A Study on Selection Ability in the 3D Space by the Finger

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Abstract. Intuitive gestures are very effective for interactions. Pointing gesture with a finger would be used for interactions like pie menu selection. It has been researched as to the appropriate numbers of menu items being displayed in a pie menu. However, no research has been made for the case where menus are selected by using gestures. We got the ability of pointing gesture (selection ability) in the 3-dimentional space from the previous research. By combining the obtained resolution abilities of pointing gesture at the 2-dimentional surface of Pitch and Yaw, it is suggested that the selection ability of selection behavior in the 3-dimentional space is 22 areas. We will experiment in order to examine whether the subjects really point 22 areas without vertical guide. As a result, we found they can point 12 areas of 22.

Keywords: Gesture, Selection Ability, Menu, Pie menu.

1 Introduction

Intuitive gestures are very effective for interactions. In recent years, the researches on interactions, which operate various products and services such as music players and TV by using gestures, are being actively conducted.

It is difficult for computers to recognize the intentions of users from their natural gestures. Although it is relatively easy for computers to recognize standard gestures like sign language (commands), users need educations and trainings to be able to use them. Both have merits and demerits. Generally speaking, gestures are very effective for interactions if the use is limited to interactions like making selections from the displayed menu[1].

However, as the case now stands, there is no coherence between gestures and the allocations of interactions, and each application and service makes its own allocations.Products and services have become diversified and multifunctional, and there are more functions and interactions which need to be allocated to gestures, thereby the allocation has become difficult.

Therefore, pointing gesture with a finger would be used for interactions like menu selection. It is possible to select with simple gesture even when there are many menu items. In addition, pointing gesture is intuitive, thus users need no special education or training.

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Pie menu is a kind of GUI menus. It displays menu items in a radial fashioncentering on the mouse pointer. Users select a menu item by the direction to which they move the mouse pointer. Pie menu can be selected by the angles. It is suitable for interactions using pointing gesture.

It has been researched as to the appropriate numbers of menu items being displayed in a pie menu. However, no research has been made for the case where menus are selected by using gestures. In order to find it out, it is necessary to know human ability of pointing properly. Therefore, we will experiment in order to examine the ability of pointing gesture (selection ability) in the 3-dimensional space.

2 Related Research

Miyamoto et al. have discussed how they should allocate menu items to the extended pie menu[2]. They examined how the selection accuracy varied depending on the sizes and locations of each area within the pie menu so that they could discuss the most appropriate area pattern of the pie menu.

Saeki et al. have attempted to examine the selection ability of pointing gesture in the 3-dimentional space[3]. The experiment was conducted without posing restrictions on the arm joints of the test subjects, which allowed the free movements. Because each test subject had different pointing gestures, they were not able to conduct statistical analysis effectively.

Therefore, we thought it was necessary to examine the range of motion and the arthresthesia of joints of shoulder, elbows, wrists and fingers separately.

Yamada and Kuriiwa, they added a limit to point and examined the selection ability of the areas[4]. They found the selection ability for Yaw (horizontal) and Pitch (vertical) using the pointing at only using a point from a wrist limited rotary motion and did it with selection ability of the 3-dimentional space by putting them together. They got vertical selection ability, they pulled a board on the angle and demanded dividing any areas on the board. They obtained a result that selection ability using by pointing in the 3-dimentional space is 9 areas.

Oba, he found selection ability using the thimble which was in condition to have enabled the rotary motion of the wrist[5]. As a result, he found that it was distributed for 22 areas.

3 The Inspection Experiment of the Selection Ability

The experiment was conducted in order to find out the test subjects' selection ability of pointing gesture. With their forearms fixed horizontally, the selection ability for Pitch direction was obtained. The selection ability for Yaw direction was obtained for the each obtained selection ability for Pitch (Fig.1.). The below restrictions were added to the vision and arm joints of the test subjects

1. Visual feedback was eliminated.
2. The joints of arms and fingers, which were except for wrists, were fixed. (Fig.2.).

Pointing gesture in this research is by using the wrist and finger joints. In the previous research, pointing gesture is separated Pitch (vertical direction) and Yaw (horizontal direction) by vertical guide(2), but it isn't separated in this research. With the forearm fixed, the hemisphere centering on the direction from the elbow to the wrist was considered.

The test subjects were instructed to point at the center of a certain area, which was a part of the partitioned hemisphere. The accuracy of their pointing gestures was examined. We made the instructions area presentation device which really expressed the areas obtained in a study of Oba into a hemisphere in 3-dimentional space(Fig.3.). A subject pushes the switch, LED in the center of each area turns on and shows instructions area to him.

In order to obtain the pointing angles of the test subjects, 3D sensor module (9DOF RAZOR[6]) was attached on top of their index finger. 9DOF RAZOR is a sensor equipped with a triaxial acceleration speed sensor, a gyro sensor and a triaxial geomagnetic sensor. The test subjects were 5 males and females who were in early twenties and righthanded. All of them had normal wrists joints. It was defined that one trial consisted of the test subjects pointing at the center of an area as instructed one time. It was defined that one set consisted of one trial for 22 areas partitioned. Three sets were completed in the experiment. The order of the trials was random within one set. Each set had different order. The experiment took approximately 40 minutes.

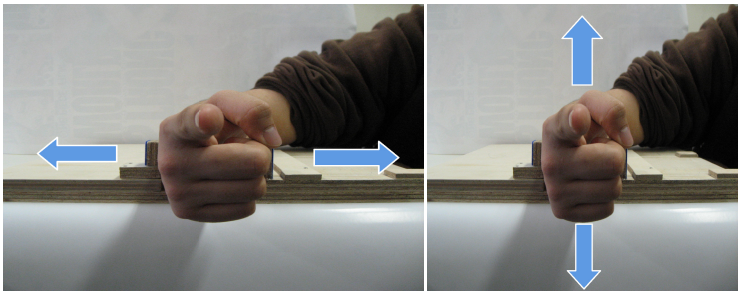

Fig. 1. Pointing Gesture by the finger(Left: Pitch, Right: Yaw)

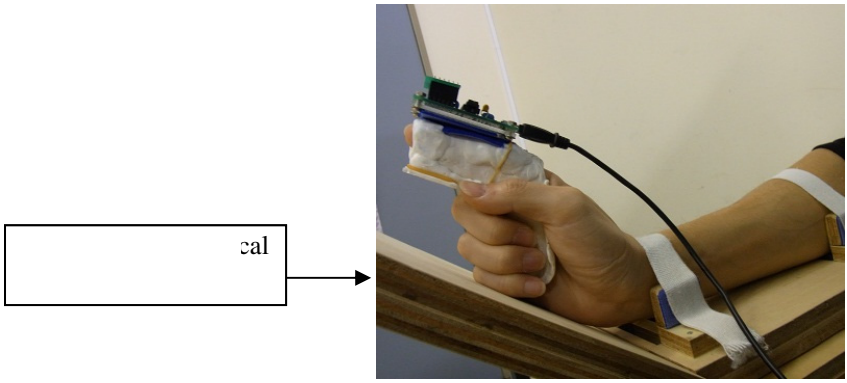

Fig. 2. The joints of arms and fingers were fixed

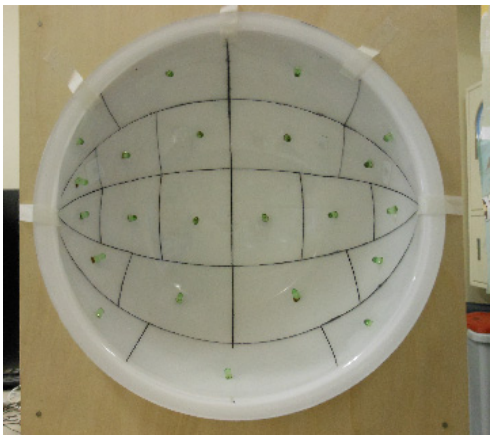

Fig. 3. The instructions area presentation device

3.1 Evaluation Method

The results of measuring the pointing angles of the gestures were analyzed. In the previous research, the pointing angles in one particular area of all the test subjects were assumed nearly normal distribution. So we let the average pointing angle in a particular area be μ and its standard variation be σ, assuming that they were able to point with the accuracy of approximately 68.3% if μ±σ was within the area.

However the pointing angles were not assumed normal distribution in this research. So we determine whether the subject can select right area using precision, recall and F-measure. I determine that the F-measure above 0.68 from previous works is possible to point at the area.

3.2 Results

We defined a area that could select correct is above 0.67 of F-measure from previous research result. We show a result in table 1. Furthermore, ending in a draw possibility refers to a judged area in the figure4. As a result, I found that we can point 12 areas in 22 areas of Oba.The area number is 1, 7, 8, 10, 12, 13, 14, 16, 17, 18, 20, and 21.

3.3 Discussion

We pictured the scatter diagram of the pointing angle to examine where subjects really pointed to when they pointed to the areas judged that they can't point(Fig.5.).

Meanwhile, we explain the conventional Pitch that previous work defined. It is an angle of the absolute coordinate system. By contrast, we get an Euler angle from a sensor. So we transform it from Pitch of Euler angle into Pitch of the absolute coordinate system. We can get the angle by using sine and cosine.

Table 1. Inspection result of selection ability

Area No.	Recall	Precision	F−measure
1	0.73	0.61	0.67
2	0.13	1.00	0.24
3	0.20	1.00	0.33
4	0.40	0.35	0.38
5	0.33	0.50	0.40
6	0.53	0.40	0.46
7	0.73	0.85	0.79
8	0.80	0.63	0.71
9	0.40	0.33	0.36
10	0.60	1.00	0.75
11	0.80	0.48	0.60
12	0.87	0.68	0.76
13	0.93	0.78	0.85
14	0.87	0.59	0.70
15	0.40	0.75	0.52
16	0.60	0.75	0.67
17	0.67	0.91	0.77
18	0.73	0.92	0.81
19	0.67	0.53	0.59
20	0.80	0.57	0.67
21	0.67	0.83	0.74
22	0.67	0.53	0.59

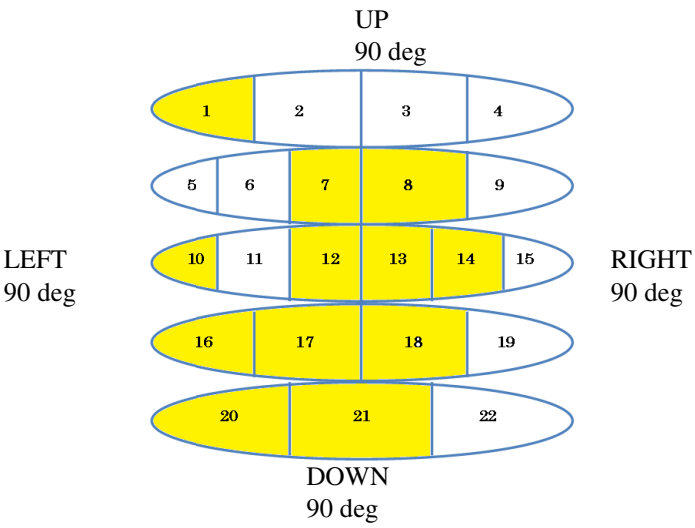

Fig. 4. Selection ability in the 3D space

As a Yaw angle becomes big, the vertical angle becomes big, and we point to upper area generally. Because when we convert a vertical angle to be provided from a sensor into the angle of the absolute coordinate system, as much as Yaw angle from a sensor becomes big, it has an influence on the angle after the conversion.

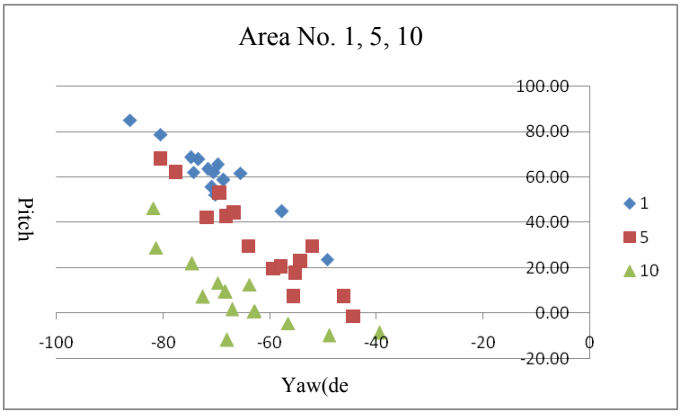

Fig. 5. Scatter diagram of area No. 1,5,10

4 Conclusion

From the result, we found that it is too difficult for pointing correct area without the vertical guide.

We think that previous research's selection ability which combining selection ability of pointing gesture at the 2-dimentional surface of Pitch and Yaw don't adupt to the selection ability by using pointing gesture in 3-dimentional space.

5 Future work

Combining selection ability of pointing gesture at the 2-dimentional surface didn't adupt to the selection ability by using pointing gesture in 3-dimentional space. So we need to get new selection ability adupted 3-simentional space by using pointing gesture.

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