Effects of Haptic Feedback on Gaze Based Auto Scrolling

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Abstract

Eye tracking enables automatic scrolling based on natural viewing behavior. We were interested in the effects of haptic feedback on gaze behavior and user experience. We conducted an experiment where haptic feedback was used to forewarn the reader that their gaze had entered an active scrolling area. Results show no statistical differences between conditions with or without haptic feedback on task time or gaze behavior. However, user experience varied a lot. Some participants were not able to associate the haptics and the scrolling. Those who understood the connection found the haptic feedback useful. Further research is required to find out a delay between the forewarning and the start of scrolling that is short enough to make the association but yet long enough to support the feeling of control and enjoyable user experience.

Author Keywords

Gaze input, eye tracking, haptics, vibrotactile feedback.

ACM Classification Keywords

H.5.2. User interfaces: Input devices and strategies.

Introduction

Eye tracking reveals the focus of the user's visual attention. Gaze input has a lot of potential for attention aware systems that can proactively assist in the

interaction tasks. Automatic scrolling of text is one example: when the reader's gaze approaches the bottom of the page, text can be automatically scrolled, saving the reader from the need of potentially interrupting manual input. Another example is an attentive reading tool that can enhance the reading experience, for example, by offering automatic translations [3] or by providing multimodal effects that enliven the text currently under focus [1].

Proactive interaction may sound great but it can also be annoying if the automation kicks in too early or in a wrong place, as demonstrated by autonomous agents [7]. Even in proactive systems, the user should feel in control; proper feedback is essential [3].

We hypothesized that a subtle notification given by haptics could forewarn the user and indicate the borders of the invisible active scroll area. This might prevent potential distraction caused by unexpected start of the scrolling and give the user a chance to revert back to the static central area. On the other hand, we deliberated the potential disadvantages of haptic feedback. In certain interaction tasks, haptics may even negatively interfere with other senses [2]. Below, we first briefly review related research and then report the method and results of our exploratory study.

Related Research
Kumar and Winograd [5] found that participants preferred gaze based scrolling over manual scrolling but some found it hard to read moving text. They found two main challenges to be taken into account when implementing gaze based scrolling. First, one should avoid the so called Midas touch where gaze input is executed without the user's intention. Dwell time can

be used to prevent accidental activations. Secondly, one should pay attention to the speed of scrolling.

People have different reading styles and habits. Some prefer staying in the middle of the screen while others prefer to read most of the text before starting to scroll. Sharmin et al [8] found that the preferred reading areas stayed the same even if the font size was varied. Gaze based auto scrolling also improved the reading speed slightly compared to manual scrolling.

Zhang et al [9] demonstrated that tracking sideways gaze movement can be used for controlling large screens, showing high potential for calibration-free spontaneous gaze interaction.

In addition to smooth scrolling, rough gaze gestures can be used to quickly browse between views. Kangas et al. [4] combined gaze gestures with haptic feedback to control a mobile phone. Quickly gazing upwards or downwards was used to browse through a list of contacts and sideways glances were used for selection. Haptic feedback supported the gaze gestures by significantly reducing errors and decreasing task time. Haptic feedback can also improve user experience [6].

Method
Tobii T60 (17″ monitor, 1280x1024 resolution) was used to track the participants' eyes (Figure 1). Haptic feedback was given via C-2 Tactor with Gigaport amplifier. Two different durations of haptic feedback were tested: a short 10 ms version that resembled a sharp tap and a longer 70 ms version resembling a softer tap with decreasing amplitude (both 250 Hz). The actuator was placed on a pillow to prevent sounds from the vibration (Figure 2).
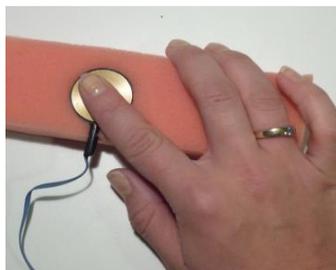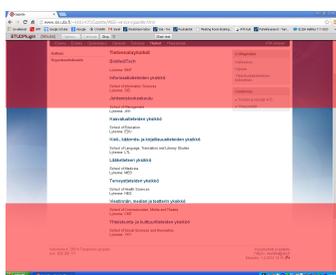
Figure 1. Test setup.

Figure 2. C-2 Tactor.

Figure 3. Active scrolling areas illustrated by color (not visible in the experiment).

Stimuli were presented with a modified version of GazeTTE[1], a Google Chrome extension for scrolling web pages by gaze built on ETU driver. The active scrolling areas and speed were based on results by Sharmin et al [2013] and three pilot tests. The gaze reactive scrolling areas were 260 pixels high (Figure 3). The scrolling speed was 67 pixels per second (about 400 rows per minute). Dwell time was set to 700 ms, after which the scrolling started. Scrolling continued as long as the gaze remained within the area. The direction of the scrolling was defined by scroll area: upwards on the top and downwards on the bottom.

Twelve participants (5 male, 7 female) volunteered for the experiment. All were novices in gaze interaction but one had used an eye tracker before. Before the experiment, participants were briefed and they filled in a background questionnaire and an informed consent form. Participant was sat in front of the monitor (about 50-60 cm from the screen) and the tracker was calibrated for each participant.

There were 18 tasks in total, divided into 3 blocks of 6 tasks. Each block included the same number of information search and reading tasks. Tasks were given one by one in a dialog on top of the screen. The participant read the task aloud, after which the task was loaded. There were three conditions: one with no haptic feedback and two with haptic feedback of different length (short and long). The order of conditions was counterbalanced between participants and task blocks. In the end, participants filled in a questionnaire and were interviewed.

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1 Available at http://www.sis.uta.fi/~csolsp/downloads.php

Results

The fastest average task time was achieved with the condition with no haptics. The condition with short haptic feedback had the longest average task time and largest variation (see Figure 4). However, the differences were not significant ($F_{1,11}=1.247$, $p>.05$).

In order to study if and how the haptic feedback affects gaze behavior, we selected one reading related task from each block. Potential major disruptions in gaze behavior should be easier to detect in reading with a clear pattern compared to e.g. a search task with more random gaze path. There were no significant differences in gaze behavior before versus after the haptic feedback was given. Thus, haptic feedback did not cause disruptions that would make the user's eye stray away from the text. Similarly, there were no significant differences in the average fixation durations and the number of fixations found in data samples 700 ms before and after the haptic feedback.

Participants filled in a 5-level Likert scale questionnaire after each block about subjective fatigue, ease, speed, comfort, usefulness, intensity and timing of the feedback. No significant differences were found. In general, participants felt the feedback did not help (Figure 5) but it did not disturb either (Figure 6). Most liked the auto scrolling and it did not disturb the task.

During the semi-structured interview in the end, eight (out of 12) participants admitted they had not understood the purpose of the haptics and did not consider it necessary. Those who had understood its purpose felt that it was useful as an indicator of the active (invisible) scrolling areas. Eight participants
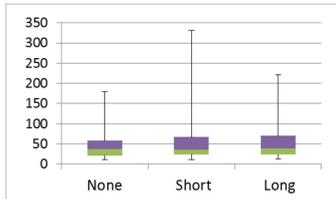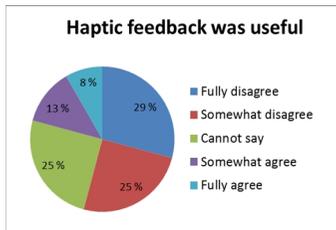
Figure 4. Average task times in seconds.

Figure 5. Most participants did not find the haptic feedback useful.
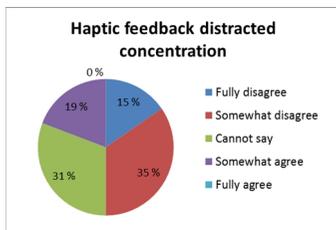

Figure 6. The haptic feedback did not disturb participants' concentration.

preferred the mode without haptics, two preferred the short and two the long version of the haptic feedback.

Discussion and Future Work

Based on our exploratory experiment, we can confirm findings from other studies showing that gaze based auto scrolling is a noteworthy option for manual scrolling. Haptics provided neither support nor distraction. However, interviews and observations made during the test revealed that some participants were not able to associate the haptic forewarning with the forthcoming scroll action. Obviously, the 700 ms delay (based on pilot tests) between the forewarning and the start of the scrolling was too long to make the connection self-evident. Further research is required to find out the effects of a shorter delay.

Acknowledgements

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We intentionally did not explain the logics behind auto scrolling and the haptics to the participants, because we were interested in the ease and intuitiveness of multimodal auto scrolling. The auto scrolling itself clearly felt quite natural at least for some users; two participants had already used it successfully in a reading task but had not paid any attention to it. When they proceeded to a search task, they asked "how can I scroll". We hope that with further fine-tuning, also the haptic notification would fluently and naturally support the auto scrolling. This would be especially useful in gaze-aware mobile tablets and other handheld devices with inbuilt haptic actuators.

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