Shortening Selection Time Using Plural Cursor in Multi-display Environment and Its Preliminary Evaluation

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Abstract. This manuscript proposes a plural cursor to shorten selection time in multi-display environments. A plural cursor is a set of copies of an original mouse cursor, which move in a synchronized manner. Each copy is assigned on a different computer screen. This manuscript conducts an experiment to compare the performance of a normal mouse cursor and a plural cursor in a dual-display environment. The results show that the total path the plural cursor has taken on average was about half the distance of the normal cursor, but their total elapsed time was almost the same. The value of myoelectric spectrum a plural cursor was lower than that of a normal mouse cursor.

Keywords: Plural cursor · Mouse cursor · Multi-display · Fitts's law · Pointing interface

1 Introduction

One of the common pointing devices is a mouse. The mouse is synchronized with the mouse cursor displayed on a computer screen, and moves the cursor to select targets.

When people use a usual mouse cursor in a multi-display environment, they have to move the mouse cursor a long distance, resulting in more time taken to click a target. This is expressed by Fitts's law. According to Fitts's law, the longer the distance from the current position of the cursor to the target, and the smaller the size of the object is, the longer the time elapsed for the selection increases.

Equation (1) shows a formulation of Fitts's law and Fig. 1 shows an illustration of the Fitts's law. T means the time to move the cursor to the target. A and B are constants depending on the input device. D means the distance from the current cursor to the center of the target. W means the size of the target relative to the moving direction of the cursor. In Eq. (1), as W is larger and D is shorter, it is easier to select a target meaning that T is short. According to this

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rule, in a multi-display environment, the distance D to the target becomes large and the time T elapsed for selecting the target becomes longer.

This manuscript proposes a plural cursol which shortens the distance that people have to move the mouse cursor in a dual-display environment. A plural cursor can be used even when the number of screens is three or more. It is expected that the elapsed time to click on a target will be shorter because this cursor shotens the distance between the cursor and the target. This manuscript also measures and evaluates the myoelectric potential of the arm when using a plural cursor.

$$T = A + B \ \log_2(1 + \frac{D}{W}) \tag{1}$$

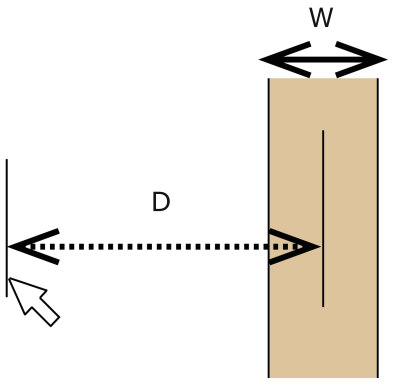

Fig. 1. Fitts's law.

2 Plural Cursor

A plural cursor is a set of copies of an original mouse cursor, which move in a synchronized manner. Each copy is assigned on a different computer screen. If users clicked the mouse, the event is sent to the copy on each screen. Although a new method by hitting the button to switch mouse cursors is conceivable, the number of times the button is hit increases and the elapsed time for switching becomes longer when the number of displays increases. Figure 2 shows the basic idea of a plural cursor in a dual-display. There are copies which move in a synchronized manner at the same coordinates on each screen. The application windows are placed at different positions so that they don't overlap on each screen.

As an advantage, the distance that users have to move the cursor to the target is cut in half because there are two cursors. From this and Eq. (1), it can be predicted that the time T elapsed for moving the cursor becomes shorter.

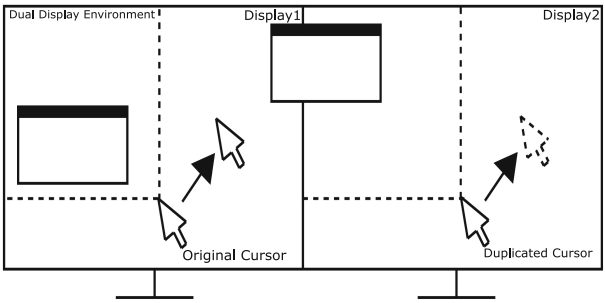

Fig. 2. Basic idea of plural cursor.

Moreover, the operation of this cursor is easy because it resembles a usual mouse cursor. It can also be said that it can be applied to three or more screens. As a disadvantage, a target on a computer screen should not be placed at the same relative position on the other screen because users could click on other targets unexpectedly. Since there are two cursors, the user may feel uncomfortable and may be confused.

3 Myoelectric Potential

We measure the myoelectric potential of the arm in order to evaluate the degrees of a user's stress when using a normal cursor and a plural cursor.

Myoelectric potential is a current flowing between one site and an adjacent site by the generation of an action potential inside and outside of the muscle cell. The action potential is a potential which is always generated by stimulation inside and outside the muscle. It is measured from the flexor carpi ulnaris muscle. This is one of the forearm muscles, and it is used in bending the wrist with a dumbbell or hitting a hammer. Figure 3 (left) shows electromyogram when a fist was clenched and Fig. 3 (right) shows electromyogram when a person is relaxing their hand. The amplitude and the frequency increase when forces are applied to the arm.

4 Experiment and Results

This section conducts an experiment to compare the performance of a normal mouse cursor and a plural cursor in a dual-display environment. It also measures and evaluates the myoelectric potential of the forearm when using them. Five right-handed subjects between the ages of 22 and 23 have experience in using a dual-display. Each subject performs the following task:

Step 1. The subject is explained the procedure of this experiment and the operation method of a plural cursor.

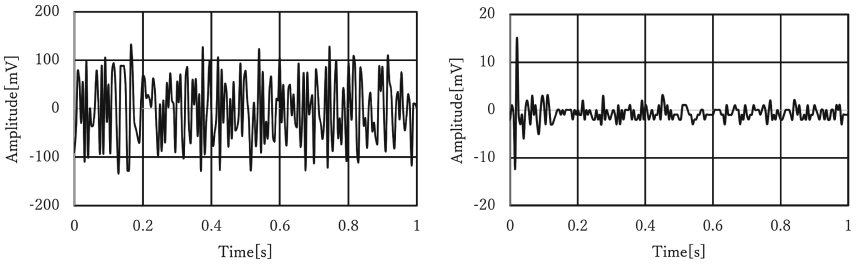

Fig. 3. Electromyogram of flexor carpi ulnaris muscle for one second. Electromyogram when a fist was clenched (left) and electromyogram when a person is relaxing their hand (right).

Step 2. The subject practices it, the experiment starts when he understands the operation method.

Step 3. Five targets are placed on each computer screen and there are 10 targets in total. Figure 4 shows an initial screen of the experiment.

Step 4. One target changes in color and the subject is asked to click on it then the next target will change in color at random. Figure 5 shows an example of the flow of this operation. This procedure is repeated 50 times. The black circles mean objects and the orange one means a target.

Step 5. The subject performs Step 3 to Step 4 using one type of cursor and after a 2 min break, he/she does the same steps with the other type of cursor. The order of the cursors is balanced for each subject, and the placement positions of the 10 targets differs for each subject and for each cursor.

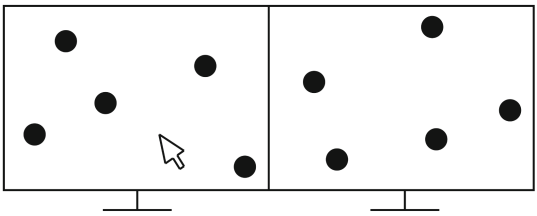

Fig. 4. An initial screen of the experiment.

The acquired data is the distance between targets[px], the path the cursor has actually taken[px], the elapsed time to complete the task[s], the number of miss-click[times] and the myoelectric potential of the dominant arm.

Figure 6 shows the experiment results. The placement position of the targets didn't have much influence on the results because there were no large differences in the total distance between targets. The total path the plural cursor had taken on average was about 47.2% that of the normal mouse cursor, but their total

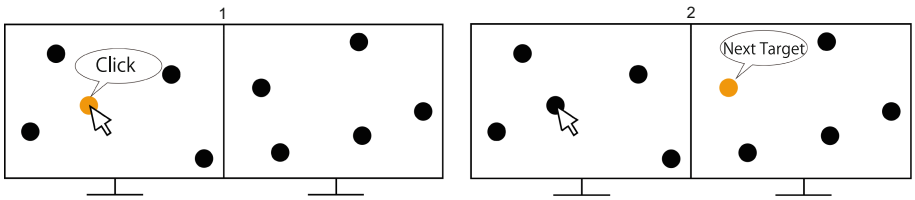

Fig. 5. An example of the flow of operation. One target changes in color and the subject is asked to click on it (left) then the next target will change in color at random (right). (Color figure online)

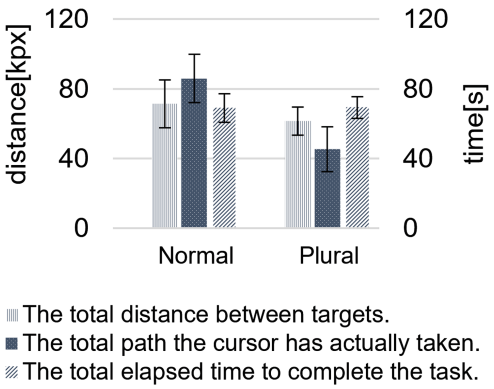

Fig. 6. Experiment results.

elapsed time was almost the same. From this, it is considered that it took time to find the position of the cursor when the screen on which the object was displayed shifted to the other screen. Therefore, it is necessary to have a mechanism to allow the user to always find the position of the plural cursor. As regards the number of miss-click, for the normal mouse cursor it is 2.5 times on average and it is 2.0 times on average for the plural cursor.

Figure 7 shows a myoelectric spectrum of flexor carpi ulnaris muscle, which was obtained from a span of ten seconds during the experiment for each mouse cursor system. From this, the integrated value at the range from 0 Hz to 100 Hz for a normal mouse cursor was 3.34 [mV] while it was 3.01 [mV] for a plural cursor. It is lower than that of a normal mouse cursor by 0.33 [mV]. The integrated value for the flexor carpi ulnaris muscle when holding the fist strongly is 199.95 [mV] and it is 8.30 [mV] when relaxing the arm. The value became smaller when operating the mouse compared to when relaxing the arm. The reason for this may be deviation of the mounting position of the sensor device or depend on the condition of the muscle.

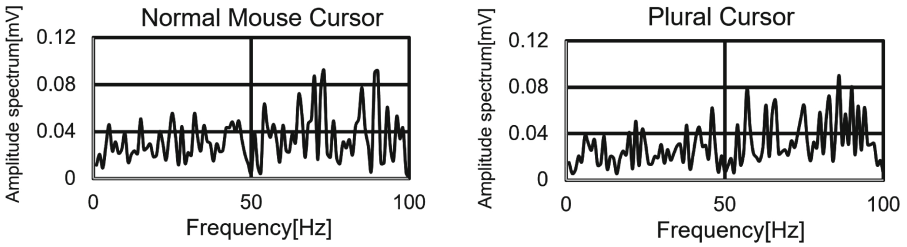

Fig. 7. A myoelectric spectrum.

5 Conclusions

This manuscript proposes a plural cursor to shorten selection time in multi-display environments. We conducted an experiment to compare the performances of a normal mouse cursor and a plural cursor in a dual-display environment. The result shows that the total path the plural cursor had taken on average was about half that of the normal cursor but their total elapsed time was almost the same. From the result of the myoelectric spectra, a plural cursor gave users less stress than a normal mouse cursor.

In the future work, we are going to discover the reason why the total elapsed time for a plural cursor to complete the task wasn't shorter and compare it with other proposed methods. In addition, it is also necessary to measure the myoelectric potential more accurately and analyze muscle fatigue.