Simulation of Motor Impairment with "Reverse Angle Mouse" in a Head-Controlled Pointer Fitts' law Task

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ABSTRACT

Testing software with individuals who have differing abilities such as motor impairments allows developers to create more accessible applications. Unfortunately, these individuals are not always available to assist with research or software development testing. To help address this issue, we propose a system which simulates the difficulties demonstrated by a motor-impaired user interacting with a head-controlled mouse pointer system. Through an evaluation using a Fitts' law experiment, we compare the throughput rate in bits per second and percent error rate of our system between users with and without motor impairments.

CCS Concepts

•Human-centered computing → Empirical studies in accessibility; Accessibility systems and tools;

Author Keywords

Accessibility; Head-Controlled Mouse Pointer; Camera Mouse; Angle Mouse; Motor Impairments; Simulation; Fitts' law

INTRODUCTION

Developing UI which is accessible for individuals with a motor impairment (MI) can be challenging for developers and researchers, especially when they don't have access to software testers with disabilities. Simulation software can both decrease the burden on MI individuals and help software designers gain some perspective on the difficulties that MI individuals face when using software [7].

Camera Mouse¹ [1] is software that tracks a user's head motion to move a mouse pointer on the screen [1] intended to improve accessibility of mouse control for MI individuals. A previous study proposes adding random noise to these camera

¹The Camera Mouse is freely available as a download at <http://www.cameramouse.org/>

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Figure 1: Mouse traces from Fitts' law task. Top-Left: baseline condition, Top-Right: participant with MI in a previous study, Bottom: simulation condition

controlled mouse movements in an effort to simulate motor impairments [8]. In this paper we instead propose a simulation by combining the Camera Mouse software and reversed version of Angle Mouse (AM) software² [9]. Angle Mouse is software that helps adjust computer mouse gain depending on mouse movement angles, allowing users to have more control of the mouse when narrowing in on a target. We reversed the AM software by raising the gain when the high angular standard deviation is high, making control of the mouse more difficult when making small adjustments to position the mouse over a target. By reversing the AM software, we are able to simulate a MI user's difficulty with small range precision by decreasing the user's control when narrowing in on a target, an algorithm that we call "Reverse Angle Mouse" (RAM).

The results of our experimentation were evaluated using Fitts' law task, (Fig. 1) a standard in assessing pointing devices [2, 3, 9]. We primarily evaluated our findings on a throughput measure, or "rate of communication" in bits per second (bits/s),

²The Angle Mouse is freely available as a download at <http://depts.washington.edu/ilab/proj/angle/index.html>

Figure 2: Average Throughput and Error Rate from the two conditions compared against the MI user

and error rate. We compare our findings in this paper to previously obtained measures for an individual with a motor neuron disease [6] and the study conducted in the previous year [8]. The results show progress towards a simulation of a MI user, but can be improved by combining the random noise generation simulation (from the previous study) and the Reverse Angle Mouse simulation in this study.

Participants and Apparatus

We performed two evaluations of the RAM algorithm. We tested our hypothesis on a preliminary experiment with eight participants. The main experiment utilized six participants, one female and five male. None of the participants had MI. The experiment was conducted on a 22-inch monitor screen at a resolution of 1920x1080, from a distance of approximately 2.5 feet. We used the same Camera Mouse settings as the previous paper; medium horizontal and vertical gain, 1.0 second dwell-time, very low smoothing, and a Normal dwell-time click area [8].

Procedure and Design

We utilized an interactive evaluation tool called FittsTaskTwo³ [2] which allows participants to use the Camera Mouse software to move the mouse cursor to a target on the screen and click on it by holding the cursor still before moving to the next one. The program saves the mouse trajectories and click data for analysis. Each participant session consisted of four sequences of thirteen targets at amplitudes of 300 and 600 with widths of 50 and 80 pixels run across the two conditions with two sessions per condition.

We conducted a preliminary experiment where the Camera Mouse code and our RAM code were running separately. Since the Camera Mouse has built in mouse smoothing, our RAM software's mouse interference was cancelled out by the Camera Mouse program. We then built a program where Camera Mouse and RAM are imbedded together, thus removing the conflicting mouse control, and reran our experiment. In this experiment, the participant was able to use the Camera Mouse to control the mouse but was also impeded by our RAM algorithm, as we intended.

³The software is freely available as a download at <http://www.yorku.ca/mack/HCIbook/>.

None of the participants had used the Camera Mouse program before. We allowed every participant a practice trial of the Fitts' law task with the regular Camera Mouse software.

The main independent variable was the input mechanism with two conditions: baseline Camera Mouse without RAM and Camera Mouse with RAM. This results in 208 trials (4 x 4 x 13) for each participant. Dependent variables are throughput (bits/s), and error rate (%).

RESULTS

The mean throughput of each condition is shown in Fig. 2a. The baseline condition throughput rate averaged 1.093 bits/s, consistent with previously reported throughput measures expected for non-MI users (1.280 bit/s) [6].

The mean error rate of each condition is shown in Fig. 2b. The baseline condition error rate averaged 24.38%. The error rate is the amount of mis-clicks over the total amount of targets.

The RAM algorithm condition had an average throughput (0.851 bits/s) compared to the throughput of the MI user (0.488 bits/sec). Although the throughput rate from the RAM is higher than that of the MI participant, it is lower than the baseline throughput (1.093) bits/sec. The error rate for RAM (41.72%) and the baseline (24.38%) is higher than the error rate reported from the MI user (19.20%). This is likely because the participants using Camera Mouse were less familiar with using the Camera Mouse, each only had one session of practice before the experiment.

The effect of average throughput and error rate was statistically significant using ANOVA: throughput; ($F_{(1,5)} = 6.620$, $p < .05$), error rate; ($F_{(1,5)} = 7.915$, $p < .05$).

DISCUSSION AND CONCLUSION

In this paper, we presented an algorithm to simulate the movements of a user with motor impairments, that works with Camera Mouse software, and evaluated its effectiveness. When looking at the cursor movement traces in Fig. 1, the trajectories from the simulated impairment could still be improved to more closely match the movements seen in the trace from the user with a MI. For future work, we plan to combine the RAM software and the random noise from the previous year's paper to try to more closely simulate mouse movements characteristic of an individual with motor impairments.

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