Evaluation System of Patient's Computer Input Ability

Yoshio Tanimoto Yasuhiko Rokumyo Kazunari Furusawa Akihiro Tokuhiro
Kibikogen Rehabilitation Center
7511 Yoshikawa, Jobogun-Kayocho, Okayama
Japan

Kenji Takami Yasuo Suzuki
Rousai Rehabilitation Engineering Center,
1-10-5, Minatoku-Komei,Nagoya
Japan

Hiroyuki Ukita
The University of Tokushima,
Faculty of Engineering
2-1,Minamijosanjima-cho,Tokushima
Japan

Hideki Yamamoto
Okayama University,
Faculty of Education
3-1-1 Tushimanaka Okayama
Japan

Abstract –**In this paper, we describe a measurement and evaluation system of the computer input ability of patients with tetraplegia. We measured the position locus of the mouse cursor when a patient operates the computer using a computer input device such as a ball mouse, trackball, touch pad, or the new device. After measurement, we analyzed the position locus of the mouse cursor to evaluate patients' computer input ability. Based on our measurement and evaluation system, it became clear that the new computer input device is useful for patients with tetraplegia.**

I. INTRODUCTION

It has recently become possible for patients with tetraplegia, whose range of motion in the upper limbs is limited, to work in a small office/home office using a computer1],2]. In rehabilitation medicine, the medical staff must measure and evaluate the patient's computer input ability and then recommend the best computer input device for each patient.

Keyboards and computer input devices such as a ball mouse, track ball, or touch pad are used for the operation of a computer. We can evaluate a patient's computer input ability with a keyboard using keyboard typing software that is on the market. No such software is available, however, to evaluate a patient's computer input ability using computer input devices such as a ball mouse, track ball, or touch pad.

We previously developed a measurement system that would help medical staff evaluate patients• • computer input ability by determining the locus of the mouse cursor.3]• Moreover, we have developed a new input device so that patients with tetraplegia can easily move the device and perform the click operation4]. In this study, we calculate three time parameters from the mouse cursor locus, including stopping, moving, and positioning, and illustrate these parameters on radar plots.

II. MESUREMENT SYSTEM

Figure 1 shows a computer screen of the system that measures and evaluates the computer input ability of patients with tetraplegia. It consists of the test area and the

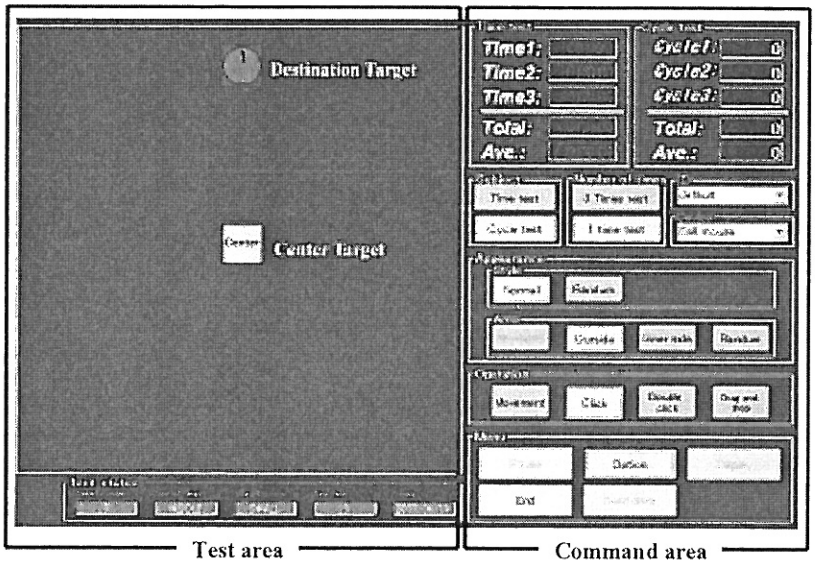


Fig.1. Measurement and evaluation system of the computer input device.

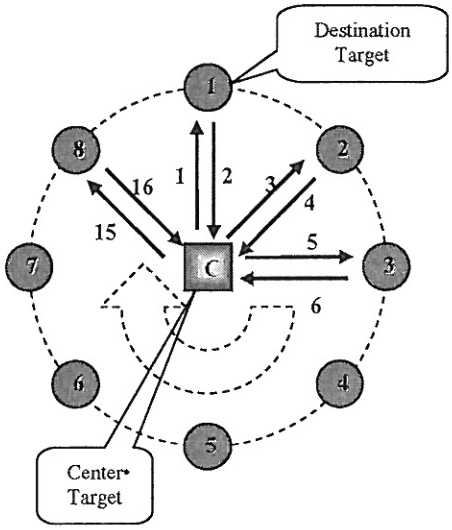


Fig. 2. Appearance style of destination target.

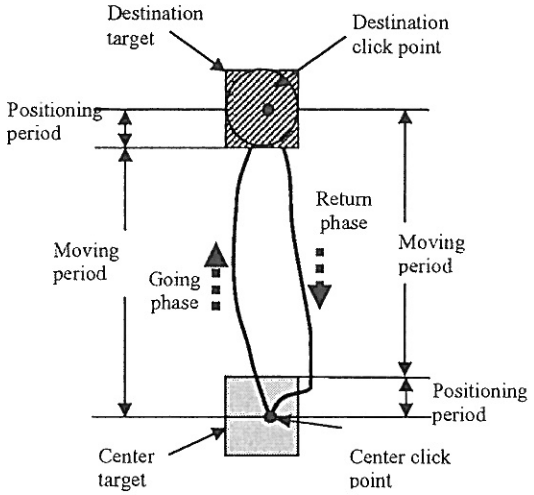


Fig.3. The locus of a mouse cursor in attempt 1.

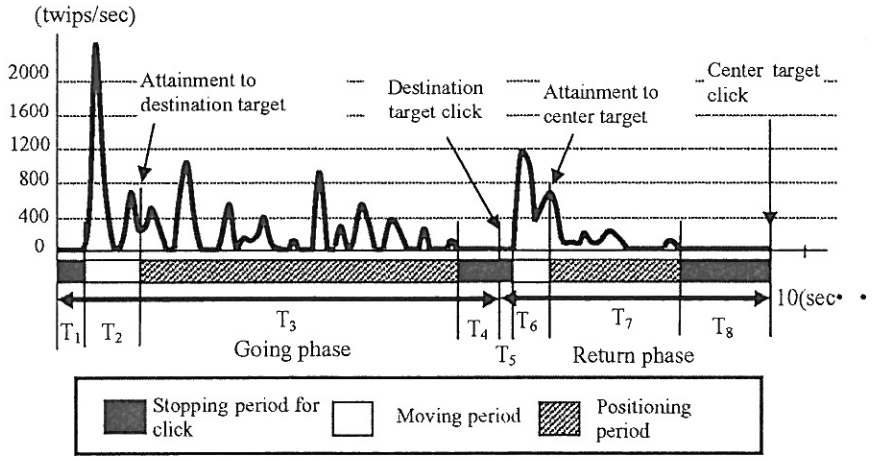


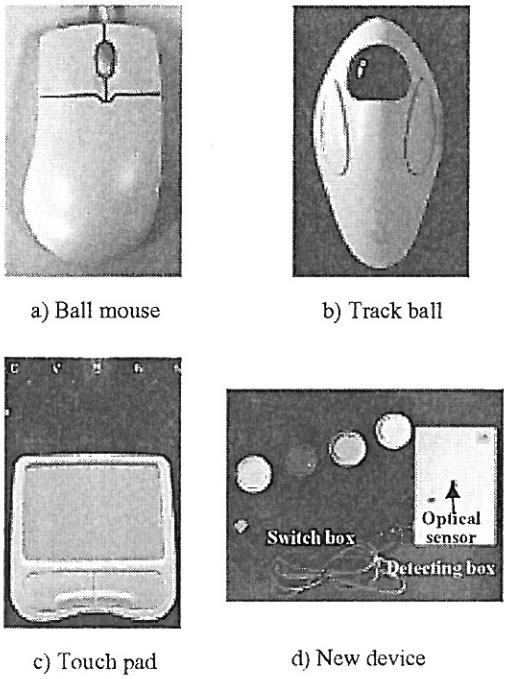
Fig.4. Velocity of the mouse cursor in attempt 1.

command area. A center target is displayed at the center of the test area, and a destination target is displayed on various places in the test area. The number of attempts, the appearance area and style of the destination target, and the operation are chosen from the command area before the measurement of computer input ability starts. The operations include a movement, a click, a double click, and a drag and drop. When the click operation is chosen, the destination target is first displayed at the top position in the test area. The patient moves the mouse cursor to the destination target and then performs the click operation on that target. Next, the destination target is eliminated from the screen, and the center target is displayed at the center position in the test area.•The user moves the mouse cursor to the center target and performs the click operation on the center target. The center target is then eliminated, and the next destination target is displayed in the test area. These operations are continued until the test time ends.

In this study, measurements were carried out when the normal style and the click operation were chosen from the command menu. Each destination target was displayed on the circle point with a number, as shown in Fig. 2. The destination target was displayed first in the top position, and then it moved in a clockwise direction through the test area. The sampling time, the coordinates of the mouse cursor position, the target number, and the operation flag are recorded after computer input ability is measured. The target number represents the number of the center or destination target displayed in the test area, as shown in Fig. 2. The operation flag represents an operation such as a click, a double click, or a drag and drop when the mouse cursor is within the area of the destination target or the center target.

The mouse cursor moves between the center target and the destination target in one attempt, as shown in Fig. 3. The period during which the mouse cursor moves from the center target to the destination target is defined as the going phase, and the period during which it moves from the destination target to the center to target is defined as the return phase.

Figure 4 shows the velocity of the mouse movement in one attempt. When the mouse cursor has stopped, the velocity equals 0 ([twips]/sec). A [twip] is a unit of length



a) Ball mouse b) Track ball

c) Touch pad d) New device

Fig.5. Four kinds of computer input devices.

on a computer screen, with 1 cm corresponding to approximately 420 twips on a 17-inch display monitor of resolution 1024 x 768. First, the mouse cursor has stopped at the center click point in the center target for a short time before the mouse cursor begins to move to the destination target. The period T1 during which the mouse cursor has stopped on the center target is the stopping period in the going phase. The mouse cursor then moves to the destination target during the going phase, repeating the stopping or moving actions. The period T2 during which the mouse cursor reaches its destination target is the moving period in the going phase, and the period T3 during which the mouse cursor repeats moving and stopping in the destination target is the positioning period in the going phase. The period T4 during which it has stopped for the click operation in the destination target is the stopping period for the click operation. In the return phase, the stopping periods T5 and T8, the moving period T6, and the positioning period T7 are elapsed similarly. Here, the summation of the stopping period for the click Sp is defined as Sp=T1+T4+T5+T8, the moving period Mp is defined as Mp=T2+T6, and the positioning period Pp is defined as Pp=T3+T7.

III. NEW DEVICE

Four kinds of computer input device were used for measurements in this study, as shown in Fig. 5. One of our goals is to develop a computer input device that will allow patients with tetraplegia to perform computer operations within a reasonably short time period. Tetraplegic patients usually cannot perform subtle computer operations, and they sometimes hold computer input devices such as a ball

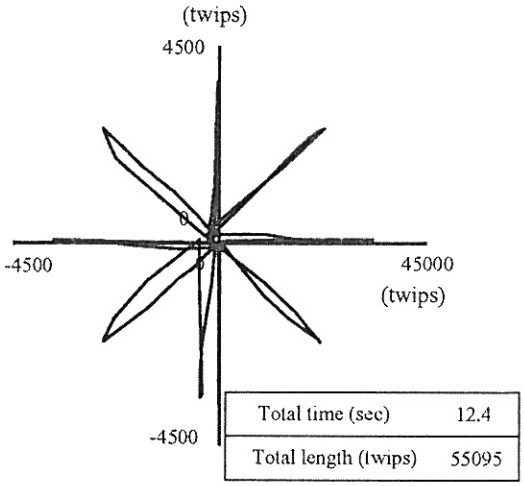


Fig.6. The locus of a healthy subject using a ball mouse.

mouse with both hands when they move the devices and perform the click operations due to finger palsy caused by cervical spinal cord injury. Our new input device consists of a detecting box and a switch box, as shown in Fig. 6 (d). The movement direction and its distance can be measured using an optical sensor on the detecting box when the patients move their right or left hand over the sensor. Patients perform the click operation by pushing the switch on the switch box with the other hand. The new input device is designed so that patients with tetraplegia can move the device and perform the click operation without holding it with both hands, so as to shorten the moving and stopping time.

IV. EXPERIMENTAL RESUTLS

Figure 6 shows the results of the mouse cursor locus when a healthy subject performed the click operation test using a ball mouse. It is clearly shown in the figure that the mouse cursor was moved fast and linearly between the center target and the destination target.

Figure 7 shows the results of the mouse cursor loci when a patient with tetraplegia (C5 spinal cord injury level) performed the click operation test using the four kinds of input device, as shown in Fig. 5. The locus of the ball mouse movement generated by the patient is very different from that by the healthy subject, as shown in Fig. 6. Total time of the ball mouse set of movements by the patient was about seven times longer than that by the healthy subject, which indicates that the patient with tetraplegia had difficulty operating the computer using a ball mouse.

The locus of the new device movement generated by the patient is most similar to that of a ball mouse moved by the healthy subject among the four devices we tested. The total time of a ball mouse set of movements was 87.1 sec, that of a track ball was 68.4 sec, that of a touch pad was 53.4 sec, and that of the new device was 47.3 sec. The new device was helpful for this patient, as shown by the fact that the total time and the total length for this device were smaller than those for the other three devices.

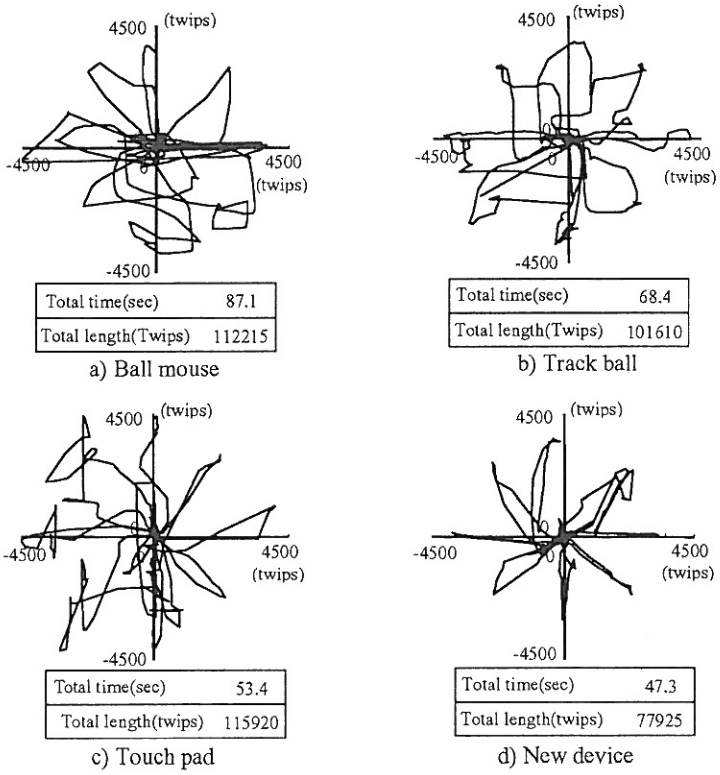


Fig.7. The loci of patient using four kinds of computer input device.

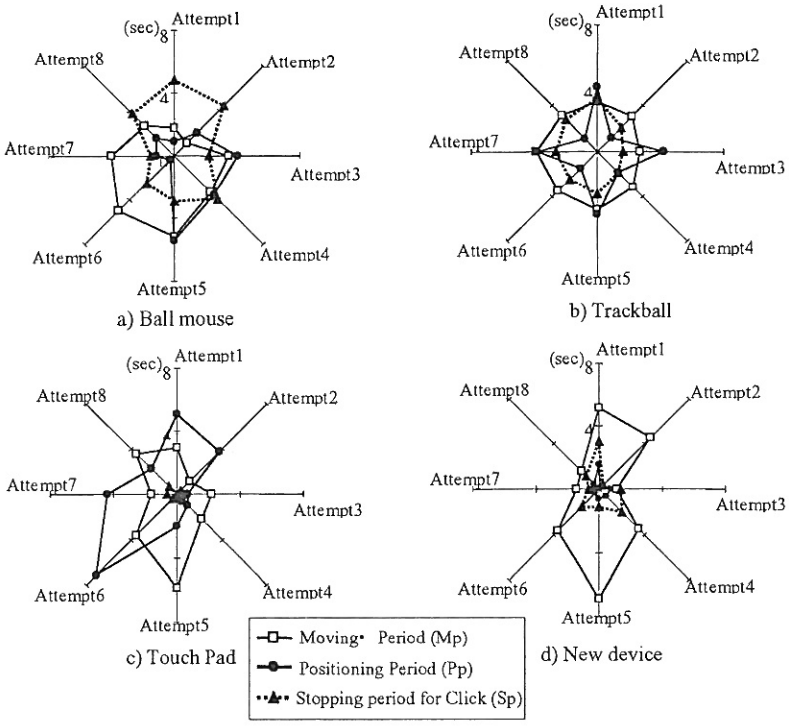


Fig.8. Radar plot in each period using four kinds of computer input device.

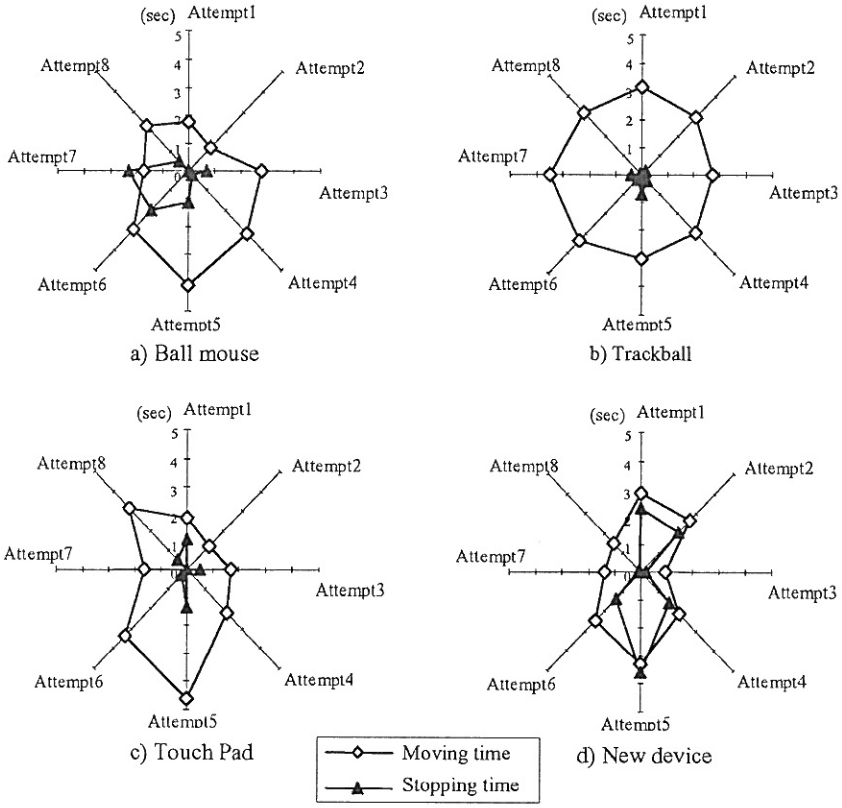


Fig.9. Going and stopping time in moving period using four kinds of computer input device.

It is necessary to analyze the mouse cursor loci to evaluate the computer input ability of patients. Figure 8 shows summations of moving and stopping time during each period for four kinds of computer input device. The stopping period for the click operation of a ball mouse and a track ball are longer than that of a touch pad or the new device, which indicates that the patient could quickly perform the click operation after he stopped the mouse cursor when using a touch pad and the new device. From the image of the click operation test, we know that he moved the mouse cursor to the target with his right hand and then performed the click operation with his left hand using a touch pad or the new input device. The stopping period for the click operation of the ball mouse and track ball is much longer than that of a touch pad and the new device because the patient lifted his right hand after stopping to make the click operation and before performing the operation. The positioning period of the new device is much shorter than that of a ball mouse, trackball, or touch pad. This result indicates that the new device is useful for patients when moving the mouse cursor during the positioning period. It was difficult for this patient to move the mouse cursor in a vertical direction, as shown by the fact that the moving period in attempt 1 and attempt 5 are longer than those in other attempts when he uses the new input device. The moving period was the same among the four kinds of computer input device.

Table 1.Average velocity of mouse cursor in four input devices.

	Moving period (twisp/sec)	Positioning period (twisp/sec)
Ball mouse	4309	1722
Track ball	2939	1158
Touch pad	4711	1877
New device	4165	2153

Figure 9 shows the radar plot of moving and stopping time in the moving period. The stopping time of the new device is longer than that of the other three kinds of input device. The results show that the patient repeated moving and stopping in the moving period using the new computer input device. He moved the mouse cursor slowly when using the track ball, as evidenced by the fact that the going time is large in all attempts and the average velocity of the mouse cursor during the moving period is lower than that of the other three kinds of input device, as shown in Fig. 8 (b) and Table 1. The patient can quickly move the mouse cursor during the positioning period using the new device and during the moving period using the touch pad, as shown in Table 1.

Using the radar plot, we can see that, among the devices tested, the new device is the most helpful for this patient. Moreover, we can determine in which direction the patient has difficulty moving the mouse cursor or performing the click operation using this radar plot.

V . CONCLUSION

In rehabilitation medicine, medical staff must evaluate the computer input ability of patients with tetraplegia because they train patients to use a computer. We have proposed herein a system for the measurement and evaluation of the computer input ability of patients with tetraplegia. Based on the experimental results, we think that medical staff in rehabilitation medicine will be able to evaluate the computer input ability of patients and to choose the best computer input device for each patient.

VI. REFERENCES

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