

An Experimental Study of Interfaces Exploiting a Pen's Merits

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1. INTRODUCTION

Recently *Pen User Interfaces* on a display-integrated tablet have been drawing attention as a new type of human-computer interface. However, the development and popularization of systems using pen user interfaces are not making progress. One of the reasons for this is that the majority of present systems with pen interfaces have misappropriately carried over interaction techniques from mouse-based interfaces. A pen is different from a mouse and therefore a study into interaction styles which exploit its merits is indispensable in designing pen interfaces.

This paper describes comparative experiments between a pen and a mouse. Such experiments were reported by Uoi [1] and Ono [2]. Uoi tested pointing and dragging with an indirect pen interface (using a CRT display and a tablet), and reported that a pen is faster than a mouse in both methods. Ono examined pointing with a direct pen interface, and reported that a pen performs better than a mouse, but that it shows greater directional dependencies. We have tested dragging for comparing two cases, where precision is required and where it is not, and two more cases varying the timing of visual feedback. Furthermore, we have tested pointing and investigated directional dependencies with pointing and dragging.

2. COMPARING TASKS USING DRAGGING

2.1. Case where precision is required and case where it is not required

Dragging is a kind of interaction method with a mouse, and is used for moving and others such as manipulations of objects. In such manipulations there are cases where precision is required, and those where it is not. To compare the performance of a pen with that of a mouse for tasks using dragging we tested two tasks as follows. One task, where precision is required, is moving and fitting a rectangular figure to a separate rectangular figure of the same size and shape (figure 1). The other task, where precision is not required, is moving and placing a small circle into a larger circle. The focus was on time taken to complete the task, and the number of times the object is moved during a task. The

subjects were nine students.

The results were as follows (figure 2). When precision is required, the average task time with a pen is shorter (80%) than that with a mouse, and the average number of moves with a pen is higher (150%) than that with a mouse. However, these differences are not validated by a t-test within a risk of 5%. When precision is not required, the average task time with a pen is shorter (50%) than that with a mouse and the average number of moves with a pen is almost equal to that with a mouse. This difference in task time is validated by a t-test within a risk of 5%.

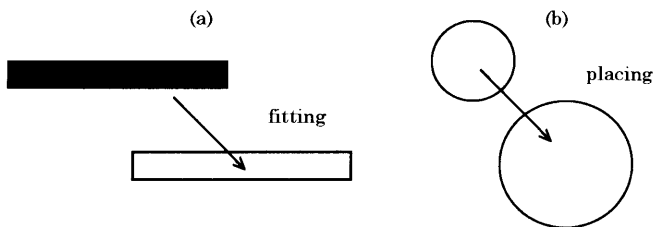


Figure 1. Tasks for experiment when dragging is used.

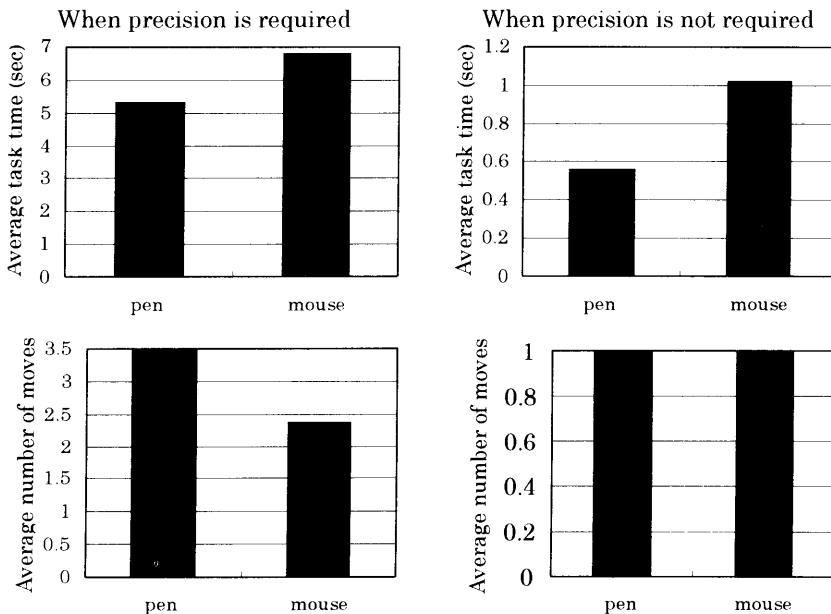


Figure 2. Task time and number of moves (A).

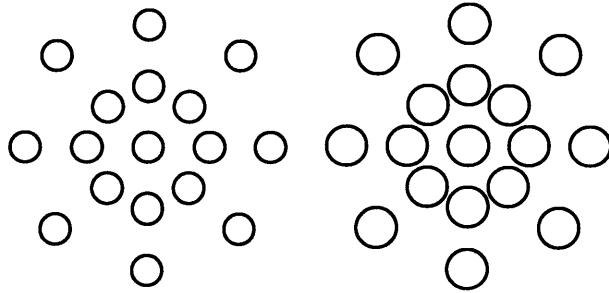
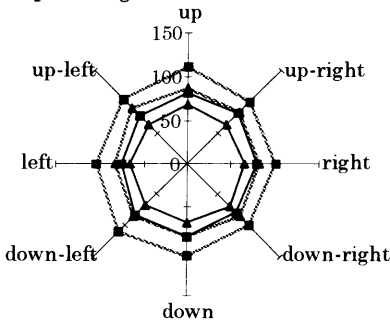
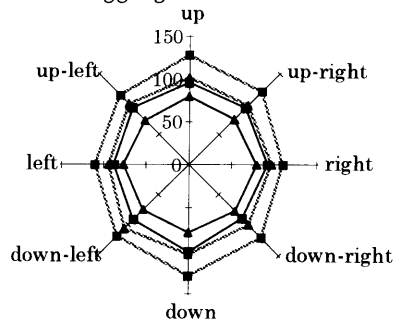


Figure 6. Group of circles for selection experiments.

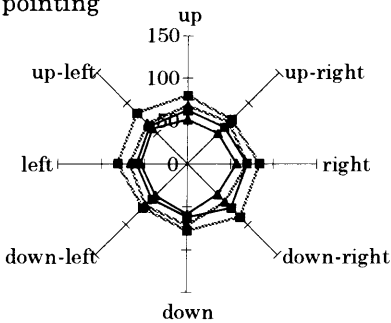
Mouse pointing



Mouse dragging



Pen pointing



Pen dragging

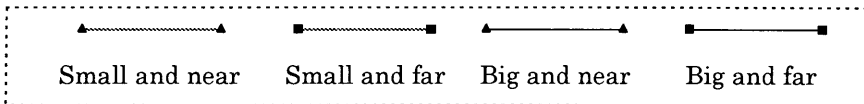
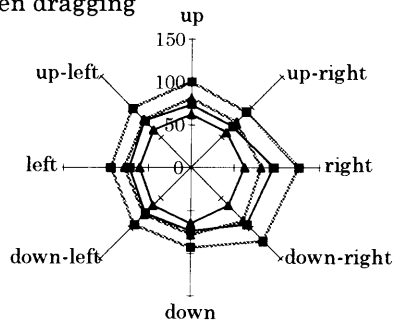


Figure 7. Task time.

2.2. Two cases where the timing of visual feedback varies

In a mouse interface visual feedback occurs continuously and instantaneously when dragging. In a pen interface there is an interaction technique called *pen gesture* that can specify the type of command, objects and parameters with one action. However, when this technique is used the type of command is not known until the user finishes writing the pen gesture. Therefore, visual feedback can not be done continuously during writing. Of course scope of pen gesture can be restricted to specify objects and parameters in order not to sacrifice visual feedback. To understand where pen gestures can be appropriately used, it is necessary to investigate whether the timing of visual feedback influences performance. We tested two cases changing the timing of the visual feedback. The two cases are: (1) visual feedback is continuous; and (2) visual feedback is commenced after the pen dragging is finished. The operation with precision required and that with no precision required were assigned to each case. The focus and the subjects are the same as in the previous test.

The results were as follows (figure 3). When precision is required the average task time in case (1) is shorter (70%) than that in case (2), and the average number of moves is lower (40%) than that in case (2). These differences are validated by a t-test within a risk of 5%. When precision is not required the average task time and the average number of moves are almost the same for the two cases. In short, the timing of visual feedback has influence when precision is required, but not when precision is not required. Therefore, the interaction technique using pen gestures can be used when precision is not required, but their use must be carefully designed when precision is required.

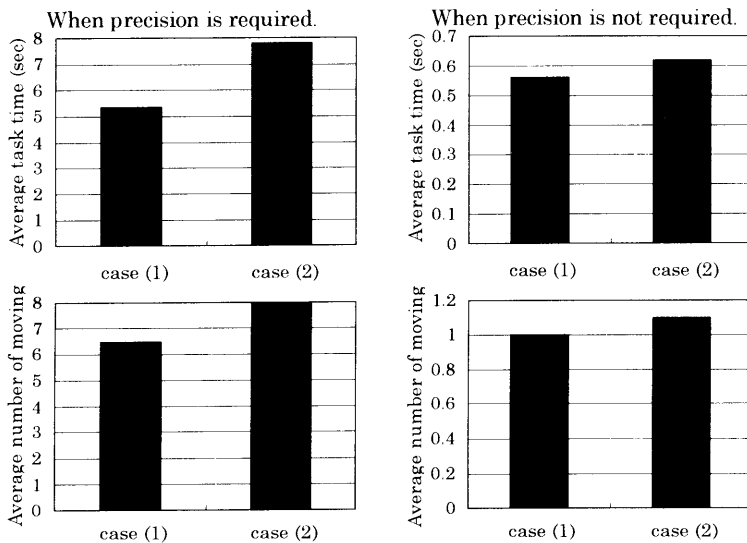


Figure 3. Task time and number of moves (B).

4. INVESTIGATING DIRECTIONAL DEPENDENCIES

To investigate directional dependencies of performance using dragging and pointing with a pen and a mouse, we experimented on a task of selecting a center circle and any one circle from a group of circles which is indicated by the system at random. These are placed in eight directions and two distances (far and near) from the center circle (figure 6). Two types of circle size were prepared (big and small). The focus was on time taken to complete the task. The subjects were different nine students. In this experiment, all subjects were right-handed and made to select each of the 16 circles 3 times, for a total of 48 selections.

The results were as shown in figure 7. The average task time with a pen is shorter (80%) than that with a mouse in all cases, and the differences are validated by a t-test within a risk of 5%. These results are the same as the previously reported results. When a mouse is used the average task time for all directions is almost equal. When a pen is used, it takes more time to move down-right than other directions, and it takes less time to move up-right or down-left than other directions. In short, for right-handed people, the directional dependencies using a pen are stronger than that using a mouse. This fact implies that pull-down menus, in which the user moves down-right repeatedly, are not suited to pen interfaces.

Two reasons that the average task time of moving down-right is longer are conceivable. One is that the circle to be selected was hidden by the subject's right-hand. The other is that moving down-right itself is difficult. From only these experiments the real reason is not clear. To clear up this point, an experiment excluding the first reason is necessary.

5. SUMMARY

This paper described experiments comparing pen- and mouse-based interfaces. From these experiments the following results were obtained: (1) A pen is faster than a mouse for pointing and dragging, (2) For right-handed people it takes more time to move down-right than other directions with a pen, (3) The timing of visual feedback has an effect on performance for tasks where precision is required.

REFERENCES

1. Uoi, H., Shinoda, M., Yamamoto, Y., Tsujino, Y., and Tokura, N.: *An experimental comparison of pen-tablet and mouse in selecting two targets* (in Japanese). SIGHI IPSJ 43-5 (1992), 33-40.
2. Ono, M.: *An experimental study of a pen's interface* (in Japanese). SIGHI IPSJ 41-13 (1992), 93-100.

3. COMPARING TASKS USING POINTING

Pointing is a kind of interaction method with a mouse and is used for selecting objects and so on. To know whether performance changes between cases using a pen and a mouse, we tested a task that is selecting in turn a mesh of 21 squares as shown in figure 4. In order to vary the movement required (long and short) during the task, two kinds of selecting sequences were prepared, moreover two sizes (big and small) of squares were prepared too. In this task precision was not required. The focus was on the time taken to complete it. The subjects were the same nine students.

The results were as follows (figure 5). The average task time with a pen is shorter (55-73%) than that with a mouse in all cases. The differences are validated by a t-test within a risk of 5%. In regard to the two selecting sequences, the differences of the task times with a pen for both cases is lower than that with a mouse. For these results it is speculated that the task time with a pen is not influenced by moving distance as much as with a mouse.

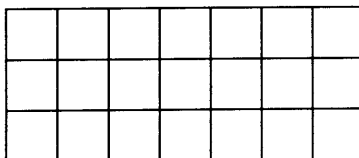


Figure 4. The mesh of 21 squares for selection experiment.

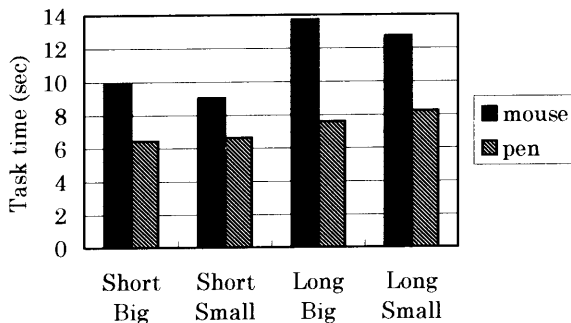


Figure 5. Task Time.