# Designing Gestures for Hands and Feet in Daily Life

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## ABSTRACT

In wearable computing environments, people handles various information anytime and anywhere with a wearing computer. In such situation, a gesture is one of powerful methods as input method because it needs no physical devices to touch and a user can input quickly. However, there are various restrictions for gesture input in daily life; gestures must be socially acceptable because a user has to gesture with unusual movements in a crowd, gestures must be flexible because a user cannot gesture when he/she has a bag with his hand that is used for a gesture. In this paper, we clarify the restrictions on gesture interfaces in daily life, then propose practical gestures for selecting simple menu items with hands and feet.

## Categories and Subject Descriptors

H.5.2 [**User Interfaces**]: Input devices and strategies; H.1.2 [**User/Machine Systems**]: Human factors

## General Terms

Experimentation

## Keywords

Wearable computing

## 1. INTRODUCTION

Wearable computing environments are becoming a reality, which supports a user's daily life by wearing a computer. In wearable computing environments, a user has to handle a lot of information and interact with a computer anytime and anywhere. Since existing input methods need to be carried around, there is a problem that a user has to take the input device our of his/her pocket. Therefore, a gesture input method is a powerful method because the input is operated by bodily motion or state and it needs no physical devices to touch. A user can input quickly by gestures.

However, we do not consider that all gestures are acceptable. There are various restrictions for gesture input in daily life. When a user has a bag or holds on a strap in a train, he/she cannot use his/her hand. A physical restriction occurs because of changing environments. Additionally gestures must be socially acceptable since conspicuous gestures affect people around the user physically and psychologically. In this paper, we describe five restrictions: physical restriction, social restriction, restriction of memory, restriction of wearability and restriction of recognition accuracy. Then we propose gestures considering these restrictions.

This paper is organized as follows. Section 2 discusses related work, and Section 3 describes environmental assumptions. Section 4 explains five restrictions on gestures in our method, and Section 5 describes the design of gestures. Finally, Section 6 presents our conclusion.

## 2. RELATED WORK

There are many researches on gesture interfaces for wearable computing. uWave[?] proposed a method for recognize eight gestures with high accuracy using by small number of training data that are from a three axis accelerometer on cell phone. however, all proposed gestures are big movement and need an input device with his/her hand. They did not taken into account frequent use of gesture in daily life.

Junker proposed a recognition method for monitoring actions of people in daily life with a wearable accelerometer [?]. It can recognize some gestures with high accuracy with an accelerometer on the arm. We do not use daily actions for gesture, we proposed simple gestures except daily actions.

GestureWrist[?] is a wristband type input device that recognizes human hand gestures by measuring the change in capacitance of wrist. Since hand gestures are slight, this method is socially acceptable. However, there is a problem that the value of capacitance varies if the position of wristband changes.

Prekopcsak proposed some design principles for everyday hand gesture [?]. They said ubiquity, unobtrusiveness, adaptivity and simplicity are important. However, these discussions are for general hand gestures. We discuss a feature of wearable computing and propose practical gestures for wearable computing environments.

Ubi-finger[?] achieved sensuous operations for information appliances by finger gestures. For operating appliances, everyone can see the gesture and confirm the change of an appliance. However, for operating information in Head Mounted Display (HMD), only the user can confirm the change. Therefore, the naturalness of a gesture is important.

There seems to be few researches for designing gestures for wearable computing in daily life. There are many situations that a user cannot gesture normally.

# 3. ENVIRONMENTAL ASSUMPTIONS

In wearable computing environments, people can handles various information anytime and anywhere with a wearing computer. Therefore, we assume that many services related to time and place are increasing. Since people must handle many information, people cannot input for difficult tasks. We suppose the information for wearable computing must be simple. Most of doing for wearable computing is just seeing contents and sometimes people inputs some command for operating. The input content must be also simple like a selection from some items. This is a passive operation for handling information, and most of the input operation in the wearable computing environments are these passive operations.

There is a positive operation for handling information, which has difficult tasks such as writing a mail and searching information. People should use buttons and keyboard for a positive operation so that they do a precise and rapid input for a long time. On the other hand, a gesture input is better than such a existing input methods for a passive operation because of rapidness on preparation.

Though a user has to wear sensor devices such as an accelerometer for gesture input, we suppose these sensors are also utilized for a life log and a health management in wearable computing environments. We suppose a user uses HMD as information presentation device. The information on HMD is not shared with other people. If a user operates information on the large display, a big gesture may be acceptable. On the other hand, swollen gestures for controlling information on HMD are not appropriate.

# 4. RESTRICTIONS ON GESTURES

There are many restrictions on gestures in daily life. In this section, we describe five restrictions : physical restriction, social restriction, restriction of wearability, restriction of memory, and restriction of recognition accuracy.

## 4.1 Physical restriction

There are physical restrictions on gestures in wearable computing environments. Especially, we focus on a physical restriction based on the change of situations. Since a user handles information with computer anytime and anywhere, his/her situation changes variously. There are restrictions for availability of hands, feet, and other part of a user. Moreover, we suppose three usual situations; sitting, standing and, walking in detail. We describe restrictions of hands, feet, head, and waist in these situations.

In a sitting situation, a user can use both hands and feet freely and precisely. When he/she holds a pencil or a cigarette, reads a book, or holds a cup of tea, one hand or both hand cannot be used freely for a certain time. However, when he/she holds something, a hand is not always unavailable. It depends on his/her intent whether he/she suspends the action such as writhing and reading. His/her head can be used freely. His/her waist cannot be moved broadly because of the chair.

In a standing situation, a user can move hands and feet freely and precisely. Both feet cannot be moved simultaneously because at least one foot needs to support body weight for standing. When he/she holds a bag or a strap on a train, one hand or both hands are unavailable. His/her head and waist can be moved freely.

In a walking situation, a user can move hands freely. The vibratory motions from his/her walk may affect the movement of hands. Since feet are always moving, it is difficult to use a foot precisely. Different movement from ordinary walk can be a gesture. His/her head can be moved freely. His/her waist cannot be moved broadly.

In this way, various physical restrictions on movements of body exist in each situation. We propose a method that multiple parts of body are allocated for the same function of gesture so that the user changes a part of body for a gesture in various situations. The availability of hands often changes in daily life. When a user holds something, he/she can use the other hand or feet for gesture input. Hands, feet, and head is useful for gesture input.

## 4.2 Social restriction

Gestures in daily life should be a small in oder not to affect people around the user. Natural and not conspicuous input methods are socially acceptable. From this point of view, we investigated the naturalness of gestures. We selected some gestures that are small but contain a certain level of change of acceleration from a head, hands, and feet in sitting, standing, and walking situations. We showed subjects the gestures and ask them to evaluate the naturalness. 5 is very natural, and they did not care about the gesture. 1 is unnatural. Table **??** shows the result of the evaluation that each number is an average and standard variation of 20 subjects consisted of 19 men and a woman.

The result shows most of scores for head gestures are low. Because a head is positioned at top of human and people do not move a head frequently, a head is very noticeable for everyone. It is difficult to use head gestures in daily life. For hand gestures, twisting a hand got high score, which is the most small movement of hand gesture. On the other hand, shaking a hand horizontally and vertically got low score. This is because these gestures have bigger motions than twisting. All scores of foot gestures are more than 3. Foot gestures are hardly noticeable because of the low position. Especially raising a toe or a heel and shaking a toe horizontally got high score. In these gestures, only a toe moves slightly. These are more unnoticeable than kicking. However, these gestures cannot be used on walking. Kicking forward is more similar to movement of walking than kicking backward.

## 4.3 Restriction of wearability

A user need to wear a sensor devices to recognize gestures. The positions of sensor devices need to be given consideration because a user always wears them. Their positions must be not obstructive for movement of daily life. They are strongly fixed to body to obtain accurate sensor data. Therefore they should be positioned on something a user wears everyday. For a head, HMD, a cap and glasses are good for the position. For a hand, a watch, a list band, a bracelet are good. Glove type is difficult for wearing all the time. For a foot, shoes, a sox,and a slipper are good. Knee is difficult to fixed because it moves frequently.

## 4.4 Restriction of memory

**Table 1: Evaluation on naturalness of gestures**

| | sitting | | standing | | walking | |
|---|---|---|---|---|---|---|
| | average | variation | average | variation | average | variation |
| shaking a head horizontally | 2.0 | 1.07 | 2.0 | 0.79 | 2.5 | 0.99 |
| shaking a head vertically | 2.8 | 1.18 | 1.8 | 1.10 | 1.9 | 0.71 |
| twisting a hand | 4.2 | 0.87 | 3.9 | 1.02 | 3.9 | 0.96 |
| shaking a hand horizontally | 3.0 | 0.79 | 2.6 | 0.75 | 2.8 | 0.78 |
| shaking a hand vertically | 2.6 | 0.88 | 2.4 | 0.75 | 2.3 | 0.78 |
| raising a toe or a heel | 4.5 | 0.82 | 4.3 | 1.02 | - | - |
| shaking a toe horizontally | 3.9 | 0.85 | 3.6 | 0.88 | - | - |
| kicking a leg forward | 3.1 | 0.99 | 3.1 | 0.88 | 3.6 | 1.27 |
| kicking a leg backward | - | - | 3.0 | 0.81 | 3.0 | 1.25 |

A user have to remember all gesture to use. It is possible that many functions are allocated to same hand or foot. However, too many gestures confuse a user because gestures are used for rapid input. When a same function is allocated to different positions, gestures for the function should be similar or something in common. If the gestures consist of opposite directions of movement, a user confuse to use. It is natural that the image of functions reflect the gestures.

## 4.5 Restriction of recognition accuracy

The feature of gesture input is rapidity. It is not good that a user repeat same gesture for low recognition accuracy. Especially when multiple gesture are allocated to a same position, similar gestures affect recognition accuracy. The wave of acceleration of gestures should not be close.

# 5. DESIGN OF GESTURES

We propose a gesture input method for hands and feet in view of restrictions. There are 4 sensors on both hands and feet in oder to be used in various situations. A user wears wristbands and shoes with accelerometer. PC receives the data of accelerometer. A user watches and operates information through HMD on his/her head. We describe a supposed task and feature of accelerometer. Then, we propose gestures for operating it.

## 5.1 Assumptions of task

We supposed a simple and passive application such as browsing information from around a user rather than operating existing desktop application. Then, the system do not handle pointing and complex operations but versatile menu system that consist of items hierarchically or selecting a item in a simple question. This kind of input system used to be operated by allow keys on PC and game device. Therefore commands of ”Enter”, ”Back” and ”Select” for selecting items are needed for this system (Figure **??**).

We proposes these commands for hands and feet. A user allocates these commands to their available parts according to their situations. A user selects the appropriate combination of gestures to input.

## 5.2 Feature of acceleration

There are two gesture input by accelerometer. They are a gesture that uses a short movement and a posture that uses acceleration of gravity. A gesture by a short movement can be used for rapid input in various situations. A posture by acceleration of gravity can be allocated to some different inputs for the angle of the sensor. Since this can change input just by changing a angle easily, it is useful when a user have to input often at a time. It always input something because condition is a input. In walking situation, it is difficult to detect a posture precisely because feet always move. A posture input is socially acceptable because a change of posture is generally smaller than a short movement of body. Then we allocate a gesture of a shot movement to ”enter” and ”back” and a gesture of a posture to ”select” in oder to select in multiple items.

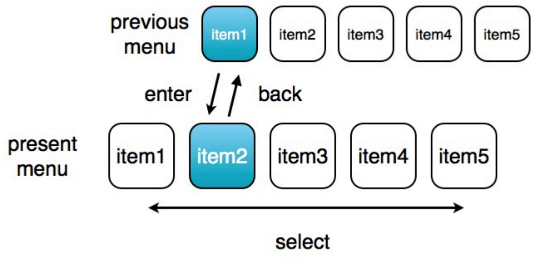


**Figure 1: Menu system**

## 5.3 Hand gestures

We show hand gestures. A gesture of twisting a hand got good scores form section **??** social restriction. Figure **??** shows a twisting gesture of a hand, that movement is small and change of acceleration is big. Twisting a hand can be used as both a gesture of a short movement by twisting a hand quickly and a gesture of a posture by acceleration of gravity. There are two kind of twisting a hand quickly that are twisting clockwise and counterclockwise. The followings are gesture inputs by hand.

**”Enter”, ”Back”:** twisting a hand quickly

**”Select”:** twisting a hand to change the angle

”Enter” and ”Back” are inputed by twisting a hand quickly. The acceleration is generated to the direction of rotating a hand. When the difference of the value of acceleration is more than a certain threshold, the gesture is recognized. The system recognizes whether it is clockwise or counterclockwise from the peak of waveform.We allocated ”Enter” is clockwise and ”Back” is counterclockwise.

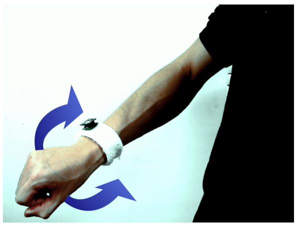

**Figure 2: Gesture input by a hand**

**Figure 3: Maximum and minimum acceleration of gravity**

"Select" is inputed by twisting a hand to change the angle and the acceleration value from gravity. Figure refude2 shows the position of maximum value and minimum value of acceleration of gravity. The system inputs a discrete value by dividing the range of acceleration by 5. 5 values can be inputed. When the number of items is less than 5, the inputed value match each items directly. When the number of items is more than 5, the system move a cursor for selecting a item. 3 that is the medium value is stopping a cursor. 2 and 4 is move a cursor slowly. 1 and 5 is a cursor quickly. We suggest 5 for dividing the acceleration value from our experience on various environment like a walking.

## 5.4 Foot gestures

We show foot gestures. Gestures of raising a toe or a heel and shaking a toe horizontally got good scores form section **??** social restriction. Figure **??** shows both gestures. Shaking a toe horizontally is a quick and small gesture. It can be used as a gesture of a short movement. Raising a toe can be used as a gesture of a posture by acceleration of gravity. However, these gestures are difficult to use on walking. In this section we describe only in static situation such as sitting and standing. Gestures on walking can be available by using different movement from normal walk. The followings are gesture inputs by foot.

**"Enter", "Back":** shanking a toe horizontally

**"Select":** raising a toe or a heel

"Enter" and "Back" are inputed by shaking a toe horizontally. The acceleration is generated to the horizontal direction. When the difference of the value of acceleration is more than a certain threshold, the gesture are recognized. The system recognizes the direction of the gesture from the peak of waveform. We allocated "Enter" is a right direction and "Back" is a left direction.

"Select" is inputed by raising a toe or a heel to change the angle and the acceleration value from gravity. The allocation of functions are similar to the gesture of hand. When a foot landed normally, the inputed value is 3. When a toe and heel is raised to near the highest position, the inputed value is 5 and 1.

**Figure 4: Gesture input by a foot**

# 6. CONCLUSIONS AND FUTURE WORK

In this paper, we described the restrictions for using gesture input for wearable computing environments in daily life. We discussed five restrictions on gesture : physical restriction, social restriction, restriction of memory, restriction of wearability and restriction of recognition accuracy. Then we proposed gestures considering these restrictions.

In the future, we plan to experiment in the long term.

# 7. ACKNOWLEDGMENTS

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