Countering Drifting: Exploring Methods to Improve Pen-based Menu Selection

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1. Introduction

Tablet computers are becoming more prevalent in the consumer market, appealing to users interested in its inductive pen technology. They are not, however, problem-free: in a previous study done with tablet computers, an effect termed as "drifting" was discovered, and found to be common amongst users.

This paper will discuss the possible solutions to the drifting effect, and the resulting experiment. By making small changes to the way the users can switch between menus at the menu label level, it is possible to reduce or remove the drifting effect that users experience. For this study, two menu interaction methods will be considered to counter the drifting problem. These include removing the drifting ability entirely, and introducing a threshold value to the menu heads.

1.1. **Background Information.**

The inductive pen technology allows users to interact directly with the laptop screen, using only the tablet pen. Input is given on the screen by touching it with the tablet pen, or by hovering the pen over the screen. Touching the screen is similar to clicking a mouse button, while hovering above the screen is similar to moving the cursor with the mouse.

Because of the two input types, however, "drifting" can occur when using the tablet computer, primarily in right-handed users. When a user opens a menu, the hand holding the pen will often occlude much of the menu contents. In order to read the item labels, the user must move the operating hand away. With the inductive pen technology, vertical movement is not registered, while the horizontal movement is, leading to the cursor "drifting" and opening an adjacent menu without the user's knowledge.

1.2. **Related Work.**

This study is based off of previous work done with menu interactions. These were done primarily by Joanna McGrenere, an Assistant Professor at the University of British Columbia, and Karyn Moffatt, one of Dr. McGrenere's PhD students. This work looked at difficulties with using the tablet pen technology, primarily missing the target item in a menu, and slipping off of the target menu item onto an incorrect one.

Drifting was a side-effect that was discovered during one of the previous studies. It was found to have happened with most users, and in all cases where it occurred, significantly affected performance. (Moffatt, 2007).

2. Experiment Description

2.1. **Experiment Conditions.**

Three conditions were designed and modified from existing code created in the previous study. Each task would be presented to the participants for a within-subjects study, giving a total of six permutations, and six possible task orders.

Condition I: Slide switch was the control method. No alterations were made to the existing code, and switching between menus was the same as the standard menu switching method currently found on the popular Microsoft Windows and Apple Macintosh OSX operating systems.

Condition II: Tap switch. The ability to switch menus by just moving the cursor over was disabled completely. In order for a user to open a new menu, the head label would have to be explicitly touched or tapped with the tablet pen.

Condition III: Delay switch. The threshold value method. It was based on the slide-switching menu programming, but instead of being able to switch right away when moving the cursor, a distance threshold value was introduced that delayed the switching.

Originally, both time and distance were considered as possible threshold measurements. A time threshold would look at the amount of time a cursor had spent in the new menu head. A longer period of time would suggest that the user meant to switch to the new menu, and the next menu would open. If the user did not intend to open the new menu, the original would remain open, allowing the user to move to the target item.

For the distance option, a threshold would be placed at a certain distance from the left of the menu head. When a menu was opened, the next one beside it could not be opened by sliding the cursor over, unless the threshold value was passed (See Fig.1 in the Appendix). This was the method chosen for two reasons, the first being that it was simpler to implement than time, and the second, more deciding reason, being that a suitable time threshold value would be difficult to calculate. Choosing a value would require knowing if a user hovered over the non-target menu due to drifting, or due to reading the target menu's contents, which would be a nearly impossible distinction from the recorded data values.

A concrete value could be chosen for a distance threshold, however: analytical work found that a 10 pixel distance would have caught 80% of the errors that occurred in the previous study. Setting the distance threshold to 10 pixels in practice seemed to be too small to be noticeable, so a 20 pixel threshold was implemented instead. For reference, the menu head width was 56 pixels, making the threshold just over 35.5% of the menu head.

2.2. **Required Tasks.**

For the study, users were asked to use each of the menu selection conditions, as described above. A word was displayed at the top of the screen, which the users had to find in the three menus present. Each menu consisted of twelve items, grouped into three groups of four related items, to reduce the amount of searching required, over time (see Fig. 2 in the Appendix). A practice set of ten selections was given at first, to allow time for describing

the task and the task condition to the user, as well as to give the user a chance to learn the menu contents before proceeding onto the task itself. After the practice set, each user was given six sets of thirty-six word selections, for a total of 216 selections for each interface method.

3. Methodology

3.1. **Study Participants.**

Participants recruited for this study were primarily students from across the UBC campus. The goal was to recruit twelve participants for the study, with two participants per task order. Users were required to be between the ages of 18 and 30 years, healthy with normal or corrected-to-normal vision, and right-handed with no physical impairments. To avoid the possibility that the users might be unconsciously familiar with the drifting effect, potential study participants had to have no tablet PC experience, and very little PDA (personal data assistant – e.g., a Palm Pilot) experience. Experience with tablets that were not the same as the display (e.g., Wacom tablets) was not considered, since it has a different interaction style.

3.2. **Experiment Procedure.**

Before the users started the actual menu-selection tasks, they were asked to perform some simple motor tests. These allowed us to look at their motor abilities, and link them to their performance in the tasks, if necessary. Users were also asked to complete a background questionnaire, looking at information about their current occupation, and their computer experience. The latter consisted of computer knowledge and exposure to computer technology.

Once all of this was complete, the subject would begin the menu selection tasks. After each set of menu selection tasks, users were given a feedback chart that displayed their number of correct selections per minute, as well as an overview of the time spent and errors made

in the previous set. This was to let users to see their progress, as well as to encourage improvement in their speed and efficiency.

After each session with one of the menu conditions, users were given a questionnaire asking about their experience with that method. After using all three interaction methods, users were asked to fill out a questionnaire comparing each condition. This questionnaire focussed on which ones the user preferred or disliked, if they felt any were easy or hard to use, and how the conditions affected their error rates.

Between conditions, users were given a distractor task, to give users a chance to remove the previous interaction method from their memory. These distractor tasks also tested, to a small degree, the participants' aptitude in English comprehension, to see if the results in the selection tasks occurred more from pattern matching or from understanding the related group in the menus.

The first distractor task, given after the questionnaire, required users to list as many words as they could that started with a given letter. The second distractor task, also after the questionnaire, required users to read a list of words out loud. This list was from the North American Adult Reading Test (NAART) and consisted of 30 irregularly spelled English words.

3.3. **Materials.**

Materials used in the study included the tablet computer and tablet pen for the main experiment tasks, as well as for an online reaction time measurer. A Purdue Pegboard (Tiffin, 1948) was used to look at motor coordination, and a Digit Symbol Substitution test (Wechsler, 1981) was used to look at perceptual speed. For looking at hand steadiness, a 9-hole steadiness tester was used. [1]

[1]Model 32011; Lafayette Instrument, Lafayette, Indiana. http://www.lafayetteinstrument.com

For each word selection trial in the experiment, a number of different parameters were recorded by the menu software. These include, but are not limited to: trial time (in milliseconds), number of errors made, incorrect words selected, number of times the target menu was selected, number of times a menu without the target word was selected, and mouse movement (in/out/hover) on menus and menu items.

4. Results

The data from twelve participants were used in the data analysis. Thirteen subjects were run in total, as an error in the study setup required an extra participant. As mentioned previously, each task order was done by two of the twelve subjects.

The desired result was that the third condition, with a distance threshold, would be considered by users as being the most preferred, and would reduce drifting time and drifting related errors. However, by the time the experiment was halfway through, the data did not seem to suggest that many significant results would be found.

Once the experiment was completed, statistical analyses were done on the collected data, and yielded a couple of significant results, as well as a few borderline significant results. Results were analyzed to a 95% confidence level.

4.1. **Significant Difference: Trial Time.**

The trial time was considered to be the amount of time it took the user to read the target word, find it in the correct menu, and tap on it. Significant results were obtained for overall trial times, with respect to interface task order. Pairwise comparisons in a post hoc analysis revealed significant differences between the delay and the tap switch methods, with the former being, on average, slower. Borderline significant differences existed between the delay and the slide switch methods. These differences existed in both task orders 3 (tap/slide/delay) and 6 (delay/slide/tap), but not in the other four.

4.2. **Significant Difference: Target Menu Activations.**

For the target menu activations, which is the number of times the correct menu was opened, there was a significant difference in the use of the interface. Pairwise comparisons found that the tap switch interface significantly lowered the number of times the target menu was opened, compared to the slide switch interface. Compared to the delay switch interface, the difference was borderline significant.

ANOVA results showed very small variances for each condition, and a high partial eta squared value for these results, indicating that the difference between methods was relatively large. The observed power was also very high, showing that there was nearly a 90% chance of finding an effect, if one existed.

4.3. **Borderline Significant Difference: Non-target Menu Activations.**

For non-target menu activations, borderline significant results were found. Similar to the significant number of correct menu activations, the tap switch interface had significantly fewer non-target menu activations, where a menu other than the target menu was opened before the item was selected.

4.4. **Other Results.**

In the questionnaires, a significant number of users felt that the tap switch method was the slowest to use. Most comments said this was due to requiring more tapping and more energy when going through the menus. Most users also felt that the slide switching method was the least frustrating; this result was borderline significant.

Most users also preferred the tap switching the least, and felt that the slide switching method was the fastest, but these results are not statistically significant. Some users seemed to think that the delay switch was the normal method of menu interaction, while others recognized the slide switch as being the standard. No confusion was present in distinguishing the tap switch between the slide switch conditions, however.

5. Discussion

5.1. **Understanding the Statistical Significance.**

While there are significant results suggesting that the drifting condition took longer than the others, per trial, the fact that only two people did each task order needs to be considered, and there is a strong possibility that this was a matter of chance, especially since the variance was large for each condition.

For the target menu activations, the fact that the tap switching method significantly reduced the number of menu openings suggests that the best way to reduce the drifting effect is to remove the ability to drift entirely. Drifting would mean that the target menu would be closed more often than intended, and since the target item had to be selected in order to proceed with the trial, it would need to be re-opened, regardless. By reducing the number of target menu activations, even considering the number of times the menu would need to be opened anyway (which is the same across all conditions), drifting is expected to be less for the tap switching condition.This explanation works also for the non-target menu activations. Drifting increases the number of times the incorrect menu is opened during a selection trial.

In the interface comparison questionnaire, users felt that the tap switching method was the slowest, even though the data analysis found little difference in tap condition, versus the other two. It is possible that because all of the users have had experience with modern computers, and have been exposed to computers for some time, the subjects in the younger age bracket are more used to the slide switching method, and the change in the mental model of having to explicitly tap on the menu affected their perceived model of the system.

5.2. **Possible Problems.**

A few problems came to light once the experiment was completed, in terms of the methodology used. One observation was that a question asking directly about perceived drifting could have been added into the last questionnaire given to the users, to see if they felt they could notice the drifting effect.

Another possible reason for the lack of a positive difference with the delay switch condition was that the threshold value could have been wrong, despite analysis of previously collected data. This would mean that the change in the menu head would not catch drifting problems.

The use of the word "delay" for the threshold condition might have led users to feel that the delay would affect their selection time. Although the distance threshold was shown and explained to each subject, any confusion that users might have had in trying the delay switch method might have had a psychological effect, where the use of "delay" had users expect a time delay, which certainly would have increased the amount of time required to do a trial.

5.3. **Future Work.**

One possibility is that there are no changes needed for the menu interaction system. Although drifting is extremely common, the perceived dissatisfaction with the tap-switch interface, which was the only interface that could have had an effect on drifting, was the least preferred. If users are capable of working around the drifting problem in exchange for being able to drift, then leaving it alone might be the best course of action. It is important to note however, that all of the participants in the study had at least some computer experience starting from the 1990's. This could affect their familiarity with the most common drift-switching menu system, altering their opinions on the subject.

Since all of the users in this study were recruited from the younger age bracket, results would be interesting to obtain for an older age group, particularly users who may not have used computers extensively and are not used to drift switching, or users who have decreased motor control. This is a potential area of future work that is being considered.

6. Conclusion

Over the course of this study, two potential menu interface methods were compared against the control method of slide switching in an experimental setup. Results from twelve participants were collected and analyzed, using a within-subjects experiment. Some interesting results were obtained, and while the desired effect with the delay switch interface was not achieved, its potential for success may still exist within older computer users.

It is unlikely that tablet computers become less popular in the near future, and if anything, they will only become more common as the technology is further developed. Considering that the drifting effect was fairly common in the previous study, it is likely still something worth looking at within the field of usability.

7. References

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8. Appendix: Example Experiment Menus

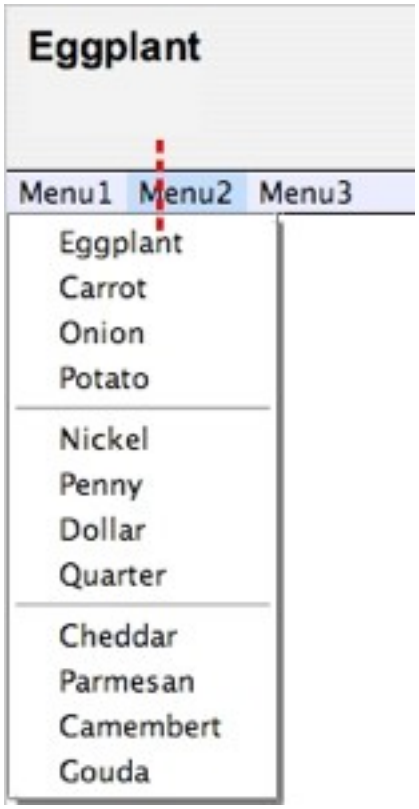

Figure 1. A screenshot of one of the menus that was given to users. The twenty-pixel threshold is indicated by the dotted red line. If Menu1 was open, and the cursor was to the left of that line, Menu1 would still be open. In this image, the cursor has moved past the threshold, and has opened Menu2.

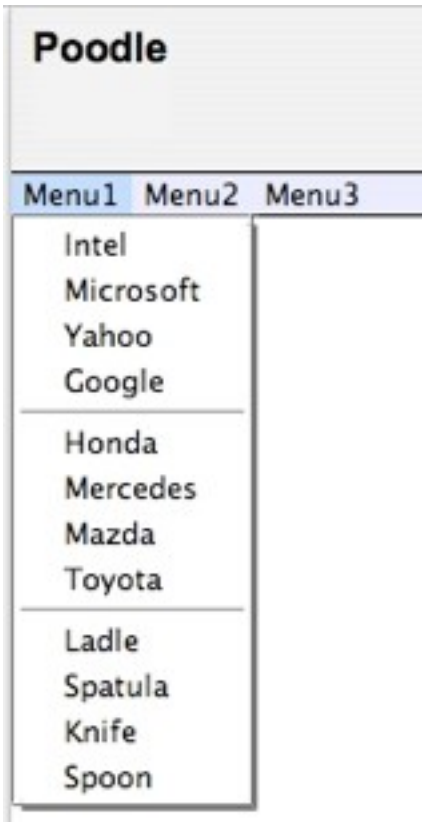

FIGURE 2. A screenshot of one of the menus that was given to users. The menu heads are the labels "Menu1", "Menu2", and "Menu3". Each menu consisted of three groups of four related items, separated by a small bar.