UbiButton: A bracelet style fulltime wearable commander (supplementary translation)

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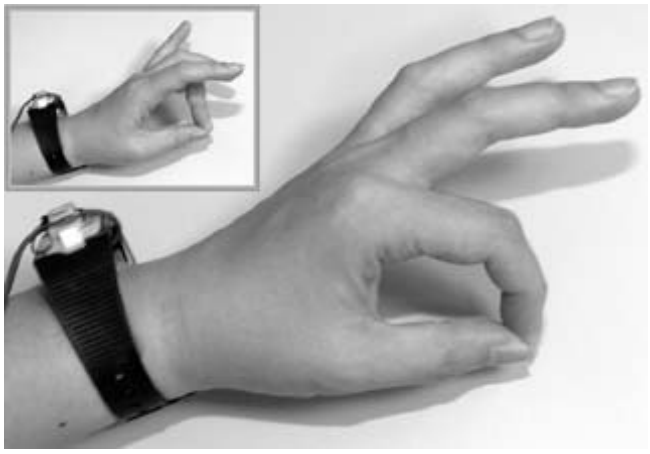

Figure 1: Sensor part of UbiButton
The shape of the finger is an example of "OK tapping".

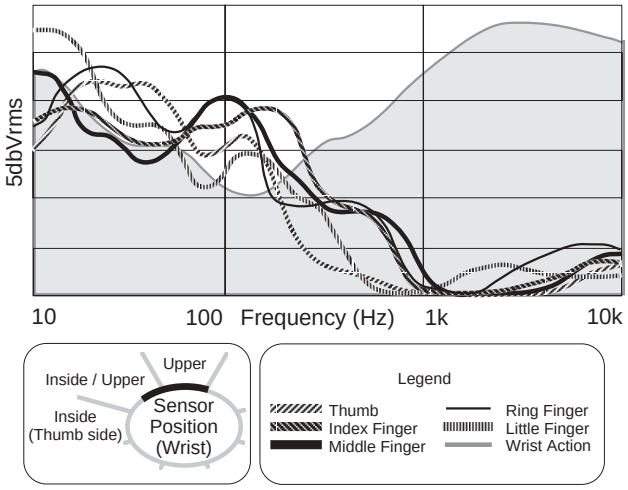

Figure 2: Frequency spectrum of wrist mounted accelerometer
The high frequency part of the noise is due to the movement of the wrist.

UbiButton

"UbiButton"[1] is a wrist-worn command input device. It has one accelerometer mounted on the upper part of the wrist, and detects fingertip-typing actions by any finger with any support object. UbiButton can also be operated by an "OK tapping" action, i.e., touching the thumb and other fingertip even when a support object does not exist such as when walking. **Figure 1** shows the sensor part of the prototype of UbiButton. The fingers shown in this figure show an example of "OK Tapping". The input operation of UbiButton looks like to playing percussion.

Detection of finger-tip typing

The accelerometer with a thin metal sheet (30 mm x 18 mm) in mounted on the upper part of the wrist [1]. **Figure 2** shows that the frequency spectrum of the accelerometer when fingertip typing action is performed by each finger. The output of the sensor when the wrist joint is bent or twisted is also shown in this figure as a noise component. This figure indicates that the frequency area of 80-200 Hz is mainly contained in the sensor output signal of fingertip typing regardless of finger used to type. Conversely, the sensor output signal when wrist joint moves does not have the same frequency area too much. Thus, the fingertip-typing action can be detected at the wrist mounted accelerometer by utilizing this frequency range. However, the difference in signal level between two kinds of action is slight. Therefore, when the detection sensitivity of the typing action is increased, misinterpretation with the wrist movement also increases. On the other hand, **Figure 2** also shows that the noise component contains a high frequency part over 1 KHz. Another experiment indicates that the signal of this frequency part is generated by rubbing the crease of the skin surface and the sheet metal of the sensor when wrist joint is bent or twisted. Therefore, 90% of the misinterpretation errors can be reduced by suppressing the sensitivity of the fingertip-typing when the high frequency part of the sensor output is detected. When fingertip typing is detected, it is converted to one pulse output signal called a "typing pulse". In the present system, the striking strength when typing is not considered and all typing pulses have the same width.

Table 1 shows the detection rate of fingertip typing for each finger. Fingertip-typing by the index, middle, and ring finger can be detected stably regardless of typing

[1] The position of the accelerometer was determined by experiment to detect typing action by all fingertips properly.

Table 1: Detection rate of fingertip typing (%)

	Surface & Style	Thumb	Index finger	Middle finger	Ring finger	Little finger
a	Thigh	69	98	99	97	31
b	Desk	99	100	100	99	98
c	OK tapping	—	100	100	99	16

"OK tapping": touching the thumb and other fingertip together

surface or style. High-speed typing can be enabled by using these three fingers in turn. For thumb and little finger, the detection rate is not so good. However, these two fingers are hard to use for speedy motion, and the rate of fatigue is higher than the other three fingers. Therefore, the usability will not be reduced even if only three fingers of the middle part are used for input for UbiButton.

"MORSL" code

UbiButton is a kind of a one-bit input device, and it is necessary to use timing information to represent multiple commands. Morse code is the most common coding scheme for a one-bit input interface, it uses the combination of the short and long width signal pulses. However, the width of UbiButton's typing pulse is unity; therefore, the Morse code scheme does apply to UbiButton. Thus, the time intervals among the typing pulses are used for coding. The interval time is converted into two kinds of symbols: short intervals are assigned to "dots", and long interval are assigned to "dashes", the short time intervals are about half the length of a long time interval. Commands are represented with the sequence of these two symbols. In this scheme, the last symbol of the sequence is always "dash", because the end of a sequence is determined when an too long interval is observed. We call this coding scheme "MORSL" [2]. The range of interval time ("dot": 50-250 msec, "dash": 250-500 msec) is determined according to an evaluation by ten subjects.

Suppression of daily-noise

It should be considered to suppressing unexpected input when building interface which uses regular body action. Because the body action assigned to input operation is often appeared in daily life. UbiButton generates typing pulses when the arm, hand, or finger on which the UbiButton is mounted hits some object. Typing pulses are also generated when the fingertip presses a keyboard or button. It is difficult to suppress the undesired typing pulse from these actions. Thus, it is necessary to filter undesired typing pulse after through a pulse generation module. One technique for suppressing the unexpected input is to assign a typing sequence that is rarely appears in daily life to the "activate" command of the PDA. The activate command is used to wake up the PDA, the target command can be accepted afterward. **Figure 3** shows an example of the distribution of generated typing sequences when UbiButton is worn for an entire day [3]. This figure indicates that a typing sequence of more than 5 strokes rarely appears regardless of the situation, and can be used as the "activate" command.

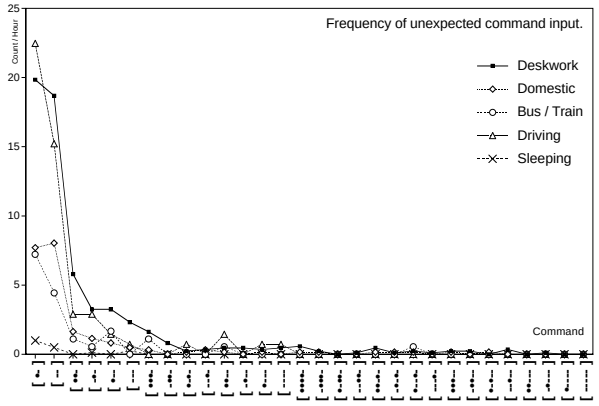

Figure 3: Frequency of unexpected input for each typing sequence
A typing sequence of more than five strokes rarely appears in daily life.

About 14 commands can be input by the MORSL coding method when the typing sequence of 2 to 4 strokes is used, and it can cover major PDA commands such as menu selection. More commands can be represented by the use of longer sequences if desired.

References

[1] Fukumoto, Masaaki et al. UbiButton: A bracelet style fulltime wearable commander. *Trans. of IPSJ*, Vol.40, No.2, 1999 (In Japanese).

[2] MORSL:MORSe code whose last element is always Long-dash.

[3] In this figure, the type of the action is divided into five situations; office work including computer operation (8.5 hours), housework (6 hours), commuting (2 hours), driving (1.5 hours) and sleeping (8 hours).