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ABSTRACT

Human-Computer Interaction (HCI) is gaining momentum as more and more people increasingly are using technology tools and devices for their daily activities. Users expect highly effective and easy-to-learn interfaces and developers and designers now realize the crucial role user interface (UI) plays. HCI and System Usability design have greater significance in media use as usability problems can adversely affect the large population of users depending on the overall usability of system design and UI design. This study was conducted to get rich and detailed feedback of users' personal experiences and usability of Websites. This was achieved by a different approach of using eye-tracking methodology in conjunction with usability software for usability testing. The study gave rich information of quantitative data from eye-tracking and usability software for better analysis of products.

KEY WORDS

Human-Computer Interaction, HCI, Usability, Eye-tracking, User Interfaces

INTRODUCTION

The Human-Computer Interaction (HCI) discipline is concerned with the design, evaluation, and implementation of interactive computing systems for human use and with the study of human dimensions and the surrounding phenomena. The primary objective of HCI is to enhance the usability of systems (Zhang, Nah, and Preece 2004; Zhang and Dillon, 2003; Zhang and Galletta 2006; Zhang and Li 2005). Usability is a term used to denote the ease with which people can employ a particular product to achieve a particular goal. It is an approach to system design in which levels of usability are specified quantitatively

in advance and the system is engineered towards these measures. HCI has gained attention during recent years due to the rapid development and advancement in information and computer technology. HCI is an interdisciplinary field that has attracted researchers, educators, and practitioners from different disciplines such as cognitive psychology, social psychology, computer science, communication, and many others (Bannon 2005; Carroll and Rosson 1996; Cowen, Ball, and Delin 2002; Galletta and Zhang 2006; Hollan, Hutchins, and Kirsh 2000). HCI is gaining momentum as more and more users of HCI applications are using information and communication technology and systems. HCI is the study of how people design, implement, and use interactive computer systems, and how technology-based systems and tools affect individuals, organizations, and society (Olson & Olson 2003; Rogers 1999; Rogers 2004). Users expect highly effective and easy-to-learn interfaces and developers and designers now realize the crucial role user interface (UI) plays (Bannon 2005). Various studies in HCI literature indicate that nowadays over 50% of the design and programming effort on projects is devoted to the UI portion (Barnard et al. 2000; Hollan et al. 2000; Kaptelinin 1996; Sutcliffe 2000). HCI is critical to the success of products in the marketplace, as well as the safety, usefulness, and pleasure of using computer-based systems.

There is substantial empirical evidence that employing the processes, techniques, and tools developed by the HCI community can dramatically decrease costs and increase productivity (Nielsen Report 2006). There are also well-known catastrophes that have resulted from not paying enough attention to HCI.

Presently, millions of users worldwide have been using a variety of computational devices such as desktop personal computers, laptops, PDAs, LiveBoards, iPods, and many others for their day-to-day personal and business-related tasks. Building applications that adapt their interfaces to the characteristics of the device on which they are running is a great challenge for developers and designers of interface design. The introduction of such devices presents a number of challenges to the developers and designers not only to design effective UIs but also to ensure that users use them comfortably for effective utilization and better productivity (Dix et al. 2004; Galletta and Zhang 2006).

Many usability methods and principles exist, such as rules of dialog design (Shneiderman 1992), usability inspections methods and discount usability methods (Nielsen 1994), and formative and summative usability evaluations (Scriven 1991; Hix and Hartson 1993). UI designers and usability teams invest huge amounts of time in this process, necessitating usability testing software to automate the whole process. Lately, eye-movement tracking or eye-tracking methodology is increasingly being employed to study usability issues in HCI contexts (Poole and Ball 2005). Eye-tracking can provide quantitative data on the areas of a screen being looked at, and the sequence and duration of eye gazes. Though eye-tracking tools were used as supporting data for the usability evaluations, usability testing software in conjunction with eye-tracking tools is a new approach for rich and detailed usability evaluation and analysis. Whereas some conventional usability methods reveal data only on a descriptive level based on a participant's verbal recall of what happened, the additional application of eye-tracking provides insight in the origins of a problem without the influences of a participant's bias and memory. Combining the eye-tracking methodology with usability testing software certainly would provide better details of user behavior for usability testing and analysis. However, there was no evidence of combining both the usability testing software and eye-tracking methodologies in the HCI literature. Thus this web usability project was conducted using eye-tracking methodology in conjunction with usability software to study the effectiveness and feasibility of a new approach.

LITERATURE REVIEW

Theoretical foundations for HCI studies have been taken from various disciplines, such as computer science, cognitive psychology, social psychology, perceptual psychology, linguistics, artificial intelligence, and anthropology. HCI research has evolved over the past few years from focusing on technical (ergonomic) aspects to conceptual (information-processing) models to work-process

(contextual) models (Dix et al. 2004; Zhang et al. 2002). Several theories exist relating different models of users, designers, and systems (Myers, Hollan, and Cruz 1996; Nardi 1996; Olson and Olson 2003; Zhang and Dillon 2003). Researchers proposed four basic models that affect the way users interact with a system: the *user's model of the system* the model constructed at the users' side through their interaction with the target system, the *system's model of the user*, the model constructed inside the system as it runs through different sources of information such as profiles, user settings, logs, and even errors, the *conceptual model*, an accurate and consistent representation of the target system held by the designer or an expert user, and the *designer's model of the user's model*, which is basically constructed before the system exists by looking at similar systems or prototype or by cognitive models or task analysis.

HCI is less focused on technology per se, than on the usage of information technology. Its objectives include understanding the psychological and behavioral interaction between user and computer systems, machines, devices, and other kinds of complex electronic artifacts. The basic assumption is that users are different and situations of usage change. An interface, function, information display, or structure may work in one situation but not in others. Instead of having the user adapt according to the technology, the interface should, according to this line of research, adapt to the user's need at the moment in an automatic and "intelligent" way (so called adaptive interfaces). In order to do so, there has to be some sort of model of the particular user, informed by either active and explicit preference setting by the user, or some sort of automatic user-modeling on the basis of the actions and behavior of the user in the system (Preece, Rogers, and Sharp 2002; Shneiderman and Plaisant 2004; Ting, Kimble, and Kudenko 2004; Ting, Kimble, and Kudenko 2005).

Ever since the invention of the World Wide Web and Internet, there is a big change happening in internet-based information technology, especially digital media and entertainment. Present day technology research is dominated by different digital media products and applications that are affecting and changing day-to-day lifestyle. Digital media products and applications such as video games, interactive TV, blogs, virtual communities, and digital schools are some examples. With these changing trends almost every segment of industry is exploring a move into digital media space. Since a better UI and its usability forms a strong basis for the success of such products, there is a strong requirement to explore different interaction design, usability testing, and evaluation methodologies. The main objective of this study is to focus on the relationship between humans and technology and on how and why people use (or reject) technology. In this regard, a popular online science and technology magazine was chosen to test how people are pursuing information online.

There are many usability methods and principles, including rules of dialog design (Shneiderman 1992), usability inspections methods and discount usability methods (Nielsen 1994), and formative and summative usability evaluations (Scriven 1991; Hix and Hartson 1993). These methods usually may also accompany think-aloud protocols and competitive analysis. UI design and usability teams invest huge amounts of time in this process. This investment necessitated the need for usability testing software that would automate the whole process. Usability testing software (e.g. Morae) supports every step of a usability test from start to finish including video and audio of the participant during the usability testing process. Any number of people can view both the screen and the participant during the test and it tracks user mouse clicks and allows you to search through them; however, the files storing usability tests recordings are very large.

Lately, eye-movement tracking or eye-tracking methodology is increasingly being employed to study usability issues in HCI contexts (Poole and Ball 2005). Although eye-movement analysis is still very much in its infancy in HCI and usability research, issues that are being increasingly studied include the nature and efficacy of information search strategies on menu-based interfaces (Altonen, Hyrskykari, and Räihä 1998; Byrne et. al. 1999), and the features of websites that correlate with effective usability (Cowen, Ball, and Delin 2002; Goldberg et. al. 2002; Poole, Ball, and Philips 2004). Eye-tracking is a technique whereby an individual's eye movements are measured so that the researcher knows both where

a person is looking at any given time and the sequence in which their eyes are shifting from one location to another. Unlike previous eye-tracking technologies, the latest eye-tracking technology enables evaluations to be conducted unobtrusively and obtain information on user interactions at a more detailed level than other evaluation methods. Eye-tracking can identify specific areas within a display that may be causing usability problems and can indicate how such issues change over time. Eye-tracking can provide quantitative data on the areas of a screen being looked at and the sequence and duration of eye gazes. The duration and number of fixations and the nature of the scan paths (the path between subsequent fixations) can be used to assess the relative usability of interface designs at a level of detail in terms of location, number of instances, and timing that may be impossible or too expensive with other usability testing methods. Whereas some conventional usability methods reveal data only on a descriptive level based on a participant's verbal recall of what happened, the additional application of eye tracking provides insight into the origins of a problem without the influences of a participant's bias and memory.

Usability testing software in conjunction with eye-tracking tools is a new approach for rich and detailed usability evaluation and analysis. From usability testing software, one can track user mouse clicks and search through them. Though tracking mouse clicks and video and audio of the participant would provide useful data to find out certain usability problems, it still falls short of explaining and identifying the exact reason and visual evidence behind the UI design and usability problems. This is where eye-tracking comes into the picture as a handy tool as it provides rich gaze and fixations data of the participant on the UI. Since you can get viewing patterns from eye-tracking and mouse click patterns from usability testing software, combining both the methods would compliment each other in usability evaluation and analysis. However, there was no evidence of using such methodology in the HCI literature. Thus this web usability project was conducted using eye-tracking methodology in conjunction with usability testing software to study the effectiveness and feasibility of the new approach.

METHOD

There have been various methods and approaches used for HCI studies including cognitive walkthrough, heuristic evaluation, and other modifications of earlier cognitive modeling**.** Ethnographic observation, participatory design, and scenario-based design are being streamlined. We used eye-tracking methodology in conjunction with usability testing software for usability testing of three Websites. In this method, user activity such as mouse clicks, web links, video and audio of the participant would be recorded by usability testing software. Simultaneously, the participant's eye would also be tracked to see their visual patterns such as gazes and fixations around the defined areas of interest in the UI. Usability interviews were conducted in two different cities of the Midwest United States. Of nineteen participants, four were registered users of the online magazine. Each participant was directed to two Websites: one being the actual online magazine Website and other being one of two chosen competitor websites (competitive analysis and benchmarking against competitors). Ten of the participants were directed to actual online magazine and Wired.com, while the other nine went to another online magazine and Slate.com. Each participant was asked to complete a series of tasks as well as give feedback in terms of what they liked and disliked about the Website and its services. Length of time for an average session was 45 minutes. Morae usability testing software was used to guide the interview sessions and to track relevant user behavior (such as time-on-task, mouse clicks, and weblinks visited). While going through the tasks an eye-tracking technology was used in conjunction with Morae usability testing software in order to record where the participant was looking throughout the session.

Eye-tracking: the tool

For this project, researchers employed an R6/VHT eye tracking system from Applied Science Laboratories (ASL). The system consists of two cameras (one pan/tilt and one stationary), a control box,

and a laptop running relevant software. The pan/tilt camera is fitted with a device that emits an LED. This LED reflects of the participant's pupil and cornea and it is these reflections that allow the system to calculate the position of the eye. The stationary camera works in conjunction with face recognition software. This software looks for three specific elements that make up a face: shape of eyes, nostrils, and edge of mouth. Researchers receive visual feedback and confirmation of an accurate definition of the face via two green boxes that appear around the participant's eyes in a video window. Finally, the face recognition software communicates the position of the participant's head to the pan/tilt eye camera. This type of head-tracking allows a degree of freedom of motion for the participant. Though the mechanical and software driven nature of the device impose certain limitations regarding how quickly it can follow and remain locked on a participant's eye, but it effectively recaptures the eye with minimal data loss. The terminologies used for eye data are:

1. Gazes—any glance ranging from 0.016 seconds up to 0.2 seconds
2. Fixation—any look lasting at least 0.2 seconds (cognitive science generally accepts 0.2 seconds as the minimum time necessary for cognition to occur)

Path of eye gaze and fixations provide very rich information of what the participant was looking for in any particular given task. Areas of interest on the interface could be created to see what amount of time each participant was spending on them. Based on the results, the interface could be changed for better usability.

RESULTS

The project successfully implemented the methodology of using Morae usability testing software in conjunction with a remote eye-tracking system. As expected, the results provided rich information with both usability testing software recorded data and eye-tracking data. A thorough task analysis was done from this data. The major findings of the task analysis are described in this section. As soon as participants opened the online magazine Website they were asked their initial thoughts. Again, organization was a plus. From recorded participant expressions and think-aloud process, many liked that sections were divided by lines and boxes. This was mainly because they thought there was a lot of information on the homepage; however, they felt even though there was possibly too much information at once, it was easier to read with dividers. Colors were also well-received and were thought of as clean and not too flashy. Supporting eye-tracking data also provided that there were lots of scattered gazes and fixations on the homepage, indicating that it has too much information in one Webpage. Participants liked the video feature. This was evident from the eye-tracking data of all the participants. But during the interview after the usability session, only a few participants expressed that the thumbnail images with mouse-over information were eye-catching—people want to click and see more. They also mentioned that videos provide quick and rich information that they want to go through, especially in the case of news and online magazine websites. However eye-tracking data supported that almost every participant's eye was drawn towards the video feature and gave strong support to keep the feature in its present location on the UI. All but one participant found the stories on the homepage. The remaining participant tried to use the search function by entering the date but was unsuccessful. The stories were eventually found on the homepage after attempting the search. Eye-tracking provided information that the gazes and fixations were quickly drawn towards the areas of interest on the homepage, indicating good usability of the feature and it was amply supported by the time-on-task recorded by the usability testing software. Many liked that the headlines were a blue hyperlink which helps separate it from the rest of the text. This was a strong feature of the homepage because it helped participants distinguish between articles and users liked that it was organized by date. The e-mail and print links provided at the beginning and end of the articles were well-received. Participants felt it was very intuitive and easy to find. Participants liked the "blog feature" as it provides the opportunity to comment on any particular article of a journalist. Both usability testing software and eye-tracking supported this finding. The sign-up process for newsletters was well-received.

A few thought the process was better than most because they were not asked to enter a lot of information and there was a helpful summary offered of each newsletter and how often the newsletter is distributed. Finding special reports was a difficult task. Though the special report section is available on the homepage, some participants still tried to find it from the search function and all but one were unsuccessful. From usability testing software data, all one can know is time spent on the task and whether the participant was successful or unsuccessful in completing the task. Only eye-tracking data gave strong visual evidence of where the participants were looking to find the special report. It showed the visual patterns (gazes and fixations) of the participant's eye and clearly indicated that participants missed the three potential areas where they could have found the special report. From the gaze and fixation patterns, the majority of the participants were searching either the top menu or middle of the homepage area. Most of the participants missed the search feature due to its lack of visibility against the background color and its location in the top right corner. Also, the search results produced article results which were different than the special reports section. One participant thought it was a successful search because the article read that it was the special report. Another participant did find the report through the search feature but it was not clear at first which link from the search was the correct one. Three ended up going to the homepage and finding the special reports section. The processes for subscription to the newsletter, regular magazine and digital subscription, gift subscription, and ordering old prints and back orders are confusing as they are not distinguished from each other well and it is difficult to find them. Participant eye data showed that the gazes and fixations are all over the homepage, indicating the confusion among the participants. Our results suggest the need for organizing all of them in one particular section. Participants expressed confusion over customer service and how to contact the webmaster.

DISCUSSION AND SUMMARY

As computing systems become increasingly central to our society, HCI research will continue to grow in importance. The present study was conducted to test this methodology and to see the new challenges that this methodology pose for the overall usability testing and analysis of UIs. This study provided rich and detailed feedback of users' experiences and identified usability issues by means of eye data and usability testing software data. On certain problems, both kinds of data complimented each other to clearly identify and strongly support the usability problems associated with the UI design. Obviously, the challenges involved in the process are the set-up of eye-tracking in conjunction with usability testing software. Though it appeared to be a complex set-up, it proved to be normal. It gives rise to new issues of testing various interfaces with the present methodology to make it a valid approach for the latest interactive web media. Since the present study is on Websites, in the future we would like to extend the study to desktop applications and other PC-based software products. This study demonstrates that using eye-tracking methodology in conjunction with usability resting software for usability testing gives better understanding of user browsing behavior as well as data and methodologies used in each approach providing rich information for better analyzing products. These results may provide new tinkers for HCI.

Future research examining using eye-tracking methodology in conjunction with usability testing software for usability testing needs to be done to investigate a number of different aspects of website design. Researchers could investigate what motivates users to pay their visual attention to different aspects of the page depending on the nature of the task and the relative arrangement of the page's content. Finally, researchers should experiment with this methodology on a different variety of Websites (e.g., informational, commercial or entertainment-focused, etc). We envisage that different Websites and different types of demographics of respondents could provide considerably different results.

REFERENCES

References will be made available upon request