Mouse Manipulation Through Switch-Control Input Device for People with Disabilities

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Abstract: - For the disabled, Microsoft has provided eight keys on the keyboard to direct the movements of the mouse cursor in the Windows Operating System. However, using them is uncomfortable because they are small, poorly located and moved slowly. This study proposes a faster switch-control computer input device using the method of two-grade movement mode, rather than that of Microsoft; this device has other additional functions to help users easily access the computer. The device has 15 switch-sockets. Eight switch-sockets are utilized to control the direction of motion and seven switch-sockets provide additional functions. The structure of this device -which allows users to create operating platforms that fit their requirements; to choose the number of required switches; to locate the switches and establish the movement speed- is an open and human interface. Six users without physical disabilities and two physically challenged users tested the device. Experimental results reveal that the average time taken using the proposed device was faster than that using the Microsoft Windows method by a factor of 6.17- 12.58. Furthermore, the users can combine the proposed device with the speed function-key for a given far target to get the cursor speed improved by 43%.

Key-Words:- Disable**,** Microsoft, Mouse cursor, Switch, Mouse

1 Introduction

Computer technology pervades daily lives, and is used to actively acquire knowledge, partake in recreational activities and access the Internet and computer-controlled technologies. Users currently move and drag a mouse cursor to select operations directly on the computer graphic user interface (GUI). The tracker types gaining popularity are mouse, trackball, track point, and touch panel.

Based on of human experiments, the mouse have provided to be the most efficient and effective tracker. [2], [3] The basic mouse operations of mouse are movement, click, drag, and double click. These operations require movement of the forearm, arm, wrist and fingers. However, users who do not have good movement control, such as the elders, those with cerebral palsy and spinal cord injuries, have difficulty performing these movements. In recent years, assistive technology devices have been developed to help such users in utilizing their voluntary movements to control the computer and computer interface devices; such devices are now commercially available to users with physicaldisabilities. Some systems utilize infrared emitters that are attached to a user’s glasses, head band, or cap. Other systems place the transmitter over the monitor and use an infrared reflector attached to a user’s forehead or glasses, etc. [4]. With such devices, a user’s head movements control the mouse cursor on the screen and mouse clicks are generated via a physical switch or a software interface. Evans *et al.* recently described a head-mounted infrared-emitting control system that is a “relative” pointing device and acts like a joystick rather than a mouse [5]. Chen *et al.* developed a system containing an infrared transmitter, mounted on the user’s eyeglasses, a set of infrared receiving modules that substitute the keys of a computer keyboard, and a tongue-touch panel that activates the infrared beam [6]. Helmets, electrodes, goggles, and mouth sticks are uncomfortable to wear and use. Commercial head-mounted devices usually cannot be adjusted to fit a user’s head. Most importantly, some users dislike anything touching their faces and vehemently object devices that attach to their heads. Reilly and O’Malley [7] proposedanon-contact, infrared-based system that tracks the reflected laser speckle pattern in skin. Other commercial systems that allow severe physically challenged individuals access to a computer are based on measuring corneal reflections.

Such systems determine the direction of a user's gaze by comparing the pupil position in an image of a user's eye with the light pattern that generated when incident light is reflected from the convex surface of the cornea [8]–[10]. Chin rests are utilized in such system, however, users typically find these chin rest uncomfortable. Furthermore, any interruption requires recalibration. Other control devices measure the electrooculographic potential (EOG) when detecting eye movements [8], [12], [13] or analyze features in electroencephalograms [14], [11]. Gips *et al.* [13], [9] designed "Eagle Eyes," an EOG-based system that allows users to use their eyes movement to control a mouse. In this system, electrodes are attached to a user's face to measure EOG changes that occur when the position of the eye relative to the head changes. Amplified voltages are translated into the position of the cursor on the screen. The testimonies in [13] demonstrate that EagleEyes has made a tremendous improvement to children's lives. Still, some users do not want electrodes attached to their faces. Another disadvantage of EOG-based systems is that electrodes can fall off when the user perspires.

In most current assistive devices, switches are used to control a computer and have been used popularly for a long time.[1] Microsoft has included many adaptations, known as accessibility options, in Windows to enable people with various disabilities to use a computer. Many of these options are found in the Accessibility Options part of the control panel in the Start menu. Accessibility Options is one of the items in the control panel, and can be opened by double clicking on the wheelchair icon. MouseKeys is one of the items in the Accessibility Options that allows a person to control the cursor movement by using the arrow keys on the keyboard. However, using MouseKeys is uncomfortable for disabled users because they are small, poorly located on the keyboard and moved slowly. Although, Microsoft has provided MouseKeys options that speed mouse cursor movement including acceleration speed and top speed; however, these settings are not the best combination of stability and speed for disabled users. For example, some disabled users cannot stably control mouse cursor movement at high- speed setting due to physical restrictions. When the settings are configured to maximize stability, the speed will be very slow and the time required to arrive at a target will be long; when the settings are for high-speed movement, mouse cursor movement will become unstable due to user physical restrictions and the time to arrive at a target will also be long.

This work proposes a fast switch-control computer input device that takes the place of a mouse in controlling cursor movement for disabled users. The device employs a two-grade movement method that controls the cursor more rapidly and accurately than the method provided by Microsoft. The device structure is an open and human interface that allows users to create an operating platform based on their physical and mental conditions by themselves, including switch location, material selection, and speed adjustment. Furthermore, the device provides additional functional switches –Drag, Move to screen center, Double click, Click, Scroll up, Scroll down, Mouse right key- that users to operate a computer conveniently and rapidly.

2 Materials and methods

2.1 Two-grade movement principle

The novel two-grade movement method utilized in this device helps disabled users move the cursor rapidly, accurately and stably to a given target. The two-grade movement mode comprises jumping movement mode and continuing movement mode. Users can decide which movement mode is the best for their needs based on the distance between the cursor and target. For example, users can select jumping movement when the distance between the cursor and target is large, and choose continuing movement when is the cursor approaches the target. Thus, the cursor can be moved to the target rapidly and correctly in this manner. To improve cursor movement speed to the target, the device has a function-switch that moves to the screen center when this switch is pressed. The switch function shortens movement time.

Figure. 1 shows the two-grade movement method utilized by this device and the method provided by Microsoft.

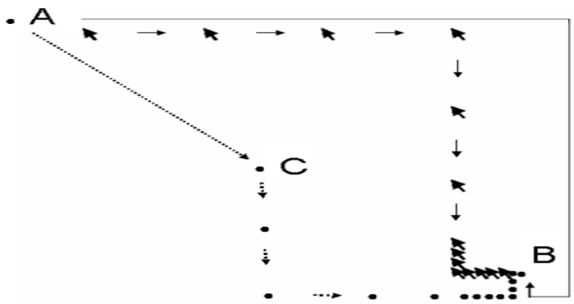


Fig. 1 The path of the cursor moving from point A to B (a) Black line: method provided by Microsoft. (b)The path of the arrow : use the two-grade movement method proposed in the study.(c) The track of dotted line and dot ●: the proposed method combined with the Move-to-screen center function switch

Choosing between jumping movement mode and the continuing movement mode depends on the time a switch is pressed (t) and delay time (t_1). The time the switch is pressed (t) is the duration that a user presses the switch and delay time (t_1) is set by users set according to their physical and mental conditions. When $0 \le t < t_1$, the cursor is in jumping movement mode. When $t_1 \le t$, the cursor is in continuing movement mode. The user determines the movement mode based on t .Distance moved is shown below:

$$d(x_{i+1}, y_{i+1}) = \begin{cases} x_{i+1} = x_i + \dfrac{W}{N_x} \\ y_{i+1} = y_i + \dfrac{H}{N_y} \end{cases} \quad 0 \le t < t_1 \qquad (1)$$

$$d(x_{i+1}, y_{i+1}) = \begin{cases} x_{i+1} = x_i + d_x dt \\ y_{i+1} = y_i + d_y dt \end{cases} \quad t_1 \le t \qquad (2)$$

Equations (1) and (2) indicate the distance moved at jumping movement mode and continuing movement mode respectively, where $d(x_{i+1}, y_{i+1})$ is the next location of the cursor, x_i and y_i are the X-axis and Y-axis coordinates of the cursor's current location. W and H are the horizontal and vertical resolution (pixels) on the screen, and N_x and N_y are the divided numbers of the horizontal and vertical on the screen. Symbols $\frac{W}{N_x}$ and $\frac{H}{N_y}$ are the horizontal and vertical distance of one time movement during jumping movement mode, d_x and d_y are the horizontal and vertical distance of each time movement during continuing mode, and dt is the interval time between two cursor movements during continuing movement mode

2.2 Device design

2.2.1 Device hardware

The device is designed based on microcomputer technology and consists of 15 switch-sockets and one USB-socket. The USB-switch is connected to the computer and provides power for the device. The seven switch-sockets are used as functional switches that provide special functions for computer access. Table 1 lists the function of each switch-socket in the device.

Table 1 The functions of 15 switch-sockets in the proposed device

Switch NO.	Functions	Switch NO.	Functions
SW1	Left Movement	SW9	Move to Screen Center
SW2	Right Movement		
SW3	Up Movement	SW10	Drag
SW4	Down Movement	SW11	Click
SW5	Left-up Movement	SW12	Mouse right key
SW6	Left-down Movement	SW13	Double Click
SW7	Right-up Movement	SW14	Scroll up
SW8	Right-down Movement	SW15	Scroll down

2.2.2 Device software

Device software comprises a microcomputer program, driver and application program. The microcomputer program installed in the device processes switch signals. The driver and application program (AP) are installed in the computer. The AP in the device is an open and human interface allowing

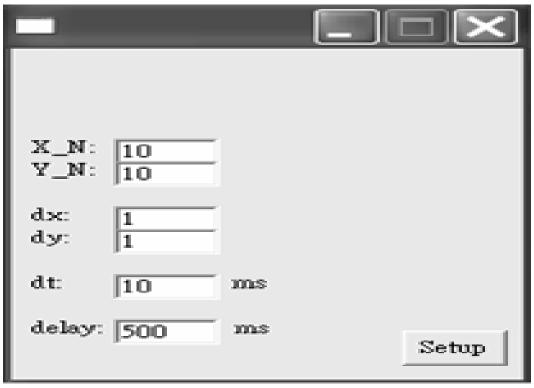


Fig.2 The diagram of parameter set provided by the device AP

a user to create an operating mode that fits their requirements based on their physical and mental conditions. Figure.2 shows the set mode of the AP, the parameters are described as follows:

X_N : the divided numbers of the horizontal on the screen is equal to N_x in Eq.(1)

Y_N : the divided numbers of the vertical on the screen is equal to N_y in Eq.(1)

d_x : the horizontal distance of each time movement in the continuing movement mode

d_y : the vertical distance of each time movement in the continuing movement mode

dt : the interval time between two cursor movements in continuing movement mode

$delay$:the delay determines whether jumping movement mode or continuing movement mode is equal to t_1 in Eq.(1)

2.3 Experiments and Results

Experiments used to demonstrate that the device proposed in this work that uses the two-grade movement approach is faster and more stable than the method employed by Microsoft. An experiment was conducted using six users without disabilities and two disabilities users.

2.3.1 Users without disabilities

Six users without disabilities were tested in twice, once using the proposed device and once using the method offered by Microsoft. Each user was given a brief introduction on how the proposed device worked and allowed to practice for five minute. After the practice period, each user was requested to move the cursor from point A to C and from point A to B using the proposed device and that provided by the Microsoft Windows operating system. Table. 2 lists the different tracks taken from point A to C and from point A to B. Computer screen resolution was set at 1024×768 pixels. The time required for each test was recorded by a Visual Basic program.

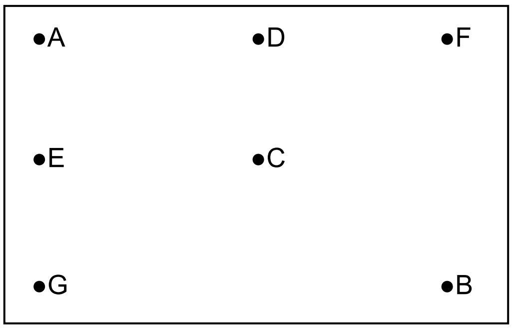
Table.2 (a) The tracks of moving the cursor from point A to C and from point A to B in the experiment (b) The coordinates of the points in the experiment (c) The position

	The tracks of course moving from point A to C: (Near target)	The tracks of course moving from point A to B. (Far target)
Test1	A→D→C	A→F→B
Test2	A→C	A→C→B
Test3	A→E→C	A→G→B

(a)

A	B	C	D	E	F	G
(20,50)	(900,600)	(512,384)	(500,50)	(20,400)	(900,50)	(20,600)

(b)



(c)

2.3.1 (a)Experiment with the proposed device

Users utilized special switches for device input and were tested with different AP parameters (see Table 3(a)). Table 3(b) and Table 3(c) show the experimental results.

Table 3 (a) The AP parameters set in the experiment (b) Time taken performed by health users using two-grade movement: Near target (c) Time taken performed by health users using two-grade movement and combining with move-to-screen-center

	Mode1	Mode2	Mode3
X_N	10	9	5
Y_N	10	9	5
dx	1	1	1
dy	1	1	1
dt	10ms	10ms	10ms
delay	500ms	500ms	500ms

(a)

	Time taken using two-grade movement from point A to C: Near target (sec)		
	Mode1	Mode 2	Mode3
Test1	5s	4.8s	4s
Test2	3s	2.8s	2s
Test3	5s	4.8s	4s

(b)

	Time taken using two-grade movement from point A to B: Far target (sec)					
	Using two-grade movement			Combining with move-to-screen-cent er unction key		
	Mode			Mode		
	1	2	3	1	2	3
Test1	13s	12.4s	8.6s	8.2s	8.2s	7.5s
Test2	8.5s	8.4s	7s	5.5s	5.2s	5.2s
Test3	13s	12.5s	8.5s	8.4s	8.2s	7.4s

(c)

2.3.1(b) Experiment with the method provided by the Microsoft Windows operating system

Microsoft provides MouseKeys setting for top speed and acceleration speed allows users to adjust the speed of cursor movement. Top speed and acceleration were divided into five speeds in this experience, ranging from low speed to high speed. Users were requested to move the cursor from point A to C and from A to B (Table 2 (a)). Table 4 presents the average time.

Table.4 Average time taken using Microsoft method moving cursor to a near target and to a far target

	Average time taken using Microsoft method ：Performed by health users	
	Moving to a near target (A→C) (sec)	Moving to a far target (A→B) (sec)
Test1	47.44 s	93.2 s
Test2	32.72 s	66.35 s
Test3	48.1 s	95.64 s

Experimental results show that the average time taken using the proposed device was faster than that using the Microsoft method by a factor of 6.17-8.10 when the cursor moved to a far target, and was faster by a factor of 10.31-12.58 when the cursor moved to a near target Furthermore, when the cursor is far from a given target, a user can combine the move-to-center function-key provided on the device, the cursor speed will improve by 43%. Table 3 and Table 4 are summarized in Table 5. Table 5 presents the average time taken comparison between using two-grade movement and using Microsoft method.

Table.5 The average time taken comparison between two-grade movement and Microsoft method summarized from Table 3 and Table 4: Performed by health users

	Summary results of Table 3 and Table 4					
	Average time taken moving cursor to a near target (A→C) (sec)			Average time taken moving cursor to a far target (A→B) (sec)		
	Microsoft method	two-grade movement	Times	Microsoft method	two-grade movement	Times
Test1	47.44 s	4.6 s	10.31 times	93.2 s	11.5 s	8.10 times
Test2	32.72 s	2.6 s	12.58 times	66.35 s	10.75 s	6.17 times
Test3	48.1 s	4.6 s	10.46 times	95.64 s	13 s	7.36 times

2.3.2 Disabled users

Two users with cerebral palsy were tested in the experiment. Two comparison tests were performed. First, the users used the proposed device to move the cursor from point A to C and from point A to B. Second, the users used the MouseKeys offered by Microsoft to move the cursor from point A to C and from point A to B. The AP parameter set of the proposed device was the same as Table 3(a) and the top speed and acceleration were divided into five speeds in this experience, ranging from low speed to high speed. The track of the experiment was the same as test2 in Table 2(a) and the time taken for each test was record by a Visual Basic program. To further improve users' operating performance, the users took their practicing the operating of the proposed device before test. When users used the method offered by the Microsoft to move the cursor, the keyboard guard was used to help them target the correct keys. When users used the proposed device, special switches were utilized for the device input and four directional switches (left movement, right movement, up movement, down movement) were selected to control the cursor movement. Table 6 lists the results of the experiment. Experimental results show that two users successfully used the proposed device to arrive at given target and the average time taken using the proposed device was faster than that using the Microsoft method by a factor of 8.03-10.46

Table.6 Average time taken comparison between two-grade movement and Microsoft method ：Performed by disabled users

	Average time taken comparison between two-grade movement and Microsoft method ：Performed by disabled users					
	Moving cursor to a near target (A→C) (sec)			Moving cursor to a far target (A→B) (sec)		
	Microsoft method	two-grade movement	Times	Microsoft method	two-grade movement	Times
Test 2	73.20s	7.00 s	10.46 Times	139.24 s	17.33 s	8.03 Times

3. Conclusion and Discussion

Experimental results show that the proposed device improves computer access physically challenged users by enhancing their cursor control. The average time taken using the proposed device was faster than that using the Microsoft Windows method by a factor of 6.17- 12.58. Furthermore, when the cursor is farther from a given target, users can combine the move-to-center function-key to arrive at a target rapidly. In this manner, experimental results for cursor speed was improved by 43%.The device also provides additional functional switches users can select that facilitate easy access to computer functions and has a user-friendly interface that allows users to create an operation platform based on their physical and mental needs.

Because of inter-individual differences among disabled users, various systems facilitate computer access for disabled users. However, the device proposed in this paper has proven to be a useful alternative. It is a user-fit device that provides faster and easier cursor movements than provided by Microsoft. In further, the proposed device may help physically challenged individuals to use a computer to acquire knowledge, use the Internet, and access computer-controlled technologies.

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