Title: Mouse Type Interface Device With Tactile and Force Display
- Multi-Modal Integrative Mouse -

The auther's name
Motoyuki AKAMATSU and Sigeru SATO
The auther's address
Industrial Products Research Institute, 1-1-4 Higashi,
Tsukuba, 305 Japan
Tel: 0298-54-6772
Fax: 0298-54-6608
E-mail: akamatsu@ipri.go.jp

Abstracts
A Mouse type interface device which allows to give tactile and force information to the computer operator has developed. Tactile information is displayed by pushing the ventral face of the index finger by a small pin from a hole of the button of mouse. Force information is given by increasing the resistance for movement of the mouse by a small electrical magnet. The tactile and force informations are controlled by software which are linked to the visual information of targets of the VDT display. The operator of the mouse can get visual, tactile and force information which indicate when the cursor is in the right position of the target. The evaluation experiments showed that additional tactile and force information made the response time short and made the effective target size large.

Keywords
mouse, sensory integration, multi-modal interface, tactile information, force information

The category: tactile and force display

Mouse Type Interface Device With Tactile and Force Display
- Multi-Modal Integrative Mouse -

Motoyuki AKAMATSU and Sigeru SATO
Industrial Products Research Institute, 1-1-4 Higashi, Tsukuba, 305 Japan

1. Introduction

In natural situations, the interface between humans and the outside world allows us to obtain different modalities of sensory information such as visual, auditory and tactile information from an object. We can then operate the object using motor function with high degree of freedom. We humans have the ability to integrate such varied sensory information and motor behaviour. With this sensory integration function, we can recognize an object and work on it freely. In contrast, because of the limited number of sensory modalities and the limited degree of freedom of operational movement, the interface between man and computer system with a VDT and a keyboard is different from that in the natural situation. Recently, there has been the spreading use of the mouse as an input device to a computer. When we work with the mouse, we move the device by our hand in a two-dimensional space indicated by a cursor on a screen . Thus, in operations with the mouse, we can obtain both visual and kinesthetic information of movement and the position of the device. In this respect, the mouse provides a more natural interface.

When we work on an object with our hands, touching the object almost always gives rise to tactile sensation in addition to kinesthetic sensation. One of the functions of tactile information is to confirm touching the object. It can be considered that in this function tactile information is a substitute for visual information. However, when one traces the shape of an object by ones finger tip, tactile information is added to visual information to help increase the velocity of finger movements and, at the same time, reduce the use of visual function. It is, therefore, expected that an interface device capable of presenting tactile information as well as usual information would improve the efficiency of operation and reduce the burden of the use of visual function at the man-computer interface. In order to introduce tactile information to the man-computer interface, some apparatus should be added to the interface devices, which makes the interface device complicated and big. In the case of a mouse, however, because of its relatively low degree of freedom, it is possible to implement some apparatus for a tactile stimulus into the body of the mouse. Thus, we have developed a mouse-based man-computer interface device which is capable of presenting tactile information.

If we touch the object with our finger, there arises not only tactile sensation but also sense of friction resistance. A sense of resistance, we call this force sensation, is proprioceptive sensation through muscle and joint receptors. Therefore, the mouse-

2. Structure of the device

2.1 Outline of structure

The device provides tactile information by means of an on-off signal which gives information of contact or non-contact with a target. If the cursor has reached the target on the visual display, information is given by means of tactile and force stimuli. Visual, tactile and force information are given with the interface device developed here, therefore, it can be defined as a multi-modal integrative mouse or a sensory integration mouse.

Additional mechanisms to be provided to an ordinary mouse are a tactile stimulus device and a force stimulus device. Signals to drive these devices are controlled by software and are sent from the I/O board of a personal computer to each device in the mouse. The mechanism of these devices is discussed below. The devices increased the weight of the mouse from the original 103 grams to 148 grams without the cables (Figure 1).

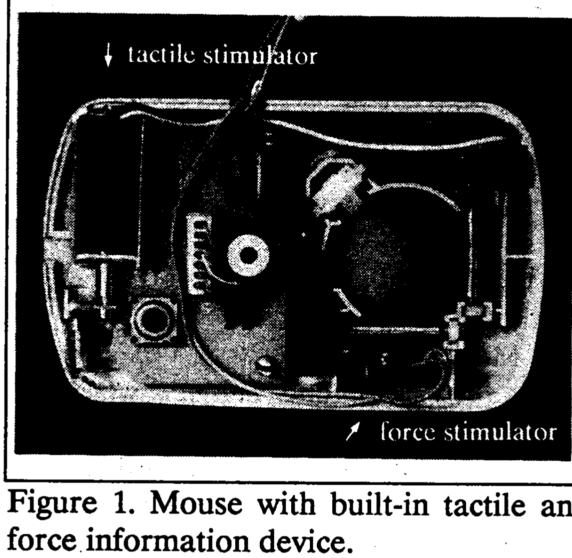

Figure 1. Mouse with built-in tactile and force information device.

2.2 Visual information presentation

The VDT display screen shows windows, on which key-like shape are displayed as clicking targets (Figure 2). By means of shading, targets appear in artificial perspective. If you click a target on the screen using the button of the mouse, the shade disappear. This is as if the key-like target has been pressed down.

2.3 Tactile information presentation

Tactile information is given by means of an aluminum pin (1 mm x 2 mm) projecting from a hole at the tip of a press button of the mouse (Figure 3). When using the mouse, the finger tip of the index finger rests on the tip of the press button. Thus, finger pad is pressed by the pin as tactile stimulus (Figure 4). The pin is driven by a pull type solenoid (KGS Corp, 31 mm x 15 mm x 10 mm) via lever mechanism and, therefore, movement of the pin is not strictly linear. The pin is covered by a rubber film, which is fixed to the backside of the press button of the mouse. The rubber film serves to return the pin to its rest position when the control signal of the tactile stimulus is turned off.

The stroke of the tactile stimulus is 1 mm. When the solenoid is driven by a 12 V direct current, the pin rises up to 95% of full stroke within first 1 msec (Figure 5). Tactile information is given when the top of the mouse cursor is on the target in the window and disappears when the top of cursor goes out of the target area or when the target is clicked.

2.4 Force information presentation

There are several ways to generate a sense of resistance, for example: increasing the friction of between the

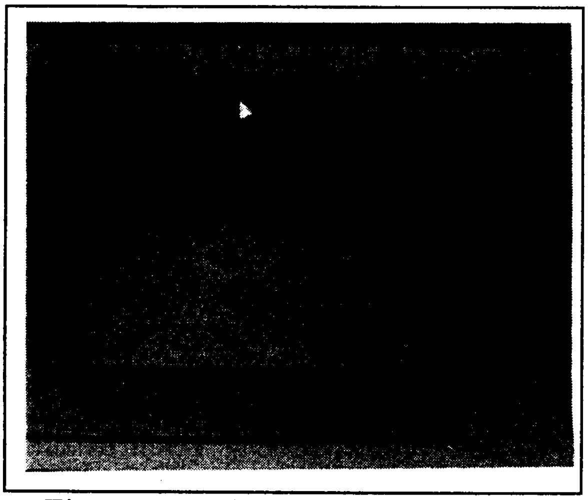

Figure 2. Design of visual display.

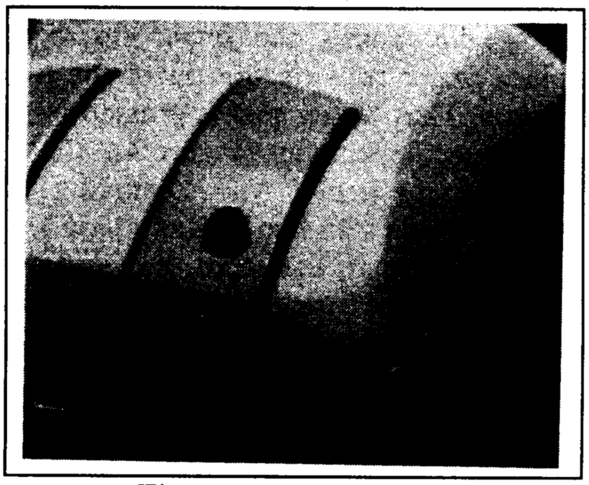

Figure 3. Mouse button.

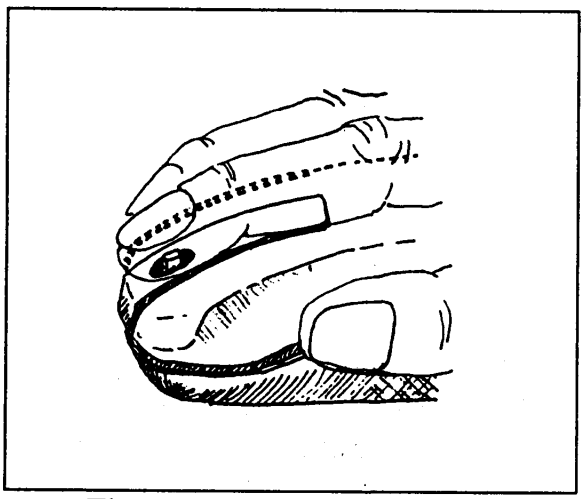

Figure 4. The use of the mouse

underside bottom of the mouse and the work surface, or increasing the rolling friction of the ball in the mouse. However, mechanical methods will have problems of space, complexity of mechanism and response speed. To avoid such problems, an electromagnet has been used to generate the force sensation. A small electromagnet (KGS Corp., 14 mm x 13 mm x 7 mm) is attached to the bottom of the mouse (Figure 1). When the mouse is operated on an iron plate, the moving friction of the mouse can be increased by applying a current to the electromagnet.

When in use, the mouse is usually pressed against the work table with a pressure of about 200 to 300 gf. A 10 V direct current to the electromagnet increases the moving friction by about 10gf. Since the moving friction of the mouse with a vertical load of 300 gf is about 80-90 gf, the increase in moving friction of the mouse by the electromagnet is 12-13%. The increase of moving friction is perceived as a sense of resistance and is used as the force information.

Force information is given when the top of the cursor is on the target in the window of the screen in addition to the tactile information. It is also generated for 3.3 second when the cursor passes the boundary of a window. A slight resistance can be perceived when the cursor moves out of or enters a window.

3. Experiment

3.1 Method

In the experiments, subjects were asked to move the mouse cursor from the start position, which was marked with a circle, to the target and press the target as quickly as possible. After placing the cursor at the start position, an auditory

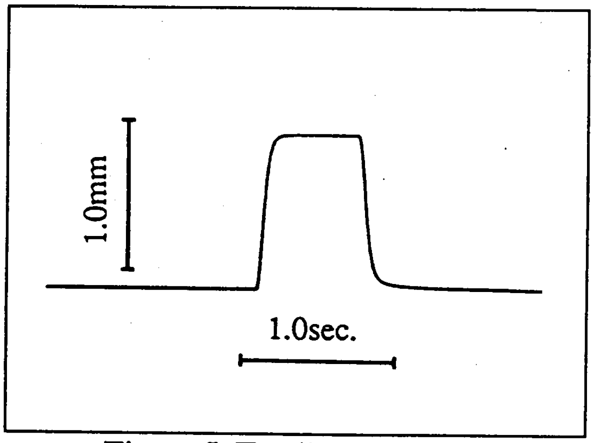

Figure 5. Tactile stimulus pattern.

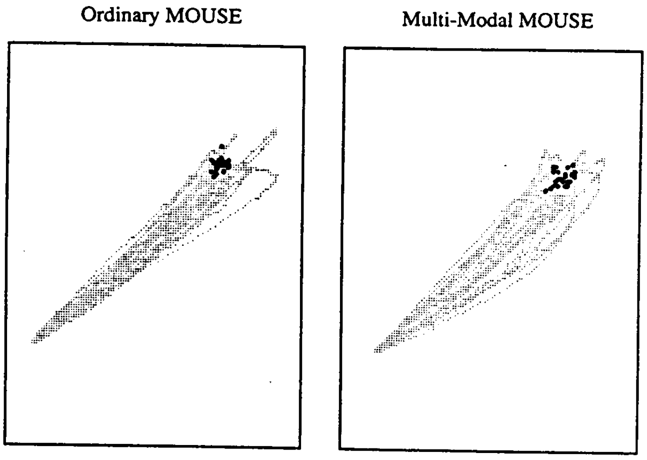

Figure 6. Examples of trajectory.

was given to make ready. Then, a "go" signal was given after a random interval from 0.5 to 1.5 seconds. The "go" signal was indicated by deleting the circle of the start position. There were two targets in the window. When the "ready" was given, which target to reach was indicted visually by an arrow. There were 25 trials for each target.

The data examined were the trajectory of the mouse movement, the response time from the "go" signal to pressing the mouse button and the position of the top of the cursor at the time when the button was pressed.

Four subjects participated in the experiments. All of them use the mouse as a computer input device in daily life. The mouse with tactile and force information and an ordinary mouse were compared.

3.2 Results

The results obtained from the two targets were similar to each other. Thus, the results from one target are shown here. Figure 6 gives samples of trajectory of both the ordinary and the multi-modal mouses. There was no clear difference between trajectories at either mouse.

The average response time was 1008 msec with the experimental mouse, and 1098 msec with the ordinary mouse. This indicated that the presentation of tactile and force information reduced the response time of the positioning task with a mouse (Figure 7).

The two types of mouse were also examined by comparing the position of the cursor at the time when the mouse button was pressed. The experimental mouse give a wider scattering of positions in both horizontal and vertical directions (Figure 7). This means that when operating the mouse with only vision, the operator

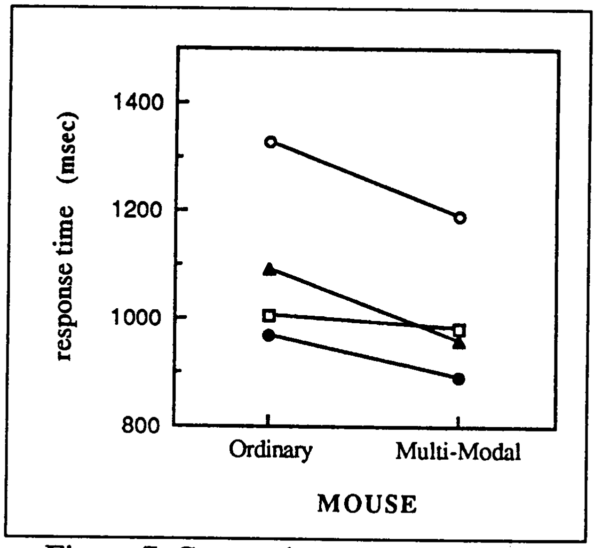

Figure 7. Comparison of the average response time.

tended to press the button when the cursor was near the center of the target area. In contrast, when tactile and force informations were provided, the button was pressed even though the cursor was not close to the center of the target area. This means that the presentation of such information the effective target area increased.

4. Discussion

Based on the observation when tactile and other somatosensory information are added to visual information the efficiency of movement improves and the load of the visual function is reduced, we developed a mouse-type interface device with tactile and force information. The tactile information given by the mouse was limited to that controlled by on-off signals. It is , however, possible to provide texture and other tactile surface information by using an actuator of which stimulus amplitude can be controlled continuously.

Our experimental results showed that the addition of tactile and force information can reduce the response time and allow the operator to click the target in a wider target area. This means that these informations make a positioning operation easier than that under visual information only. According to Fitt's law, increasing the size of the target results in reducing the time required for operation. Therefore, the increase in effective size by the tactile and force information decreased the response time. Another factor which reduces the response time is the effect of sensory modality in sensory-motor linking. The subject can respond quicker to a tactile stimulus than to a visual stimulus with motor responses. There may also be an effect of S-R compatibility on the reaction time. With the multi-modal mouse, the tactile stimulus is given to the same finger that presses the button of mouse. This is more compatible task than that with only visual information. Inferring from the results of psychophysical studies on sensory integration, it is also expected that the use of the multi-modal integrative mouse would reduce the load of the visual function in computer works.

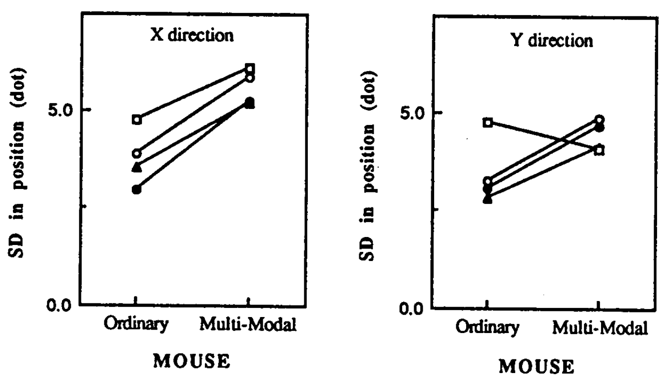

Figure 8. Scattering of button pressing position.

References

1)S. K. Card, W. K. English and B. J. Burr: Evaluation of mouse, rate-controlled isometric joystick, step keys, and text keys for text selection on a CRT, *Ergonomics*, 21, 601-613, 1978

2)M. Akamatsu: The influence of combined visual and tactile information on finger and eye movements during shape tracing, *Ergonomics*, 34, 1992 (*in press*)

3)M. Minsky, et al: Feeling and seeing: Issues in force display, *Comput. Gr.*, 24, 235-243, 1990

4)P. M. Fitts: The information capacity of the human motor system in controlling the amplitude of movement, *J. Exp. Psychol.*, 47, 381-391, 1954