A Study on the Usability Testing of Gesture Tracking-Based Natural User Interface

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1 Research Significance

This paper compares the difference between the commercialized gesture tracking-based interface and the traditional computer mouse through a usability testing. It is then examined the possibility of applying this technological difference to a variety of content. To achieve this, Kinect sensor device, which is one of the commercialized gesture tracking-based interface, has been used and evaluated its performance through Fitts' law. Fitts' law is mainly used in human-computer interaction, which is an authorized tool to evaluate a cursor click and movement on the computer screen. In this paper, three factors – distance, width, and angle – between cursor and target are used to define the index of difficulty into 96 steps. The response time between two randomly selected cursor positions is then measured for each step. By comparing the measured time values, the possibility of using gesture tracking as an alternative interface to the computer mouse is verified.

2 Experiment Environment (Usability Testing)

2.1 Experimental Subject

50 users who are familiar to computer usage are involved in the experiment. In this way, a total number of 4800 data are collected from the experiments of 50 users. The left-handed or right-handed users are randomly selected, where all experimental subjects have been used computer for more than eight years and composed of either undergraduate or graduate students with the average age of 28. Note that subjects having trembling hands and low visions are excluded for an accurate calibration of gesture tracking-based interface. Among 50 users, 40 users have been classified as an expert group, whereas the rest of 10 users as a non-expert group.

2.2 Experimental Setup

Fitts' law is used to evaluate the usability of gesture tracking-based interface technology presented in this paper. Fitts' law provides an indicator that can quantitatively evaluate the operation time according to the index of difficulty. Thus, it can be used as a qualified tool to evaluate the performance of cursor click and movement on the computer screen. [1-3]

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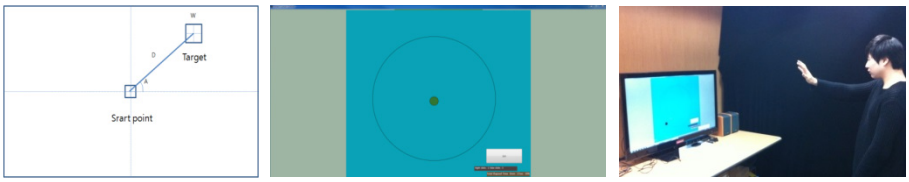
At each step, the proposed experiment considers as a successful task if the user is able to move its cursor to click on the target. To achieve this, the usability testing program has been developed as shown in Fig. 1(b). As shown in Fig. 1(a), the index of difficulty is determined by three parameters: the distance between the current cursor position and the target position (D), the width of target (W), and the approach angle between the cursor and the target (A). Thus, the index of difficulty is judged to be difficult if the value of distance (D) increases whereas the value of width (W) decreases. The advantage of using Fitts' law is that it provides a linear relationship between the index of difficulty and movement time. Thus, the index of difficulty can be defined in a variety of ways depending on its purposes of using Fitts' law. [4-6]



(a) (b) (c)

Fig. 1. (a) Three parameters (distance (D), width (W), and approach angle (A)) that define the index of difficulty, (b) Snapshot of the proposed usability testing program, (c) Snapshot of usability testing

The index of difficulty is consists of 96 steps, where the distance parameter (D) is divided into 3 levels ({125 pixel, 250 pixel, 375 pixel}), the width parameter (W) is divided into 4 levels ({50 pixel, 75 pixel, 100 pixel, 125 pixel}), and the approach angle parameter (A) is divided into 8 levels ({0°, 45°, 90°, 135°, 180°, 225°, 270°, 315°}) as shown in Table 1. Since the cursor position is randomly generated at each step, the experimental subject is not able to predict the cursor location of next step. Note that the position and size of the target are appropriately determined in a left and right direction with respect to the cursor location according to the difficulty at each step.

Table 1. The number of experiment parameters and their level values

Parameters	Parameter Level Values	Level Number
Distance to the target (D)	125, 250, 375 [pixel]	3
Width of the target (W)	50, 75, 100, 125 [pixel]	4
Approach angle to the target (A)	0, 45, 90, 135, 180, 225, 270, 315 [°]	8

2.3 Experimental Procedure

Prior to each experiment, the experiment procedure and correct posture are informed to each subject for an accurate calibration. Experiment environment is organized so that each subject can focus on the experiment. In addition, the lighting condition of

environment is adjusted to increase the recognition rate by reducing the maximum amount of reflected light.

Prior to each experiment, five minutes of practice period is given to each subject. The actual experiment starts when the subject presses 'Start' button in 'Experiment' toolbar. Before generating the target point, the subject waits after moving its pointer on the top of 'Start Point' button. When the experiment is started, each target is randomly generated according to the condition of three parameters: position, width, and approach angle (a total of 96 steps).

The subject presses 'Start Point' button when he/she recognizes the position of target point. The response (movement) time is recorded when the subject immediately moves and presses its pointer to the target. In order to maintain the consistency of experiment results, five minutes of break period is given to each subject between each session to avoid additional factors such as concentration and fatigue. In this way, the experiment is progressed to a total of 50 users in accordance with four conditions in each session.

3 Experiment Results and Analysis

3.1 Average Response (Movement) Time

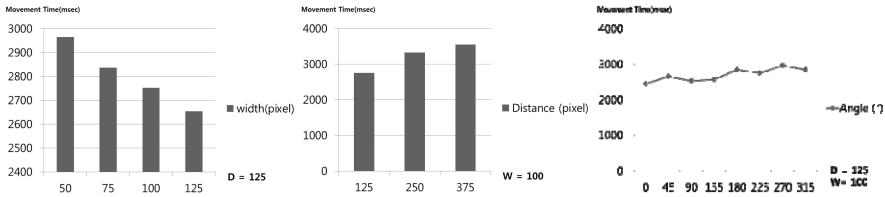
To examine the impact of response time for each parameter, the response time with respect to each parameter is presented as graphs. Fig. 2(a) shows the average response (movement) time for each width value when the distance between cursor and target is set as 125 pixels. As shown in Fig. 2(a), the average response time was decreased as the value of width pixel increases.

Fig. 2(b) shows the average response (movement) time for each distance value when the width of cursor and target are set as 100 pixels. As shown in Fig. 2(b), the average response time was increased as the value of distance between cursor and target increases.

Fig. 2(c) shows the average response (movement) time for each approach angle value. A short average response time was observed when the target was located relatively above the horizontal center of display. Particularly, the minimum average response (movement) time was observed when the approach angle to the target was

Table 2. Experiment results of each parameter

Distance [pixel]	Width [pixel]	Approach Angle [°]	Movement Time [msec]
125	50	0	2965
125	75	45	2837
125	100	90	2752
125	125	135	2654
250	50	180	3625
250	75	225	3561
250	100	270	3327
250	125	315	3412
375	50	0	4021
375	75	45	3829
375	100	90	3551
375	125	135	3315



(a) (b) (c)

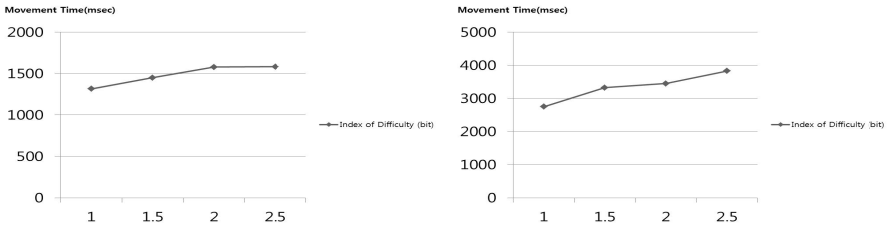
Fig. 2. (a) Average response (movement) time for each width value, (b) Average response (movement) time for each distance value, (c) Average response (movement) time for each approach angle value

Table 3. Comparison between mouse and gesture tracking-based interface

Distance [pixel]	Width [pixel]	Index of Difficulty [bits]	Mouse Movement Time [msec]	Gesture Tracking Movement Time [msec]
125	75	1.4150	1263	2837
125	100	1	1316	2752
250	75	2.1154	1349	3561
250	100	1.5849	1451	3327
375	75	2.5849	1451	3829
375	100	2	1578	3451

0°. Note that the response time was slightly increased when the approach angles were 45°, 90°, and 135°. As shown in Fig. 2(c), the average response time was increased as the value of approach angle to the target increases.

Table 2 shows the usability evaluation results between computer mouse and gesture tracking-based interface. Based on the measurements in both cases, it was confirmed that the index of difficulty and the movement time were linearly distributed as shown in Fig. 3. Fig. 3(a) shows the results when the computer mouse was used, where the measured index of difficulty was 1.2680 bits/sec. In contrast, the measured index of difficulty was 0.5312 bits/sec when the gesture tracking-based interface was used as shown in Fig. 3(b). Thus, if the numerical results of the index of difficult from the proposed experiment were only considered, we could conclude that the performance of gesture tracking-based interface is less efficient compared to the performance of computer mouse.



(a) (b)

Fig. 3. The relationship between movement time and index of difficulty (a) mouse, (b) gesture tracking-based interface

4 Conclusion

While it is important to know the capabilities and limitations of computer in an interface design, it is even more important to understand the capabilities and limitations of user first. This applies for both gesture tracking-based interface and regular computer mouse.

This paper examined the impact of response (movement) time for a recently commercialized gesture tracking-based interface by varying the distance to target, the width of target, and the approach angle between cursor and target.

The experiment results of the proposed interface showed that there is no problem with the usability of gesture tracking-based interface in contents such as games that have relatively large menu size and the accuracy is not critical. However, the computer mouse showed the outstanding performance for the tasks that require sophisticated user interface.

In the previous studies, several factors were not able to consider at the same time and there was a drawback that the index of difficulty in Fitts' law was not able to combine with other factors. Thus, more research is needed to provide a natural user interface to user while maintaining the performance. In addition, the detailed verification is further required by using the modified Fitts' law. [7-8]

These experiment results may help us to predict the performance degree of Kinect as well as to provide the guidelines for the development and evaluation of all interfaces that use gesture tracking-based interface.

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