Common Input Devices for Malaysian Computer Users with Motor Impairments

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Abstract

This research aims to investigate whether there are common input devices that are more effective than a standard mouse for Malaysian computer users with motor impairment. The tasks range from very controlled Simple Reaction Time (SRT) tasks to Fitts' Law and browsing tasks. There are several potential contributions of the research beyond finding the input device that is more effective than a mouse: 1) The Fitts' Law model and information architecture for people with motor impairment and 2) the relationship between subjective and objective measures in highly controlled as well as naturalistic tasks.

Introduction

Various studies with people with motor impairment had strongly suggested that access to computers and the Internet could provide means of freedom and better opportunities in education, employment, and their social lives in general. The use of a suitable input device plays a significant role in ensuring optimal access to computer. Undoubtedly, people with disabilities would benefit from the use of assistive input devices and technologies. However, in many low-income and middle-income countries, in which Malaysia still belongs to, only 5%-15% of people who require assistive devices and technologies have access to them [20]. Most of the times, in situation when access might be possible, costs are prohibitively high.

Taking these factors into consideration and in view of the current scenario of people with disabilities in Malaysia, a study to investigate the use of other common input devices by people with motor impairment was conducted in order to understand whether there is any device that can perform more effectively than a standard mouse.

In this study, the choice of common input devices was based on previous study on input device usage by older person [9], hence user performance was compared using mouse as the baseline and notebook's touchpad, touch screen and tablet with stylus. Although there are various representative tasks for pointing such as target acquisition, steering and many others [16], the focus of the study was on three types of 'motor' tasks, ranging from a very simple to a natural one.

The three tasks used were the Simple Reaction Time (SRT) tasks, experimental Fitts' Law tasks and browsing tasks. The SRT task are essentially aiming and clicking tasks that was used to measure how accurately people with motor impairment can aim and click on a target when the location of the target remained constant. In contrast; in Fitts' Law tasks, the location of the next target was always random. On the other hand, whilst Fitts' Law tasks provided an objective comparison of performance differences by devices, the browsing tasks allows us to get an insight into tasks that are closer to real-life activities such as browsing the Internet.

Related Work

Numerous research involving people with disabilities and input devices have been conducted especially in the West such as in the USA and UK. Some studies that focused on people with motor disabilities include the evaluation of joysticks for people with tremor [12], mouse and keyboard manipulation difficulties [17, 19], and comparison on the use of input devices by older adults [2]. Some focused on various means of providing assistance to improve computer access for people with disabilities while some were related to the use of a mouse either by providing means to assist cursor movement or to improve mouse operation [3, 4-6, 9, 18].

The growth of the Internet, computing access and its associated facilities provide significant advantages to everyone including people with disabilities. It was reported that the people with disabilities are among heavy participants of public services and potentially have most to gain from convenient, customer-focused channels of electronic deliver [10]. However, in addition to the prohibitive cost of current computer systems, a lack of suitability and adaptability were the major barriers to easy access of computers by people with disabilities. Unfortunately, no research has been found that investigated the use of computers among people with motor impairment in Malaysia, especially in the context of computer input devices.

Overview of the Research

The research goals are to:

1. Find out whether there is common low-cost input device that is more effective and preferred than a standard mouse.
2. Investigate the performance using common input devices in controlled and naturalistic tasks (SRT, Fitts' Law and browsing) through subjective and objective measures.
3. Fit the empirical data to the various Fitts' Law models proposed by MacKenzie and Buxton [8] and to investigate the best fitting model.
4. Investigate the effects of individual differences in reading speed and comprehension on browsing performance.
5. Investigate the effect of information architecture (depth vs. breadth) on browsing performance.

Research Procedures

Taking into consideration the effect of fatigue and conditions of potential participants, it was decided that the study would be conducted in two modules. The first module involves a pilot and main study to meet the first four objectives while the second module would focus on the last objective of the study.

Pilot Study

In this study, 3 people with motor impairment were recruited (P1 has Multiple Sclerosis and uses a wheelchair, P2 is tetraplegic and uses a wheelchair, P3 has Cerebral Palsy). A 12" Twinhead notebook was used while devices used were JNC Optical mouse, the notebook's touchpad, 4" x 3" Tablet with Stylus (Cordless Natural Pen Device) and MagicTouch Add On Touchscreen. The participants signed consent forms and filled in

demographics, computer, input devices and Internet experiences. The participants then performed the SRT test [16].

The controlled experiment consists of three tasks (the order of the tasks was balanced across participants). The first task was discrete pointing using the devices using the Generalized Fitts' Law Model Builder (GFLMB) [15]. The second task was to measure participants' reading and comprehension skills.

A Reading test set was constructed using 8 articles of four different complexities based on the Flesch-Kincaid (FK) grade level [11]: FK12, 14, 16 and 18 (since potential participants for the experiment would be adults with minimum education of 12 years). The length of each articles were between 240 and 250 words. Each article has five questions to be answered. Two articles were used for each level to improve reliability.

The third task was a browsing task where the participants browse through online information to answer questions. The information was presented in an 8x8 web hierarchy (this was indicated as the most effective information architecture on browsing studies with older persons). The final leaf pages contain articles of 140-150 words. The participants' browsing time was defined as the moment they clicked ready to the moment that they clicked the 'answer found' button. This was when the information disappeared and they answered verbally.

At the end of the experiment, participants answered a post-task questionnaire on opinion on the use of each device. They were also asked to give their overall opinion of the experiment. The post task questions were adapted from Perceived Usefulness and Ease of Use (PUEU) questionnaire [1] while questions on the usability of the device and the overall opinion were adapted from Computer System Usability Questionnaire (CSUQ) and After Scenario Questionnaire (ASQ) [7]. To anticipate fatigue caused by lengthy experiment, the participants were asked to perform the SRT test using only the mouse just to test the SRT protocol. Their SRT scores varied from 0.28 to 0.63 seconds.

Results from Pilot Study

Based on a pilot experiment done with students, out of the 5 models proposed by MacKenzie and Buxton [8], the Sum-Of and Smaller-Of models are the best fitting models (they do not differ significantly). Therefore, the pilot data was fitted to these two models. Figure 1 and 2 present the Fitts' Law data as modelled using the Sum and SMALLER-OF models.

It can be observed that for both models, the fit was the highest in term of R2 when a mouse was used. The Smaller-Of model has significantly better fit across all devices compared to the Sum model. Therefore, it was decided that from here on the data will only be analyzed using the Smaller-Of model.

Results from the reading tasks show that as the level of difficulty increases, the time taken to read the articles increased. However, the participants' comprehension scores did not correlate with FK levels.

The results of browsing tasks show that using a mouse and a tablet with stylus yielded a similar browsing time (77s – mouse, 78s – tablet) and using touchpad and touch screen also yielded a similar browsing time (both at 112s, which was worse than when a mouse or a tablet with stylus was used). In addition, feedback from the post task questionnaire

indicated that there was no consensus as to the device was the preferred one or the easiest.

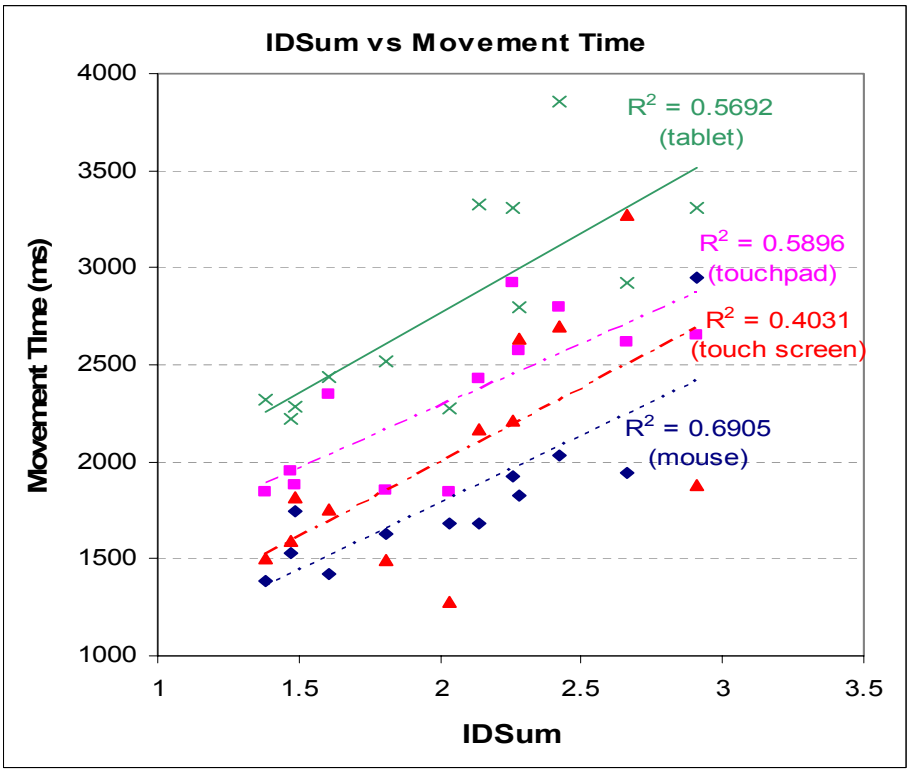

Figure 1: The Sum model

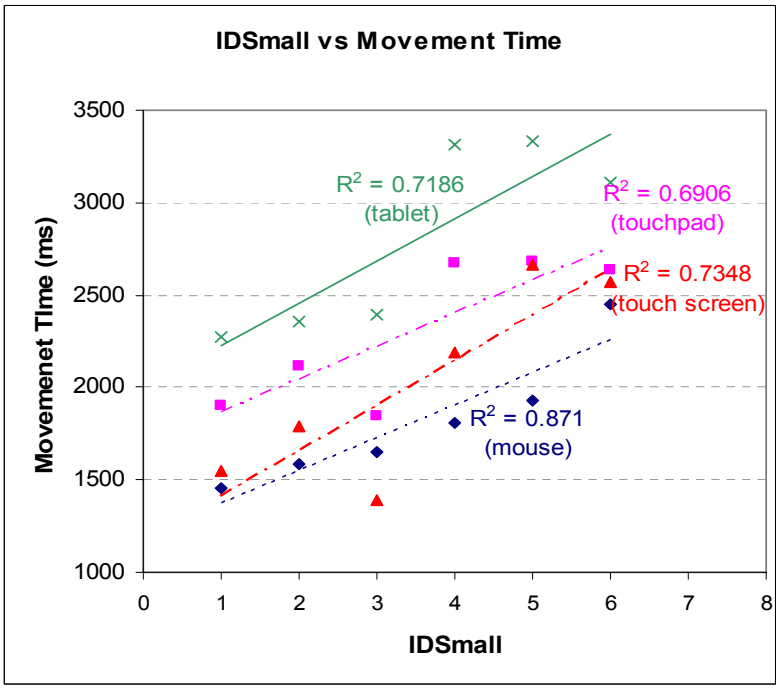

Figure 2: SMALLER-OF model

Implications from Pilot Study

The pilot study carries two implications. First, participants took between 3 and 5 hours with breaks to finish the study even though they are regular computer users (computer use per week ranges from 60 to 65 hours). Since some of the time were spent doing the reading tasks, it was decided to drop articles at FK18.

Second, there was no consensus yet as to which device was the best. From the Fitts' Law tasks, the tablet with stylus was by far the worst device (reinforced by users' complaints when performing the Fitts' Law tasks). However, the median times of the browsing task seemed to indicate that tablet with stylus was not the worst device. However, as we had to shorten the time the participants take, we decided to drop the tablet with stylus as it was the device with the worst performance in the Fitts' Law tasks and the most complained one.

Main Study

The real study was conducted with 18 participants with various types of motor impairments ranging from cerebral palsy, spina bifida, quadriplegia, tremor and arthritis. The apparatuses and methods were the same as those of the Pilot Study, except the tablet with stylus was no longer tested. Most participants were familiar with computer and mouse; some were familiar with touchpad. Most of them were not familiar with touch screen.

Results from Main Study

Results from the SRT test suggests that the participants performed the fastest when using a mouse, followed by a touchpad and then the touch screen. The means are significantly different for those three devices.

Figure 3 shows Fitts' Law model for the three devices. Using Zar's method [21] for comparing the three regression lines show that even though the slopes are not significantly different from each other, the intercepts are, and therefore these are still not the same lines. In other words, the mouse was significantly faster than the touchpad, which in turn faster than the touch screen, confirming the results of the SRT. The ANOVA of the R2 also reveals that, the fits are significantly different. Interestingly, the mouse has the lowest fit of the three devices, indicating that there is a large variation in the participants' performances when using the mouse compared to the performances when using the touch pad or the touch screen.

Results for reading time and comprehension were similar to the Pilot Study. Nevertheless, it was discovered that valid predictions of text comprehension could possibly be hindered by surface characteristics of the text, reader's cognitive aptitudes and cohesion and coherence of the text [13].

For the browsing data, the average browsing times for the participants were 63.3s (mouse), 71s(touch screen) and 74.2s (touchpad). One-way ANOVA shows that the average browsing times for the participants are significantly different across the three devices. The LSD posthoc analysis also reveals that each device's browsing time average is different from one another. The result is that, in line with the data from the SRT and Fitts' Law that mouse is the best device. However, the device with the worst performance this time is the touchpad rather than the touch screen.

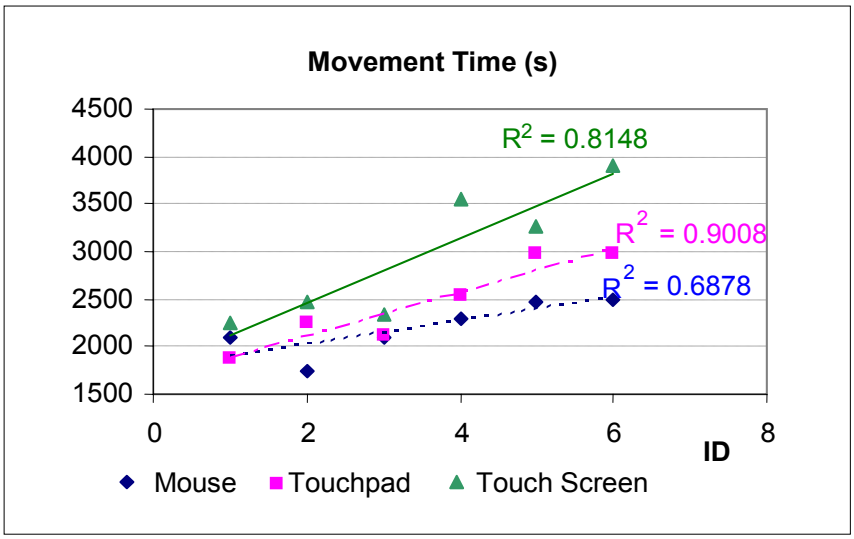

Figure 3: The SMALLER-OF model for all devices

For the post-task questionnaires, the means differences were analyzed usingx ANOVA. Table 1 shows the significant questions with $p<0.05$. An LSD posthoc analysis was performed for those that were significantly different. The posthoc pair wise comparisons were done on mouse vs. touchpad, mouse vs. touch screen, and touch screen vs. touchpad subsequently.

When asked to rank the devices in terms of ease of operation and preference, the ranking was identical. Ten people ranked mouse, 5 ranked touchpad and 3 ranked touch screen first.

Table 1. Results from the Perceived Usefulness and Ease of Use Questionnaire
NS = not significant, * = $p<0.05$, ** = $p<0.01$, *** = $p<0.001$

Question	Posthoc
Using the device in my job would enable me to accomplish tasks more quickly	NS, ***, *
I found it easy to get the device to do what I want it to do	NS, ***, ***
I found the device to be flexible to interact with	***, ***, NS
I can accurately complete my tasks using this device	NS, ***, ***
I feel comfortable using this device	NS, **, NS
Overall, I am satisfied with the ease of completing the tasks	NS, ***, ***
Overall, I am satisfied with the amount of time it took to complete the tasks	NS, ***, ***

Current Status

The second phase of the study was designed to meet objective (5). In essence, apart from investigating the effect of information architecture on browsing performance, it would also

provide evaluation on users' performance when using the three devices. Results that will be obtained could be compared with the results in main Study.

There are inherently several limitations of the study. Given the large variability in motor impairment found in our participant pool, there is always a possibility that any non-significant results are a result of this large variance. However, since all the objective measures showed significance, we could probably assume that the non-significant results in the subjective ratings (which are less affected by motor impairment as they are measures of opinions) are due to lack of noticeable differences in the aspects investigated.

The participants were all computer users who are mostly familiar with the mouse. This could definitely sway the results toward the mouse. A follow-up study with non mouse users could definitely provide a more objective result. Despite of these limitations, this study provides some insight into the types of common input devices that Malaysian computer users can potentially use.

Conclusions

This study investigates whether there is a better common input device than a standard mouse for Malaysian computer users with motor impairment. The study found that overall the mouse is still the device of choice, although familiarity might have affected the results (given that almost all of the participants were familiar with the mouse). However, the other devices did not lack behind much from the mouse, opening opportunities for training using devices in which touch pad or touch screen is the standard input devices rather than mouse (such as in laptops).

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