Analysing Mid-Air Input For Horizontal And Vertical Axes For Pointing Tasks

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ABSTRACT

In the previous studies of mid-air input techniques there were no or little comparison on vertical versus horizontal input modalities. Further users are accustomed to indirect mapping techniques while using mouse and track pad to move the mouse cursor. Here the movement of the physical input device is perpendicular to the display screen. On the other hand, users are also acquainted to discrete mapping manipulation techniques from phones and tablet devices. We capture and examine the difference between mid air input for vertical and horizontal planes using a leap motion [3] capable of recognizing the gestures coupled with a custom built java application for the Fitt's law that adheres to the standards. We do this by analyzing the data gathered using task completion time for Fitts' Law task defined by the ISO 9241-9 standard [2].

AUTHOR KEYWORDS

Gestures; Horizontal mid-air input; Vertical mid-air input; ISO 9241-9; Fitts' Law task.

INTRODUCTION

Gesture driven input devices like Microsoft Kinect or Nitendo Wii or Leap Motion [3] are on the rise in the market and as the gestures become much natural, easier and less likely to be misinterpreted by the device recognizing the input gesture. It is just a matter of time might that these devices are completely accepted by the consumers as another input device if not completely ubiquitous as mouse or touch screen. Here we intend to study the different modalities available to users through Leap Motion hardware [3], which namely are vertical and horizontal. To determine which modality out performs the other for pointing tasks, we constructed an experiment using the Fitts' law task suggested in Soukoreff's paper[4] using the standard for evaluating pointing devices a multidirectional tapping task as defined in ISO9241-9 standard(2002)[2]. We will be measuring the task completion time for different difficulty levels for both modalities and comparing the measured data to come to a conclusion, we intend to compare the data in a granularity wherein we would be able to conclude on an average data which modality is performing better in certain directions of movement. We hypothesize that the vertical plane mid-air input modality is faster than horizontal plane mid-air input modality for on an average.

EXPERIMENT

Our aim is to compare the task completion times using basic Fitts' law pointing task with mid air input on vertical and horizontal planes for different Index of difficulties. We also intend to discover which input modality, horizontal or vertical, serves better in performance in terms of movement time for different directions of movement and index of difficulties. We used the IS0 9241-9[2] standard for conducting a multi-directional tapping task. The user was asked to point at the target and hit of targets is registered via a keyboard key input to register the hit. As part of the experiment the size of the target and distance between the source and the target was also varied. This varying of size and distance between source and target are associated to the different difficulty levels. The user is asked to do the tasks whilst standing.

APPARATUS

The experiments are performed on a 32" Telefunken TV, a native resolution of 1920 × 1080. The display was placed on a table in landscape orientation, in front of the user at a distance 3feet from the user. We are using Leap Motion [3] to capture user's hand features and use this data to manipulate the on screen. Specifications of the leap motion detector as hardware component and the specifications of software for manipulating incoming data can be found on https://www.leapmotion.com/. The Fitts' Law task runs on a MacBook Pro Core i5. A keyboard is used to register participant input when he/she feels that the required target is acquired.

TASK

The ISO 9241-9[2] standard is used for performing the Fitts Law task using leap motion for mid air input. The user has

to reach the target form the source and click on it. The size of the target and the distance between the source and the target is varied [2] (This represents the different indexes of difficulties). For both horizontal and vertical inputs modalities, the user has to perform the task for four levels of difficulty (treatments are stated previously). For each level of difficulty the user has to do the selection 11 times.

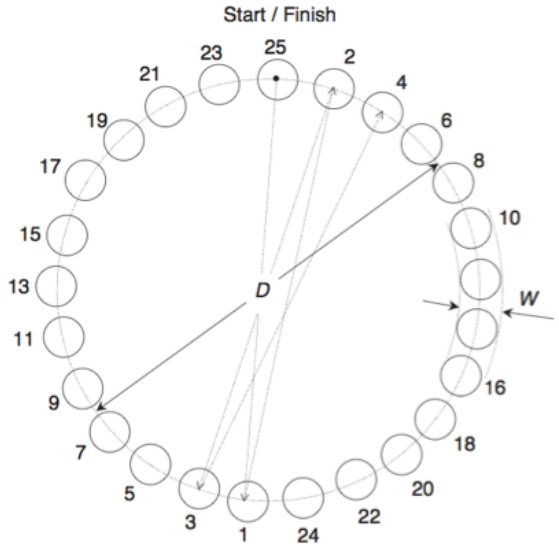


Figure 1: Mid air pointing task - Soukoreff et .al [4].

INDEPENDENT VARIABLES

Index of difficulty (Id):

The levels of difficulties suggested by Soukoreff et. Al [4] are between 2 to 8 bits. Though Soukoreff suggests to explore the complete range from 2 to 8 we do not do that completely because higher index of difficulties the tasks become very difficult as the target size reduces (as width could not be varied after a certain extent) very much. So, the different treatment for index of difficulty we selected are as shown in the below table1.

Table 1: Index of difficulty (Id) used in the experiment

Distance	Width	Index of Difficulty
600	150	2.3219280949 (i.e $\log_2 5$)
900	150	2.8073549221 (i.e $\log_2 7$)
1000	125	3.1699250014 (i.e $\log_2 9$)
1000	100	3.4594316186 (i.e $\log_2 11$)

The targets are arranged in a circular ring. So the distance between consecutive targets is always the same (Diameter of the ring). And the width of the target is always the same from all directions as the targets themselves are circular.

DEPENDENT VARIABLES

Movement Time:

Time is measured as the movement time between the source and target, so the first registered hit to the target is not considered for the analysis because we asked the user to explore the screen – so there is no means of saying all users traversed the same distance before they registered their first hit via the keyboard. we are trying to measure time for movement between equal distances as shown in figure1 and thus from the 1st hit onwards the targets are equidistant from their source, So the subsequent time to hit 2nd target and further on targets is recorded in milliseconds by resetting the timer every time the new target is hit (this is automatically done by the custom built Fitts' Law java Application running on the MacBook Pro Core i5).

PARTICIPANTS

Ten unpaid participants [5 Males & 5 Females] aged between 20 and 25 years old were recruited for the experiment. All of them were students from the non-computer science background and were right handed. Participants had little experience with popular mid air input devices like Kinect. All participants own smartphones and are used to touch based technology on a daily basis. None of the participants have any kind of motor or visual disability (Perfect to corrected vision).

EXPERIMENTAL DESIGN

1	Number of conditions: **2** (Vertical and Horizontal)
2	Number of levels for each condition: **4** (Index of difficulties for each condition)
3	Number of tasks for each index of difficulty: **11**
4	Number of tasks per participant: **88**
5	Number of participant: **10**
6	Total number of tasks: **880**.

METHOD

The user is warmly welcomed and served with refreshments so that he/she can calm down and feel comfortable. Participants are ensured that it is just an experimental study and subjective analysis of the result is not what is aimed for. Participants are informed about their rights that: At any moment they can stop participating in the experiment without giving a possible reason. They have the right to obtain further information about the experiment once the experiment is carried out. They have the right to exclude their results from the experiment if they wish to do so even after the experiment. Participants are also allowed to take as many breaks in between task if they feel any kind of fatigue. Also, if they feel tired during a task then the task can be stopped at any moment but, it would have to be later restarted. The experimenter then explains the user the purpose of the study and the tasks which are supposed to be done. The experimenter then presents the user with the consent form and steps through it part by part to make it

easier for the user. The user is also given some time to read the consent form by himself/herself and sign it. Then some general information about the participant is collected along with his frequency of interaction with some day to day and specific technologies and gadgets. The user is then invited to the experiment area where all the setup is ready. The user is then made to stand in front of the big screen. The users distance from the screen is constrained by putting a fixed chair in front of him/her. The experimenter introduces the user to the Leap Motion device and what range of area does it explore.

EXPERIMENT PROCEDURE

Distance of the participant from the screen is physically restricted by fixed chair in front of him/her. In order to make the participant used to the mid-air direct input technique, the participant is allowed to play a game 'IONE' downloaded from AirSpace [1]. The participant is allowed to play until he/she scores 3000 points (or) till he/she feels accustomed to system. After this the experimenter starts the tasks, the participant is supposed to move the cursor to the target, which is indicated in red, and press any key on the keyboard when he/she feels that the cursor has hit the target. And the next target appears. In one task the participants acquire 11 targets. During the tasks if the participant felt that something went wrong or there was a glitch in the system, the task was stopped and restarted in a later trial. Participant is advised to take a break after each task is finished. The tasks are repeated for 4 levels of treatment for index of difficulty. Once the participant finishes all tasks of this modality. He/She then starts the task with the other modality. The same procedure is repeated for the other modality. The setup is as shown below in Figure 2.

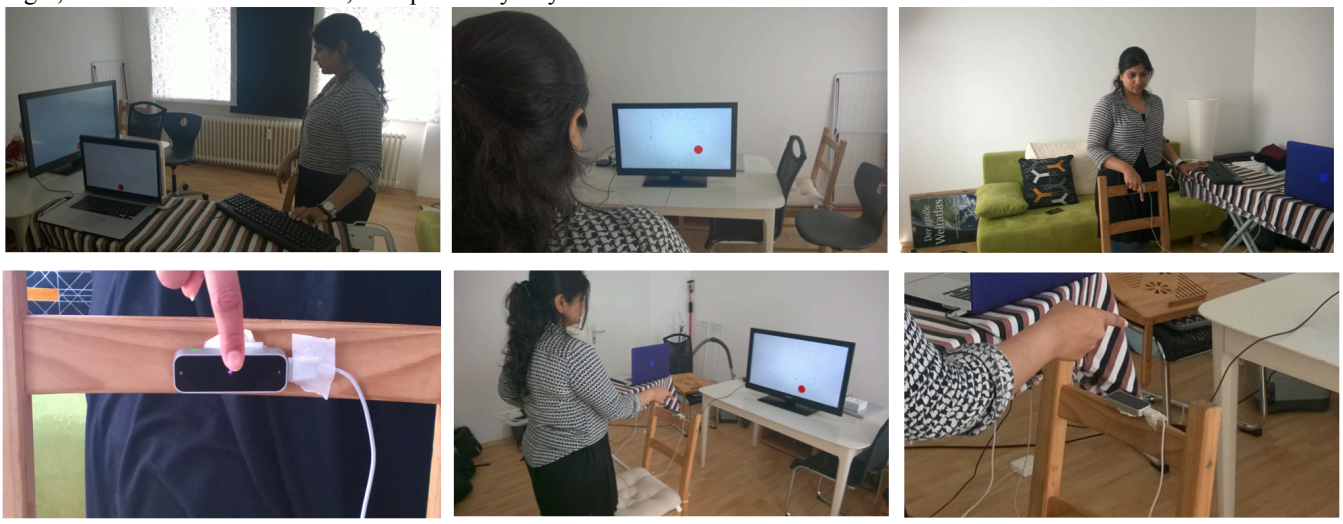
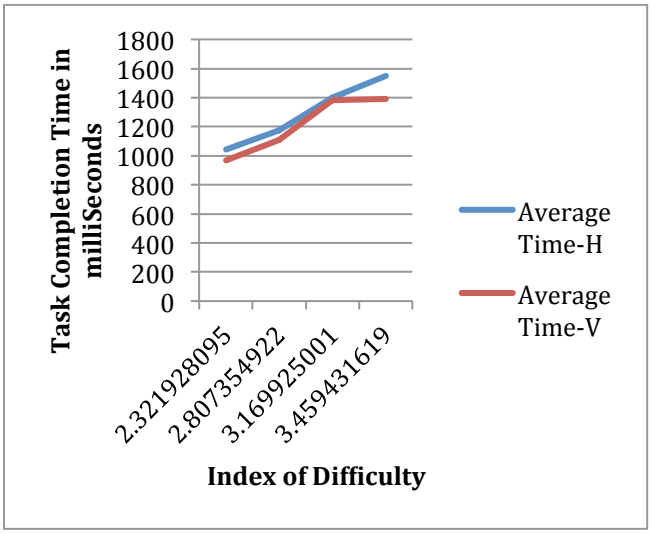


Figure 2: Experimental setup for Fitts' Law pointing task. Top left picture shows the setup in general, Top center picture shows the distance from the screen the user was asked to stand from the 28''screen, Top right picture shows the user is at a distance from the screen and behind the chair on which the leap motion is fixed, Bottom left picture shows the way horizontal modality is setup and used for our experiment, Bottom center picture shows the user at the same distance from the screen in the vertical modality setup, Bottom right picture shows the way the vertical modality is setup and used by the user for the experiment.

CONCLUSION



From the measurement gathered from both modality experiments we inferred that vertical modality with Index of difficulty 3 and 4 dramatically outperforms Horizontal modality as compared to the very similar performance with index of difficulty 1 and 2, with this inference we predict that with more users and higher index of difficulty vertical modality will drastically outperform when compared to horizontal simply because vertical modality resembles the direct manipulation similar to touch screen on tablets/smartphones sort of devices.

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