommendations regarding remote control design based on users' eye gaze and fixations while looking at the remote control. Moreover, in the future, we may conduct eye tracking studies with experienced users of Windows Media Center and Mediaroom. These studies would allow us to compare and contrast users' TV viewing behaviors based on their experience levels with each system. Will users' fixations and gaze patterns change as they become more familiar with a TV system?

9. ACKNOWLEDGMENTS

Authors' names are listed alphabetically. The authors would like to thank David Sloo, Afshan Kleinhanzl, Michael Darnell, and Sheri Panabaker for supporting this research and offering insightful feedback on earlier drafts.

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