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A Pilot Study on the Control Performance of Foot-Controlled Mouse Devices for the Nondisabled People

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Objective: In this study, two types of foot-controlled mouse devices are compared with a hand mouse in the input tasks requiring repetitively switching between a keyboard and a mouse.

Background: Foot-controlled mouse devices have been developed for persons with impairments in the mobility of their hands. However, some researchers insisted that the foot-controlled mouse devices could be effectively used by the persons with no limits to their hand mobility. There are needs to investigate the efficiency of the foot-controlled mouse devices, when they are used by the nondisabled people.

Method: Participants conducted the input tasks, requiring repetitive switches between a keyboard and a computer mouse. The used computer mouse devices were two types of foot-controlled mouse and a typical hand mouse. Participants performed three types of input task for five days and three types of task performance were measured; the number of completed input tasks within a given practice time, subjective satisfaction level and the time wasted for the mouse control.

Results: For five days, the performance of input tasks sharply increased in input tasks by foot-controlled mouse devices rather than a hand mouse. After five days, the level of satisfaction on the foot-controlled mouse devices approached to about 76% of a hand mouse satisfaction level. The control time of the foot-controlled mouse devices also approached to about 109% of a hand mouse control time.

Conclusion: After only five-day practice, the input task performance by foot-controlled mouse devices approached to that of a hand mouse. This result may suggest that the foot-controlled mouse devices can be effectively used as an alternative input device for the nondisabled people, if input tasks are easy and enough practice time is provided.

Application: The results of this study might help to design foot-controlled mouse devices and to expend the usage of them.

Keywords: Foot-controlled mouse, Learning effects, Input devices, Disabled people

1. Introduction

The input devices were typically designed for persons with no impairments in the mobility of their hands. Computer interaction with these input devices by the disabled people may be impractical depending on their individual disability. They may experience any of several difficulties, such as frequent typing mistakes, multiple keystrokes, inability to accurately and repeatedly control the device, or the inability to access the device partially or entirely. Many researchers had developed alternative input devices for the disabled people such as alternative keyboard and mouse devices; eye-input devices and voice recognition tools (Hutchinson et al., 1989; Karl et al., 1993; Shneiderman, 2000).

The foot has not been extensively used as a limb to control any devices. Input devices controlled by the foot are not popular in our daily life. A few examples are foot pedals to drive cars and foot switches for industrial workers. These devices are activated by just pushing them as required. The foot produces simple vertical movements for controlling the devices.

The foot-controlled mouse devices developed as an alternative of a hand mouse for the disabled people are requiring more complex foot movements, compared to the traditional foot-controlled devices. When the complex foot movements are required, the controllability of the devices may be questionable. Many previous studies indicated that foot movements were less efficient than hand movements (Hoffmann, 1991; Springer and Siebes, 1996; Hong and Kim, 2012). Regardless of this low efficiency, people with impairment of hand mobility may unavoidably use the foot-controlled mouse devices as an alternative mouse.

However, some researchers suggested a possibility that the foot-controlled mouse could be effectively used for the nondisabled people (Simpson, 2013). When nondisabled people conduct the input tasks that require repetitively switching between keyboard and a typical hand mouse, they are suffering from the time lose in the process of switching two input devices. This is because the keyboard and hand mouse are controlled by the same hand. If a foot-controlled mouse is used as an alternative of the hand mouse, it may be contribute to the reduction of the time lose.

In this study, two types of foot-controlled mouse devices are compared with a hand mouse in the input tasks requiring repetitively switching between a keyboard and a mouse. It is measured how the efficiency of the devices is changed according to the degree of practice.

2. Method

2.1 Participants

Four paid volunteers (1 male, 3 female) were recruited from Korea National University of Transportation. Participants ranged from 20 to 28 years old (mean = 23). All were daily users of computer hand mouse. None had prior experience with foot-controlled mouse devices. All participants had no impairment in the foot and hand mobility. They took part in all experimental conditions.

2.2 Apparatuses

Input devices used in this experiment were a hand mouse and two types of foot-controlled mouse devices. A typical optical mouse was used as a hand mouse. Two foot-controlled mouse devices were selected among commercially available devices (Figure 1). Footime mouse (Bili Inc.) is a two-part input device; the "slipper" that goes on a user's foot is for cursor control, and the pedal is for mouse clicks and shortcuts. The slipper-shaped cursor control is the similar to the typical hand mouse. The pedal for the mouse clicks and shortcuts includes several push buttons.

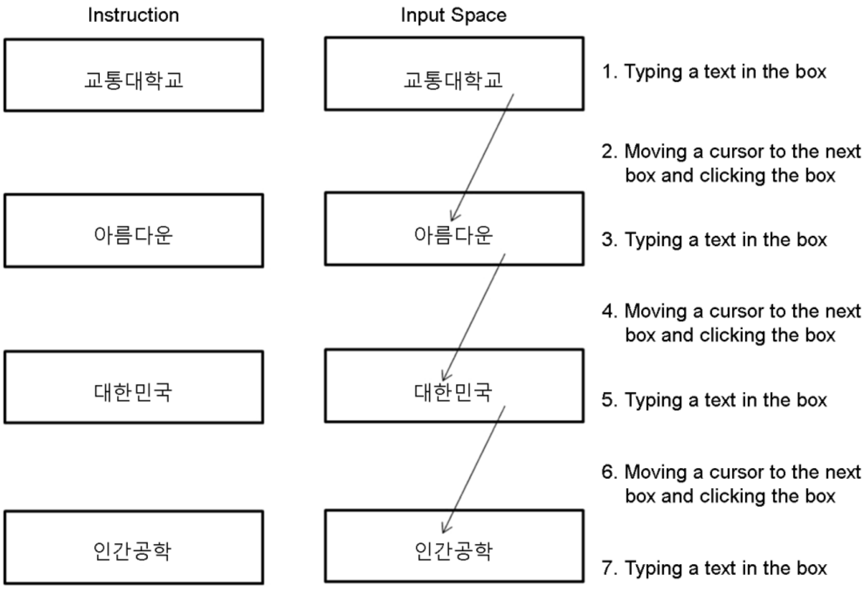
No-Hands mouse (Fentek Inc.) consists of two pedals; a cursor pedal and a click pedal. The cursor pedal is mounted on a base that stays stationary on the floor. The pedal itself pivots on top of the base and moves in any direction a user presses his/her foot. This movement will be translated into cursor movement on the screen. The more firmly a user presses on the pedal in any direction, the faster the cursor goes. The click pedal is also mounted on a base like the cursor pedal. The pedal only allows movement in an up and down rocking-like motion from heel to toe. The toe click is equivalent to the left button and the heel click is equivalent to the right button.

(a) Footime Mouse (b) No-Hands Mouse

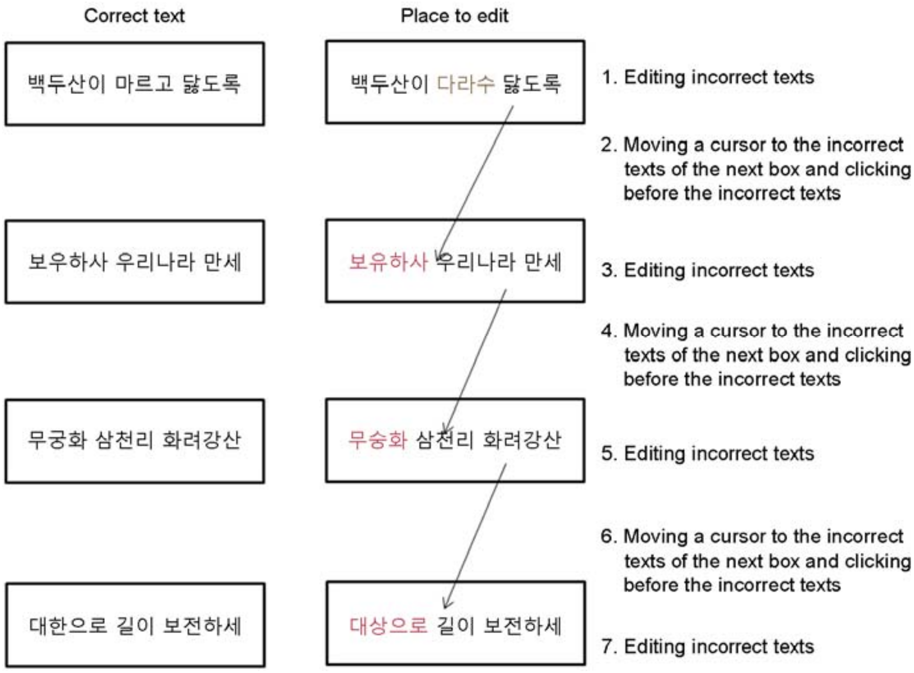
Figure 1. Two types of foot-controlled mouse devices used in this experiment

2.3 Tasks

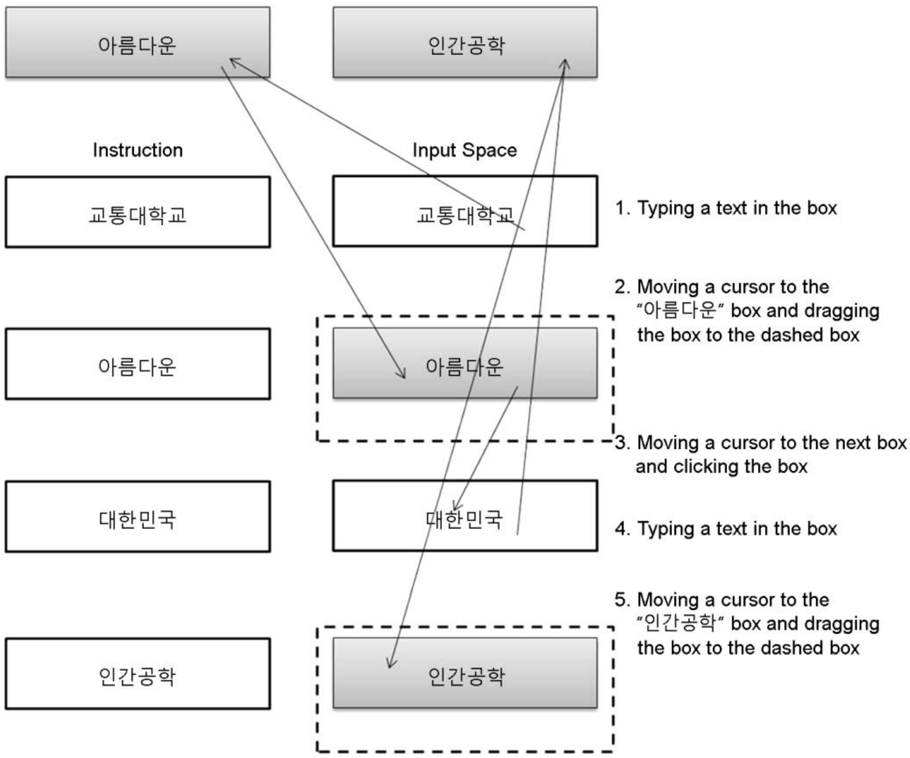
All participants performed three types of input tasks, requiring repetitive switches between a keyboard and a computer mouse. Figure 2(a) shows the simplest input tasks among three input tasks. Participants should type a short word indicated in the instruction box of the left side. After clicking the input box of the right side by the computer mouse, participants input the text using the keyboard. A series of this task is conducted in a screen. Figure 2(b) is a task to correct the text after finding an incorrect



(a) Type 1: Typing a short word indicated in the instruction box of the left side



(b) Type 2: A task to correct the text after finding an incorrect text



(c) Type 3: Input task requiring mouse drags, text inputs and cursor movements

Figure 2. Three types of input tasks requiring repetitive switches between a keyboard and a computer mouse

text. More precise mouse work is needed than the first input task. The cursor should be exactly placed and clicked in the front of incorrect text within the input box. Figure 2(c) is the most complicated input task, requiring mouse drags, text inputs and cursor movements. The third task is an input task adding mouse drag work to the first input task. Participants should input a text in the input box in the top of the screen and the box should be dragged into the appropriate position.

2.4 Design of experiments

Participants conducted three types of input tasks using three types of computer mouse devices for five days. Input tasks for a day were divided into a practice session and a test session shown in Table 1. The practice session for the foot-controlled mouse devices took 55 minutes including 2 times of 5 minutes break. Three types of input tasks were sequentially performed during practice session. The practice session for the hand mouse took only 20 minutes without a break. The short practice time was setup because participants were already experienced enough to the hand mouse control. In the test session, participants conducted 5 times of three input tasks using each mouse devices.

Table 1. Experiment schedule for a day

	Foot-controlled mouse (Footime mouse & No-hands mouse)	Hand mouse
Practice session	15 min. Practice	20 min. Practice
	5 min. Break	
	15 min. Practice	
	5 min. Break	
	15 min. Practice	
Break	5 min. Break	5 min. Break
Test session	Test (5 times repeated)	Test (5 times repeated)

3. Results

3.1 The number of input tasks completed for a practice session

The number of input tasks completed for a practice session of each day was measured in input tasks using each computer mouse devices and a keyboard. If all three types of input tasks were completed, it was counted as 1, two types of input tasks as 2/3 and one type of input tasks as 1/3. Figure 3 shows the phenomenon that the number of completed input tasks is changing with the practice. For five days, the performance of input tasks sharply increased in input tasks by foot-controlled mouse devices than a hand mouse. In particular, learning effect of the Footime mouse was highest among three mouse devices. Two-way ANOVA (2 levels for the foot-controlled mouse devices, 5 levels for the practice) was conducted. Footime mouse was more efficient than the No-Hands mouse ($F(1, 39)=33.15$, $p < 0.001$). The number of completed input tasks was insignificant different according to the practice ($F(4, 39)=43.60$, $p < 0.001$). There was no interaction between foot controlled mouse devices and practice ($F(4, 39)=0.30$, $p = 0.88$).

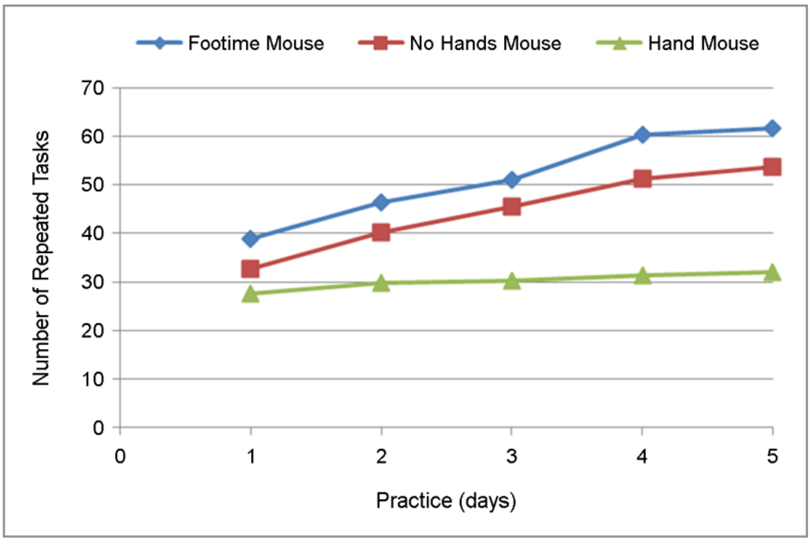


Figure 3. Changes of the number of completed input tasks according to the practice

3.2 Analysis of satisfaction levels

Subjective satisfaction level was measured after the completion of experiments in each day. Seven point rating scale ranging one (very low) to seven (very high) was used for the subjective rating. Seven point stands for the satisfaction level that is the same to the hand mouse satisfaction. The satisfaction level on the foot-controlled mouse devices increased with the practice ($F(4, 119)=5.19$, $p < 0.01$) as shown in Figure 4. The Footime mouse provided higher satisfaction than the No-Hands mouse ($F(1, 119)=26.88$, $p < 0.001$). After five days, the satisfaction level of Footime mouse approached to about 76% (=5.7/7.0) of a hand mouse satisfaction level. On the other hand, the simpler the input task was, the higher the satisfaction level was ($F(2, 119)=13.57$, $p < 0.001$). That is, the first type of input tasks provided the highest satisfaction level as shown in Figure 5.

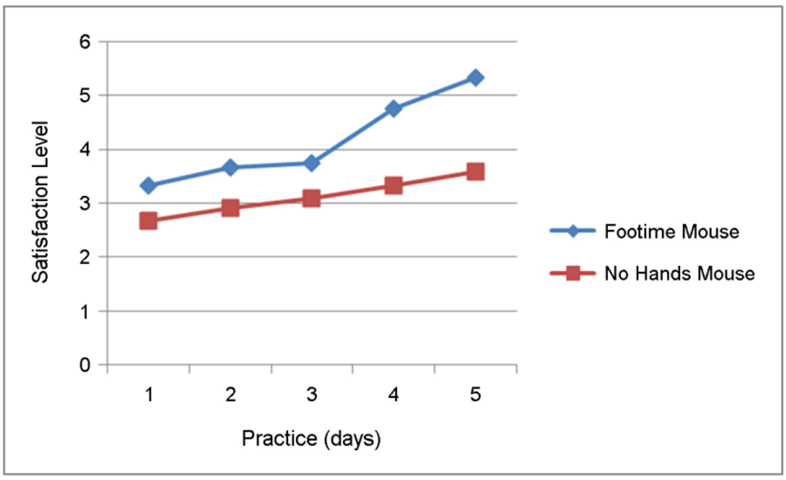


Figure 4. Changes of satisfaction level according to the practice

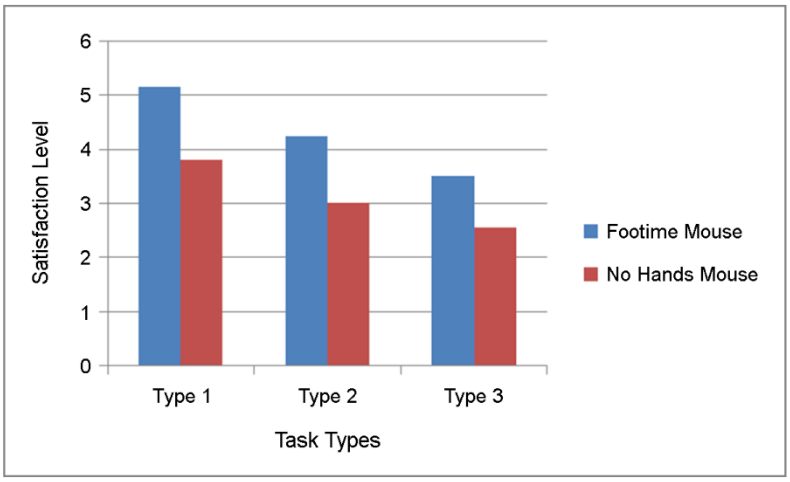


Figure 5. Satisfaction level according to the types of input tasks

3.3 Analysis of mouse control times

The mouse control times were measured in the test session of each day. The mouse control time was significantly different according to the three main factors (task type, date and mouse) and there were significant interaction between all pairs of three main factors (task type*date, mouse*task type and date*mouse task) as shown in Table 2.

Table 2. ANOVA of mouse control times

	DF	Seq SS	Adj SS	Adj MS	*F*	*p*
Task Type	2	263.652	263.652	131.826	440.18	0.000*
Date	4	39.461	39.461	9.865	32.94	0.000*
Mouse	2	79.318	79.318	39.659	132.43	0.000*
Task Type*Date	8	9.9	9.9	1.238	4.13	0.000*
Task Type*Mouse	4	68.356	68.356	17.089	57.06	0.000*
Date*Mouse	8	14.719	14.719	1.84	6.14	0.000*
Errors	151	45.222	45.222	0.299		
Total	179	520.628				

As shown in Figure 6, the mouse control times of the foot-controlled mouse devices sharply decreased with the practice, while the mouse control time of a hand mouse was not significantly changed according to the practice. On the other hand, when the difficulty of input task was low, the difference between control times of each mouse devices was not large, while the difficulty was high, the difference was large.

The standard deviations of mouse control times were analyzed. The standard deviation was significantly different according to the three main factors (task type, date and mouse) and there were significant interaction between task type and mouse and between date and mouse task as shown in Table 3.

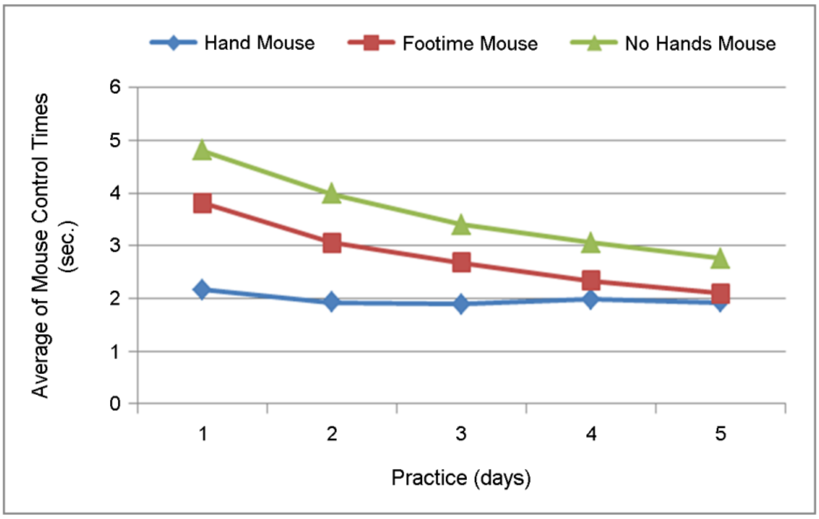


Figure 6. Change of mouse control times according to the practice

Table 3. ANOVA of standard deviations of mouse control times

	DF	Seq SS	Adj SS	Adj MS	*F*	*p*
Task Type	2	48.1491	48.1491	24.0746	42.3	0.000*
Date	4	13.0838	13.0838	3.271	5.75	0.000*
Mouse	2	29.0116	29.0116	14.5058	25.49	0.000*
Task Type*Date	8	7.3129	7.3129	0.9141	1.61	0.127
Task Type*Mouse	4	17.3352	17.3352	4.3338	7.61	0.000*
Date*Mouse	8	10.9623	10.9623	1.3703	2.41	0.018*
Errors	151	85.9435	85.9435	0.5692		
Totals	179	211.7985				

As shown in Figure 7, the standard deviations of the mouse control times of the foot controlled mouse devices sharply decreased with the practice, while those of a hand mouse were not significantly changed with the practice. On the other hand, when the difficulty of input task was low, the difference between the standard deviations of each mouse devices was not large, while the difficulty was high, the difference was large.

4. Discussions and Conclusion

Foot-controlled mouse devices were developed for persons with impairments in the mobility of their hands. However, there may

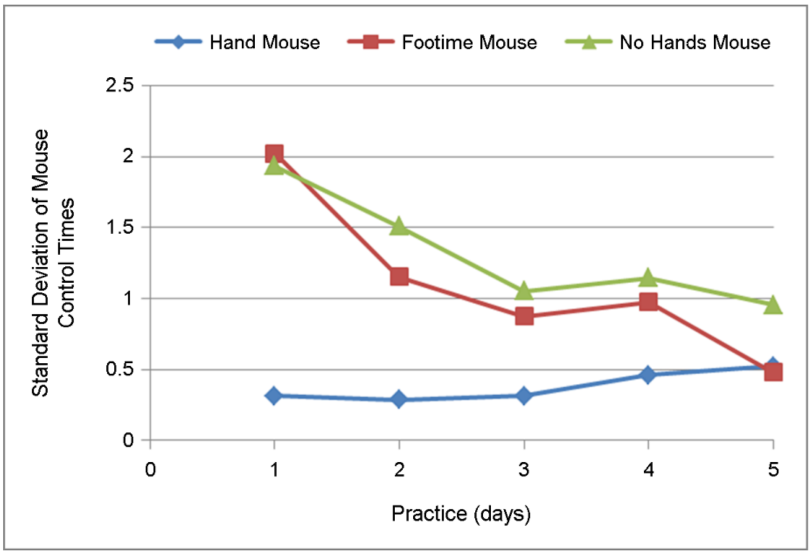


Figure 7. Change of standard deviations of mouse control times according to the practice

be some possibility that the foot-controlled mouse devices could be effectively used by the nondisabled people, because computer interaction requires too much workload on the users' hands and there is a need to share the workload with the other limb.

This study investigated the efficiency of the foot-controlled mouse devices, comparing with that of a typical hand mouse, when they are used by the nondisabled people. The input tasks requiring repetitive switches between a keyboard and a computer mouse was conducted by the participants. The control times of foot-controlled mouse devices decreased with the increase of practice time, while those of a hand mouse were not decreased. After five days, the control time of the foot-controlled mouse devices approached to about 109% of a hand mouse control time. The satisfaction level of the foot-controlled mouse devices also approached to about 76% of a hand mouse satisfaction level. The control performance of the foot-controlled mouse devices was higher in the simple input tasks than the complex input tasks.

There was also significant difference in the control performance according to the types of foot-controlled mouse devices. The Footime mouse was more efficient than the No-Hand mouse in the control time and satisfaction level. To sum up, the foot-controlled mouse devices can be effectively used as an alternative input device for the nondisabled people. If input tasks are easy and enough practice time is provided, the effectiveness of the foot-controlled mouse devices would be more increased.

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