Differentiation on Information Gathering Ability in Real and Virtual World

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Abstract

Information gathering ability in Virtual Environment (VE) refers to user's ability to learn information such as text, numbers, or annotations. To find the usability of a designed interaction technique, information gathering ability is broadly used as a criterion. However, determining which technique is effective in a comparative analysis based on a usability test is difficult. Also measuring user's information gathering ability in Information Rich Virtual Environment (IRVE) is difficult due to the higher cognitive load associated with travel. In this study, we measured one's information gathering ability with respect to textual information in different worlds in order to find a difference and set a minimum guide line for determining the usefulness of a designed interaction technique. The results indicate that although user's path of finding information is similar, one's information gathering ability differs between the real vs. the virtual world conditions.

Keywords: Virtual Reality, Information Gathering Ability, Path analysis

1. Introduction

One method of evaluating interaction techniques is adopting the information gathering ability test [2, 4]. In the test, numeral and textual information is presented to user. In the lack of a reliable experimental protocol, usability of different interaction techniques based on the information gathering ability of user would be difficult to be determined. Traditionally one of the major concerns in virtual environments research is on the ease of information acquisition about virtual objects alone, such as the number of virtual books on the table or the common theme of paintings on the wall, while traveling in a virtual environment [11]. However, the information gathering ability we measured is different as it focuses on learning the posted numbers or textual information. Anecdotal evidence also described that interaction methods, traveling, and several other factors can affect the usability and the cognitive load on a user [7]. We also consider that a large amount of information in a virtual environment can affect the cognitive load on a user. Our main goals are (1) finding user's information gathering ability with respect to text information in a virtual world compared to the real world, and (2) performing a comparative analysis of user's path on finding the textual information in the virtual world vs. real world.

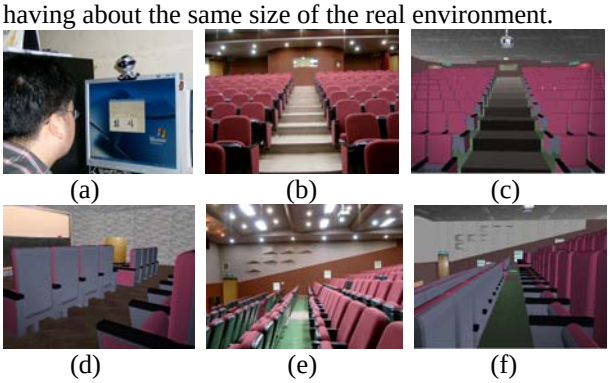
Mainly, we referenced the common theory of magical number seven. The theory states that there is always a limitation on processing information and the limitation is seven, plus or minus two [8]. Based on the theory, we evaluate the information gathering ability of participants in three experimental conditions: desktop condition, real world condition, and virtual world condition. After the experiment, user's path in finding the textual information is analyzed [11]. In the virtual world condition, Simulator Sickness Questionnaires (SSQ) [5] and Steed-Usoh-Slater (SUS) presence questionnaires [10] were used to measure the usability and the sense of presence.

2. Related Studies

In psychology, studying about user's cognition on information (the storage and retrieval of information) has been of interest for thousands of years [1]. Hence, the measurement on information gathering ability is used in different research areas such as internet based systems, virtual reality, and even economics. Especially in computer science areas, short-term memory test i.e. recall that can last up-to a period of 20 minutes, has been studied [1]. Furmanski et al. compared user's information gathering ability with the help of a web-based collaboration tool vs. browsing on the Internet [4]. The task of the user was to seek knowledge regarding a given topic. In virtual environment research, one paradigm of using the information gathering ability is for determining usability of a newly designed technique as opposed to existing techniques. Bowman et al. [2] used several quality factors for determining efficiency among several travel techniques. The information gathering ability is one of the quality factors they used to measure the effectiveness of different travel techniques.

3. Experimental Environments

The experiment is conducted in three different conditions: desktop condition, real and virtual environment condition. The desktop control condition is performed showing twelve words to user using computer screen (CRT monitor). Each word is displayed in ten seconds. In contrary to the desktop control condition, other two conditions are conducted in a real environment and a virtual environment. A lecture hall is selected as the real environment and the virtual environment which is designed by referencing the real environment. The area of the real environment is about $13.7m \times 18.3m$. The virtual environment is designed having about the same size of the real environment.



(a) (b) (c)

(d) (e) (f)

Figure 1. Desktop experimental environment (a), trail virtual environment (d), and real environment (b, e) and virtual environment (c, f) of a lecture hall

The twelve words used in the desktop experimental environment are also used in the virtual and the real environment. In order to have the same localization in real and virtual environment, all text information is displayed using the world-fixed method [3]. Also collision detection technique is applied in order not to pass through the virtual chair or the virtual wall. A VFX-3D (HMD) is used with Polhemus Fastrak tracker. Two different virtual environments, a trial environment and an experimental environment, are designed using the Simple Virtual Environment (SVE) toolkit [6].

4. Experiment

Forty five subjects participated in the experiment. In each experimental condition, fifteen subjects performed a given task. The desktop control condition is designed in order to compare one's information gathering ability in different world conditions. In the real and virtual world condition, a simple task is allocated to all subjects: finding the posted words in the environment. Also all subjects are requested memorizing the posted words after finding them. Especially in virtual environment, one of travel techniques, gaze-directed travel technique, is used for navigating the environment with which user can travel the virtual environment depending on the direction of user's gaze indicated. While traveling the virtual environment, constant travel speed is maintained.

5. Result and Discussion

5.1. Evaluation

A simple rating question is used to measure participants' immersiveness with which subject rate the immersiveness between 1 and 7 where 7 is the highest. The mean value of the immersiveness in the desktop control condition and in the real world condition is the same (5.5). Even if the immersiveness is not significant ($p = 0.22$), the mean of the immersiveness in virtual world condition (6.3) is slightly higher than other conditions.

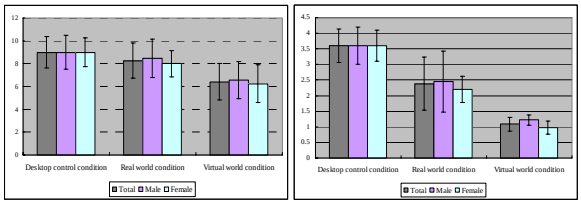


Figure 2. Mean values of gathered information (left) and mean values of gathered information divided by total time spent in minutes (right) depending on each condition

Participant's gathered information average is 9 in the desktop control condition, 8.3 in real world condition, and 6.4 in virtual world condition. The total gathered information is significant ($p<0.01$) by a standard single-factor ANOVA analysis. Also the gathered information depending on gender is significant; male ($p=0.0189$) and female ($p=0.0097$). Additionally, we analyzed the gathered information by dividing subject's total time spent. It is also significant ($p<0.01$) by a standard single-factor ANOVA analysis. Overall task completion time in average is about 375 seconds in virtual world condition and about 227 seconds in real world condition. In general, almost all subjects spent more time in virtual world condition. Especially female person spent more time in virtual world condition than male person. In result, male person gather slightly more information than female person in real and virtual world condition.

In virtual world condition, the sense of presence using the Steed-Usoh-Slater presence questionnaires (SUS) [10] is measured. The responses of subjects were as close as a real world experience which is much higher score comparing to Usoh and his colleague's result [10] in virtual environment.

Table 1. Computation of SUS score across all participants

	SUS Mean	SUS Count
SSQ score	5.25±1.12	3.26±1.83
Highest Possible Score	7.0	6.0

Through the simulator sickness questionnaires (SSQ), subject's initial symptoms are assessed. The SSQ lists 16

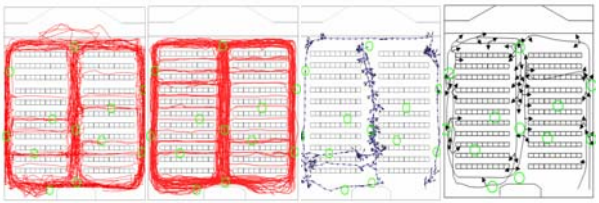
common symptoms rated by the participant on a four-point scale (0=none, 1=slight, 2=moderate, 3=severe). These ratings combine to form three subscale scores and a total severity score. The three subscale scores are nausea, oculomotor discomfort, disorientation [5]. In the simulator sickness questionnaires (SSQ), some of subjects slightly feel dizziness and nausea. A few subjects also have a hard time finding the information.

Table 2. Computation of SSQ scores across all participants

	Mean	Std	Low	High	Highest Possible Score
Nausea	22.90	16.44	0	57.24	200.34
Oculomotor Discomfort	34.36	21.07	0	68.22	159.18
Disorientation	31.55	24.37	0	69.60	292.32
Total severity	34.40	20.05	0	52.36	235.62

5.2. Path Analysis

In the real and virtual world condition, the user's pattern on finding the posted words is measured. Figure 3a and 3b show aggregate paths (Spaghetti plot visualizations) taken by participants in the virtual world condition and in the real world condition. The paths taken by participants in the real world are more concentrated in the aisles and in-between the rows of chairs. Also the aggregate paths taken by participants in the real world condition are more collinear than paths taken by participants in the virtual world condition. Otherwise, the paths taken by participants in the virtual world condition are more erratic than the result in the real world condition. And figures 3c and 3d shows the visualization of a representative path instance of a participant in the virtual world condition and a participant in the real world condition respectively. From these visualizations it can be observed that participants in the real world conditions explored the environment as they traveled, whereas participants in the virtual world condition traveled in a linear path, stopped and then proceeded to explore the local surroundings.



(a) (b) (c) (d)

Figure 3. The movement traces for all subjects in the virtual world condition (a) and the real world condition (b). The path of all subjects showing path and direction of gaze arrows in virtual world condition (c) and the path of a subject's path and direction of gaze arrows in real world condition (d). Several circles denote the positional information of the used words

6. Summary

In this paper, one's information gathering ability is measured in different worlds. Through the experiment, we found that people gathered slightly more information in desktop control condition and real world condition than in virtual world condition. Even if cognitive load in two different worlds, real and virtual world, is broadly equivalent [9], there is a miner difference. Also in virtual world condition, people have a hard time finding the posted text information. But we found one's information gathering ability in virtual world condition follows the theory of magic number seven, plus or minus two. Therefore if a designed technique shows the result on information gathering ability about seven, plus or minus two, we can imagine that the technique might produce good usability of using it.

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