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Proposal of a New Mouse with Realtime Mickey Ratio Adjuster Controlled by Grasping Force

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Abstract: According to Fitts' law, pointing tasks is easier when the target is larger and the distance is shorter. Large Mickey Ratio provides short distance but small target, small Mickey Ratio means, as opposite to above, large target but long distance. This paper proposes a realtime adaptive Mickey Ratio adjustment for an answer of this dilemma.

Keywords: mouse, Mickey Ratio, Fitts' law, grasping force

1. Introduction

Fitts' law gives time T that takes an operator for a pointing task on a target of size S at distance of D[1]. It is:

$$T = a + b\log_2(D/S + 1) \qquad (1)$$

where "a" and "b" are experimentally determined constants.
Necessary time is thought to be related to difficulty of the task. Easier task needs less time. Fitts' law indicates that pointing task is easier when the target is larger and the distance is shorter.
Considering cursor motion driven and controlled with mouse, Mickey Ratio gives the gain of cursor speed with mouse motion. Larger gain gives faster speed. It offers as same effect as smaller target at shorter distance. Smaller gain causes equivalent effect with larger target at longer distance. Constant gain is not effective to decrease D/S of the equation (1) even if it is adjustable before tasks are started. In general cases, it can be selected or adjusted according to an algorithm as shown in table 1.

Table 1: *Algorithm of non-adaptive gain adjustment*

1. Consider which parameter, D or S is major in the task.
2. Adjust or select Mickey Ratio to optimize the selected parameter in 1.
3. If parameter D is major in the task, Mickey Ratio is adjusted to be suitable for movement to long distance. In this case, it may be uncomfortable in pointing the target after the cursor reaches near around the target. If parameter S is major, everything is opposite to above.

As long as Mickey Ratio is not realtime adaptive adjusted, it is impossible to set Mickey Ratio that both stages are optimized.

2. Realtime Adaptive Gain

Usually, Mickey Ratio is not adjustable during a pointing task is driven. It means that even if Mickey Ratio is adjustable before the task, D/S of equation (1) is constant in each task. Therefore, Mickey Ratio adjustment problem includes a difficult dilemma. If Mickey Ratio is large, approach is easy but positioning the pointer is difficult. If Mickey Ratio is small, positioning is easy but approach is tiring. This is called “gain dilemma” in the followings.
One solution of this dilemma is to let Mickey Ratio be realtime adaptive adjusted. In each pointing task is driven, when the pointer comes near around the target, Mickey Ratio should be adjusted to smaller.
The most important point of this idea is that during each task, **parameters D and S are not simultaneously effective**, although they present as D/S in equation (1). D is effective when the pointer moves toward the target (in following part of this paper, it is called "approaching phase"), and S is effective after the pointer comes near around the target (in following part of this paper, it is called "positioning phase").
If during each task Mickey Ratio were adjusted larger in approaching phase and smaller in positioning phase, the easiness of the task would increase. This is realtime adaptive Mickey Ratio adjustment. And it suggests that pointing tasks include two stages, approaching and positioning.

3. Complexity Avoidance

To adjust gain, new switches or other new gears shouldn't be supplemented, because they increase the complexity of operation system. That has the opposite effect to the purpose of "increase the easiness of remote pointing tasks". The realtime adaptive gain adjustment should be controlled **automatically** or, at least, naturally.
Some studies are known for icon selecting tasks using computer mouse. Effect of tactile feedback is analyzed by Akamatsu et al. [2]. Study of Worden et al. shows that sticky icons are effective, especially for older adult people [3]. Dennerlein et al.[4] describe advantage of force feedback in some targeting tasks.
Worden et al. explain that “sticky icons” are icons which

have automatic Mickey Ratio reduction when the cursor is on the target icons. Mickey Ratio is the gain of mouse to cursor motion. It determines the number of the cursor motion pixels on the screen in response to a single increment of the mouse motion. Decreasing Mickey Ratio locally on the icons, effective size of the target becomes larger, which makes it easier to stop the cursor on the target icon [3)]. Sticky icons can be physically actualized by force feedback in case of computer mouse[2)].

The "sticky icon" is thought to be a special variation of realtime adaptive gain adjustment. Because the machine knows where the targets exist in those icon selections, it is easy to distinguish positioning phase from approaching phase. In those cases, the task is in positioning phase when the cursor is near around or on the icons to be selected. Force feedback is sometimes expensive especially for civilian machines such as computer mouse.

In general cases, the target exists only in the user’s idea or is created instantly during the pointing task. The target cannot be distinguished by the pointing machine before the user finishes each pointing task. Information of pointer position is no useful to gain adjustment in these general pointing tasks. Approaching to positioning phase translation is quite a psychological process of the user, some physical or physiological parameter may be influenced. It is only user’s operation itself that is available for realtime adaptive gain adjustment function. To provide natural usability of this new mouse, the signal for switching gain (Mickey Ratio) between these two phases should be detected from the user’s physiological or physical behavior. This study proposes that grasping force is available.

Napier’s study indicates that grasping style is adaptive, and it depends not only on the grasped object but also on the purpose of grasping [5)]. Although Napier didn’t mention to grasping force, it is expected to be an important parameter.

In precision tasks, more stiffness and robustness of hand position are necessary than those in rough tasks. For this purpose, it is expected to be natural that muscles of arm and hand are more tensioned to keep enough stiffness and robustness of hand position.

To apply this to pointing tasks, in positioning phase, task requires more precision operation than in approaching phase. It means that muscles are expected more tensioned in positioning phase than in approaching phase. This tension has an ability to indicate positioning phase. Grasp operation terminal such as joystick switches, levers, computer mouse etc. are expected to be grasped naturally stronger in positioning phase than in approaching phase.

Therefore, using grasping force of operation terminal, automatic realtime adaptive gain adjustment can be realized without increase of operation complexity.

In the following part, for an example, computer mouse with cursor speed adjustment by grasping force is described[6)].

4. Construction of Proposed Mouse with Mickey Ratio Adjustment by Grasping Force

The proposed mouse has two major advantages as follows:

1: Mickey Ratio (= gain of the mouse) adjustment function on the mouse breaks the gain dilemma.

2: Cursor speed adjustment with grasping force supports natural usability.

As these new functions can be contained in mouse body, adding to these, users can receive the advantage only by replacing mouse. No extra driver is required.

4.1 Gain dilemma

Considering of computer mouse usability as a grasp operation terminal of a remote pointing device, cursor speed (or Mickey Ratio) adjustment includes the gain dilemma as mentioned in chapter 1. For example, when someone is drawing a picture by graphic editor software and is dragging an object to exact position; adjusting Mickey Ratio larger, the cursor speed is faster, then it becomes easier to move the object but is harder to place the object to exact position, and adjusting Mickey Ratio smaller, the cursor speed is slower, it becomes harder to move but easier to place. This dilemma is caused by the fact that the cursor speed is not adjustable during each dragging tasks driven.

4.2 Analysis of dragging tasks

As mentioned above and shown in Fig.1, dragging action is separated in two serial phases; approaching and positioning.

If the cursor speed were realtime adaptive (it means Mickey Ratio is adjustable during each dragging action), the dilemma mentioned above would disappear by adjusting the cursor speed high in approaching phase and slow in the positioning phase. High cursor speed makes approaching phase easier and low cursor speed makes positioning phase easier and more comfortable. This proposed mouse has the cursor speed adjustment function on it.

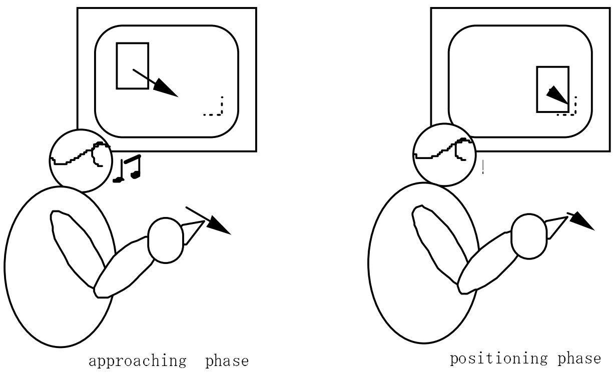

Fig. 1: *Two phases in a dragging task*

In the positioning phase, mouse is expected to be grasped more firmly than approaching phase, or it is easy for the user to grasp more firmly than before, when the user drives cursor to the target point carefully. It is natural human action. It is thought that muscle contention is more important in precise positioning. Then the Mickey Ratio adjustment system of the proposed mouse detects this grasping force. It enables to distinguish positioning phase from movement phase automatically, and the adjustment system sets the Mickey Ratio lower in the positioning phase. That makes the cursor move slower. Therefore, the proposed mouse is expected to support more natural and more comfortable usability than current type of mouse.

4.3 Method of realization

Fig. 2 shows the block diagram of proposed mouse. The grasping force detector and the Mickey Ratio adjuster (shown in thick line) are added to current mouse.

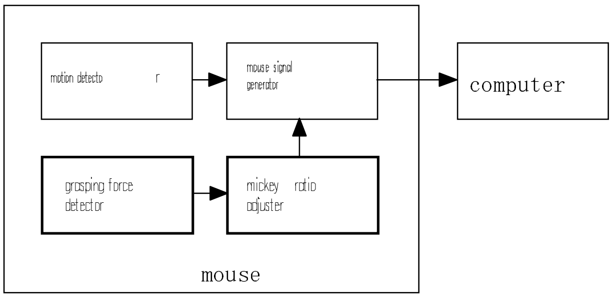

Fig. 2: *Block diagram of cursor signal in proposed mouse*

Then Mickey Ratio adjuster can discriminate between two phases, cursor signal is generated referring to grasping force. In the approaching phase, the mouse is grasped loosely, Mickey Ratio is adjusted to large, high-speed cursor signal is generated, the cursor moves fast on the screen. In the positioning phase, the mouse is grasped tightly, Mickey Ratio is adjusted to small, low speed cursor signal is generated, the cursor moves slowly on the screen.

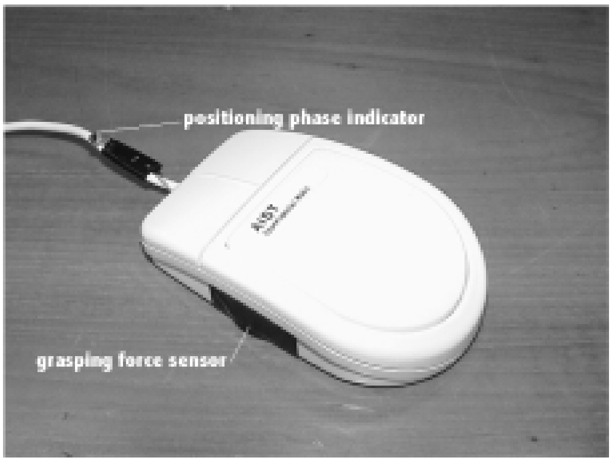

Fig. 3: *Experimental sample of mouse with realtime adaptive Mickey Ratio adjuster*

Fig. 3 shows an experimental sample of this mouse. To detect grasping force, thin type flexible pressure sensor is used. It is the black part of the side wall of mouse body. As shown in Fig. 4, this sensor is constructed with two stripe electrodes printed on a flexible print circuit sheet and pressure sensitive conductive rubber sheet. This grasping force sensor and Schmitt trigger inverter gate detects positioning phase.

To adjust Mickey Ratio realtime and adaptive, some logical gates and frequency converter circuit using flip-flop IC are inserted between encoders (which detect mouse motion on the mouse-pad) and the cursor signal generator. Though this sample has only 2 levels of Mickey Ratio adjustment, it is possible to design Mickey Ratio varies more levels or continuously.

It is also important that these sensor and circuit are not expensive.

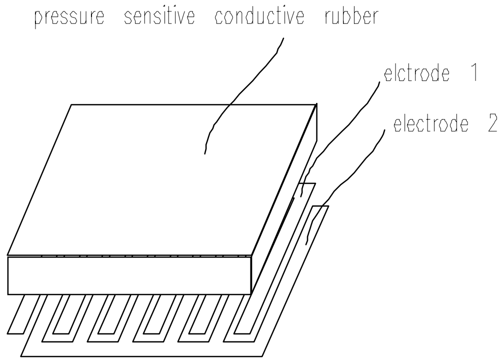

Fig. 4: *Construction of grasping force sensor*

Because the proposed mouse can contain cursor speed adjustment function in its body without any extra equipment or software, users can receive the advantage mentioned above only by replacing mouse.

4.4 Advantage of the proposed mouse

A new type of computer mouse that has a function for realtime adaptive Mickey Ratio adjustment by grasping force is proposed. It is expected to make computer mouse more natural and more comfortable human-computer interface device.

5. Conclusion

A computer mouse with realtime adaptive Mickey Ratio is proposed.

Pointing tasks of computer mouse are separated in approaching and positioning phases. Realtime adaptive Mickey Ratio adjustment has advantage that easiness of both of two phases increase. This is caused from the fact that distance to the target is major effective parameter in approaching phase and target size is major effective parameter in positioning phase.

Because the purpose of realtime adaptive Mickey Ratio adjustment is increase easiness of pointing tasks, it must be added without any new complexity.

In general pointing tasks, these two phases cannot be known before the task is started. The boundary between two phases exists only in the user's mental or psychological process, it is difficult to detect itself. Detecting of grasping force has a possibility to provide natural usability to realtime adaptive gain adjustment for grasping type operation terminal.

Generally, there are many types of remote pointing devices, for example, industrial robot manipulators, cranes, surgery

manipulators, and so on. Computer cursor on the screen is also a kind of remote pointing devices. On the other hand, there are many types of operation terminals, for example, keyboards, joystick switches, levers and so on. Computer mouse is only a type of operation terminal.
Adjusting gain between operation terminal and pointer, there is also a dilemma as same as in the case of computer mouse; if the gain becomes large, the motion of the pointer is faster, convenience of approach increases but positioning of the pointer should be more difficult. If the gain becomes small, everything is opposite to above. The motion of the pointer is slower, positioning of the pointer should be easier but convenience of approach decreases.
The idea of realtime adaptive gain adjustment is expected to be effective in those general remote pointing devices.

6. References

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