Rapid Prototyping of Accessible Interfaces With Gaze-Contingent Tunnel Vision Simulation

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ABSTRACT

Active involvement of users with disabilities is difficult to employ during the iterative stages of the design process due to high costs and effort associated with user studies. This research proposes a user centered design (UCD) strategy to incorporate the use of gaze-contingent tunnel vision simulation with sighted individuals to facilitate rapid prototyping of accessible interfaces. Through three types of validation studies, we examined how our simulation techniques can provide the opportunity for continued evaluation and refinement of the design. Our simulation approach was effective in emulating scanning behaviors caused by tunnel vision along with grasping user feedback to recognize user interface and usability criteria early in the design cycle.

Keywords

Accessibility design; Rapid Prototyping; Simulation; Gaze Tracking.

1. BACKGROUND

UCD assumes an iterative design process, and by rapidly generating prototypes, technology designers have the increasing opportunity to test and refine their design with users. In theory, the inclusion of users should also encourage the development towards accessible solutions [7]. Some variations of UCD specifically advocate constant communication between designers and users with disabilities [3, 8].

Despite the emphasis on inclusion in UCD, active involvement of users with disabilities is difficult to practice. According to [1], user studies are time consuming and costly, and the diverse range of abilities of users complicates the designing of inclusive interfaces. For instance, people with low vision suffer from varying levels of visual impairment [5]. Even from the same eye disease such as Retinitis Pigmentosa (RP), the progression of constricted visual fields, as well as poor visual acuity or light sensitivity, varies among individuals. There are practical challenges for designers in conducting representative user trials or quickly getting a sense of how a person with a visual disability would experience the interface. Moreover, repeated tasks and sessions involved in user studies require great physical effort especially from the users with disabilities.

Due to a number of challenges in incorporating the perspective of users with disabilities, simulating possible interaction patterns has been introduced for evaluation. For example, low vision simulation programs including predicted models [1] are available. Low-tech simulation glasses are also well known to cheaply support the designers [2]. However, they lack the immediacy and the ease of transition between observing interaction patterns via wearable simulators and directly refining the development. While employing self-observation techniques is necessary, we need to encourage the use of simulation as part of the design cycle to grasp subjective and objective evaluation measures.

2. GAZE-CONTINGENT SIMULATION IN DESIGN PROCESS

Our research proposes a design process that utilizes a gaze-contingent interface to simulate a visual impairment and assist in the simulation of the impairment in accessible interface design and evaluation. In this work, it emulates "tunnel vision" by estimating the real-time gaze position of a person to represent limited peripheral vision (Shown in Figure 1) such as that found in RP. Our simulation technique responds to the following objectives: developers can 1) quickly observe the effects of prototypes under a simulated visual condition and 2) recruit sighted participants for representative user trials to gain simulated user feedback. As illustrated in Figure 2, paths labeled as (1) and (2) respectively correspond to meet the two aforementioned purposes in the design process.

Even though our current version of the simulator focuses on

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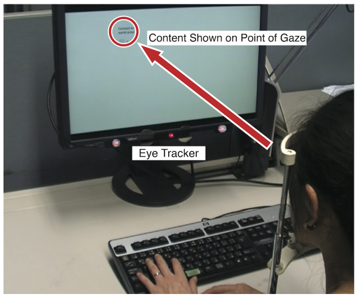

Figure 1: Sighted participant seeing a web page under a five degree field of the content at the real-time gaze position. This size of the area technically corresponds to how the field of view is restricted to central vision [9]

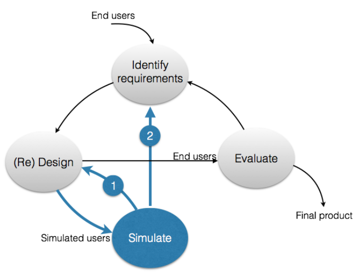

Figure 2: Simulation incorporated in the UCD process composed of 3 stages [6]. The path labeled as (1) serves for inspecting prototypes for redesign, whereas the path labeled as (2) goes through evaluation studies of the prototypes, both under simulated conditions of users with disabilities.

a certain visual impairment, we aim to pave the way for our simulation technique to offer the immediacy and flexibility to directly refine the design while examining simulation effects. It is then important for simulated evaluation studies to allow for collecting both subjective and objective data on the designed interface. To validate our design approach, we designed visual navigation aids and investigated how our tunnel vision simulation can be used to reveal similar design and evaluation input on our prototypes as those captured by RP users with limited peripheral vision.

3. FINDINGS

Through three types of validation studies conducted, we found that the gaze-contingent tunnel vision simulator can be used to identify basic interface problems and obtain user feedback from simulated tunnel vision participants. From the eye movement study, we examined that the simulator affected sighted individuals on their scanning behaviors regarding a number of saccadic movements that exceeded the simulated visual angle. These scanning pattern characteristics were similarly found for increased saccade frequency under tunnel vision [4]. Moreover, the simulated user interface (UI) and usability evaluation studies against our prototypes addressed necessary quantitative and qualitative results that corresponded with the RP participants.

From UI testing, we were able to explore design alternatives and verify which one to carry forward to the next usability testing stage. Out of five prototypes tested, both simulated tunnel vision and RP groups showed similar visual preference over one navigation cue with a radial design. It was found to be simple for the users with tunnel vision to visually reach the target by tracking the static lines for navigation instructions. It received highest ratings for the ease of completing visual-search tasks for web content. In usability testing, our navigation aid was analyzed to limit cognitive load of both groups for layout understanding. While statistical evaluation was also feasible due to controlled test conditions offered by the simulation approach, we saw the importance of enabling developers to consider human factors from simulated subjective perspectives.

It is important to note that we do not advocate completely excluding the actual end users in the design cycle. Especially at the initial user research and near the end of the higher-fidelity prototyping cycle, understanding consequences or coping strategies involved in an impairment day-to-day experiences will give the designers insights in forming new accessible requirements. Simulated evaluation is beneficial to easily check and modify their low- to mid-fidelity prototypes. We aim to lessen a certain amount of cost regarding time and effort in constantly inspecting basic interface changes.

4. CONCLUSION & FUTURE WORK

This paper presents a starting point for utilizing the gaze-contingent tunnel vision simulator in a continual design-evaluation cycle. Our future work primarily involves investigating the effects of different simulation-based techniques from the viewpoints of the developers. We also need to support configuration for multiple visual conditions. We hope to provide a new paradigm to facilitate rapid prototyping developments of accessible interfaces.

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