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An Evaluation of Visual Reality in Virtual Environment

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Abstract The object of this research is to evaluate the rate of visual reality in virtual environment displayed with 3D Visual and Auditory Environment Generator (VAEG). VAEG is a part of prototyping simulator designing products harmony with human emotion. Size, Length and Distance were selected as minimal elements that composed hierarchical environment. Various methods, such as estimating size/distance, sketching map and searching objects, was employed in comparing differences between visual reality of virtual environment and that of real environment. Differences were utilized to estimate the rate of visual reality in virtual environment. Participants (m:56, f:28) in three experiments navigated the virtual environment, performed tasks, and answered to a questionnaire. Correlation between sketched map and a questionnaire was calculated to find complementary elements improving the reality of the system.

1. Introduction

Today's companies are interested in developing new products harmony with human emotion which are provided with good design, convenience, satisfaction, and so forth [1, 2].

A new research area called captology was introduced to investigate the possibility of computers as persuasive technology [3]. It is based on the assumption that computer systems may persuade users into better feelings and positive attitude [4].

3D Visual and Auditory Environment Generator (VAEG) displays 3D objects like as telephones, architectures, a small village using virtual reality technology. Companies can estimate and evaluate the rate of emotion on new products and environments with VAEG before producing them, then redesign them to improve the rate. VAEG-like systems have been already developed, however, the reality displayed by systems has not been evaluated [5,6].

The presence of systems is important in emotional engineering because high quality of presence in virtual environment reflects emotion of products more realistically in physical environment. Since previous works focus on factors of presence [7,8], new researches to evaluate a total developed system are needed in engineering area. Based on previous researches in human engineering, this research estimate the rate

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of visual reality in virtual environment and find complementary elements improving the reality of the system.

2. Evaluating Model of Visual Reality

Witmer and Singer(1998) categorized factors of reality: scene realism, consistency of information with the objective world, meaningfulness of experience, separation anxiety/ disorientation [9]. Above factors except meaningful- ness of experience were evaluated by using estimating size/distance, drawing-map measure, searching object and a questionnaire. Factor meaningfulness, such as motivation to learn, or perform, task saliency, and previous experience, was excluded because it was not much related to the reality of the system. Only hierarchical information, such as size, distance and orientation was measured because non-hierarchical information, such as color, texture, the quality of material and lighting was also dependent to the performance of graphic hardware. It is really hard to display the depth of color from light to screen in real-time (called ray tracing technique). So the focus of this paper is to infer presence degree of the virtual reality system through the verification of perceptual accuracy of size, distance and comparison with reality in virtual reality which is possible to come true in this time. Main process of experiments was comparing differences between visual reality of virtual environment and that of real environment

Size and distance are composed with length that is a basic component in hierarchical information. Distance was classified with traversed distance and perceived distance [10]. Perceived distance was measured in estimating distance and traversed distance was measured in drawing-map. Unit of object is important in size and distance. we can recognize the size of object by distance between vertices of specific object. And we may perceive distance between two objects by that if we see one in the interior of the other. Namely the concept of size and distance can be different, and it is based on the existence of unit object is based on the circumstances are perceived by observer. So, we can assert size and distance estimation in KIST

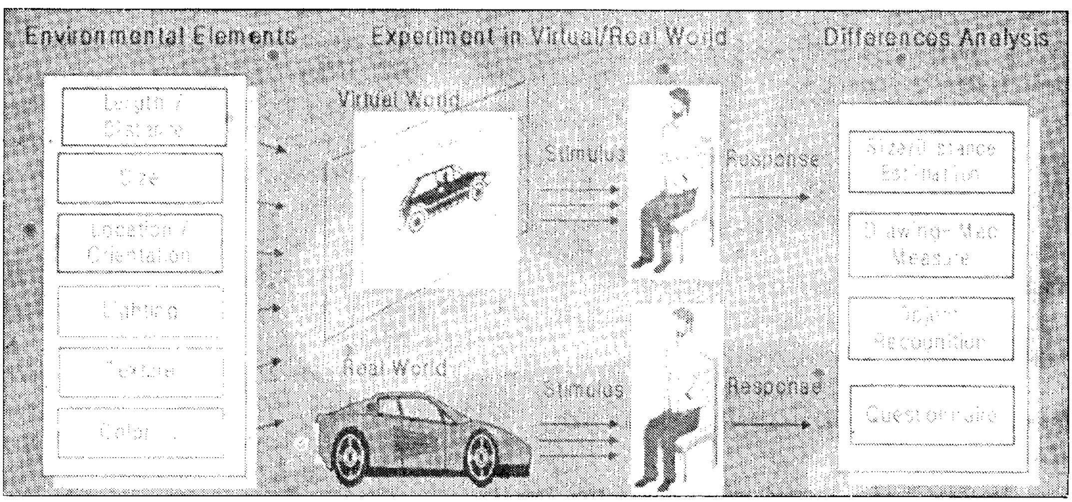


Figure. 1 overview of research

is proper. Estimating size/distance was experimented in virtual environment and physical environment, then estimated data were compared [11].

Hierarchical layout of environment and orientation was tested in drawing-map measure [12]. Participants who had no experience on experimental environment navigated virtual and real environment for a given time, then each one of them sketched his/her cognitive map. Sketched maps were graded by valuers according to guide items.

Searching objects was utilized to measure the remained information on experienced environment [13]. Participants were required to find designated objects after navigating virtual and physical environment.

3. Experiments

Participants who had never been to a small village navigated physical and virtual environment by bicycle. It was assumed that force-feedback was not supported because it affected visual reality little.

Differences between groups in virtual and physical environment were excluded statistically with a simple questionnaire.

3.1 Estimating Size/Distance

Participants estimated the size and distance in a fixed point after adapting themselves for 10 minutes in each environment.

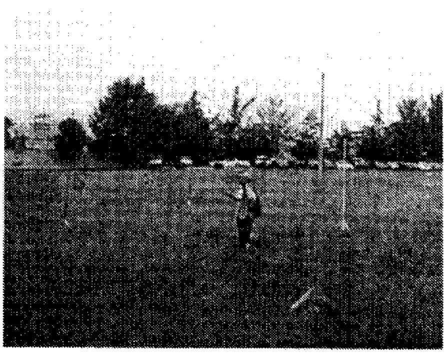
Sizes of bars were 0.75, 1.15, 1.55, 1.8, 2.15, 2.75, 2.9, 3.3, 3.5m and distances between participants and bars were 5.5, 8.3, 13m.

3.2 Drawing-Map Measure

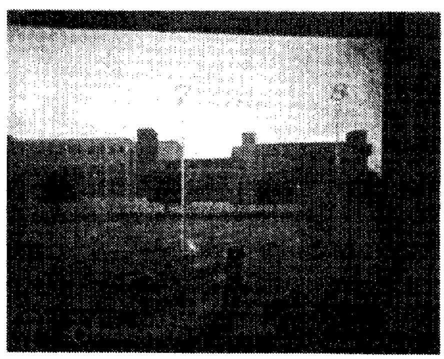
Participants navigated for 10 minutes in physical and virtual environment while one group watched video screen in this experiment. The filmed path in video environment was determined with the average path that participants of physical world navigated. Only in virtual world participants experienced pretest world for a while in order to be familiar with virtual environment and controlling interface.

3.3 Searching Object

After navigating each environment, participants were requested to search designated objects that were modeled in same shape and located in same position. The time spent in searching objects, the case of error and the path were observed.

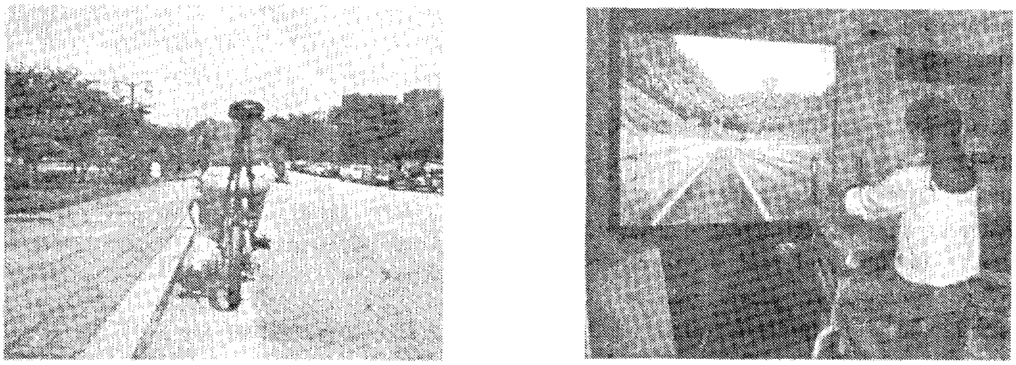


(a) Physical world



(b) virtual world

Figure 2. Experiment of estimating size/distance in physical and virtual world



(a) physical world (b) virtual world

Figure 3. Navigation in physical and virtual world

(a)Size (b)Distance

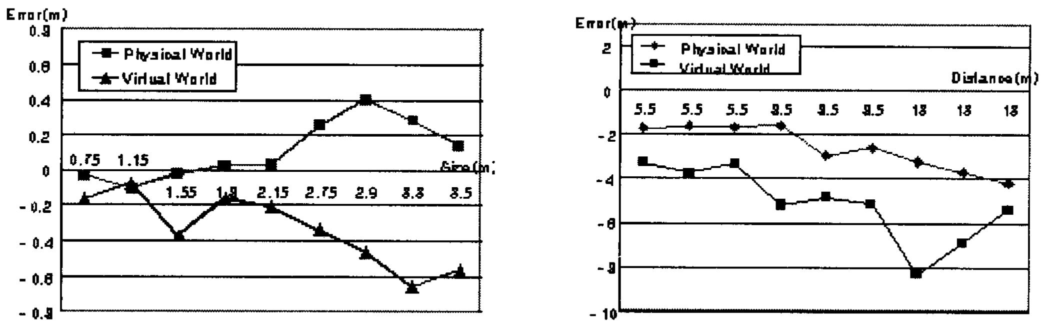


Figure 4. Error of estimating size/distance in physical and virtual world

4. Results

4.1 Estimating Size/Distance

Average errors between fixed size/ distance and estimated size/distance were presented in Figure 4.

The result notices that participants under-estimated the size/distance in virtual world. The average rate of size (virtual/physical) was 0.83, $p<0.05$ and average rate of distance (virtual/physical) was 0.60, $p<0.05$. The reason of under-estimation seems to be a narrow FOV that cause displaying part of size/distance in virtual world.

4.2 Drawing-Map Measure

5-point ordinal scale was employed to grade map sketched in virtual and physical environment according to base items; map goodness, object classes, relative position /size (Figure 5).

Item map-goodness is total similar level of map. Object-classes present similar level of objects and relative position/size of

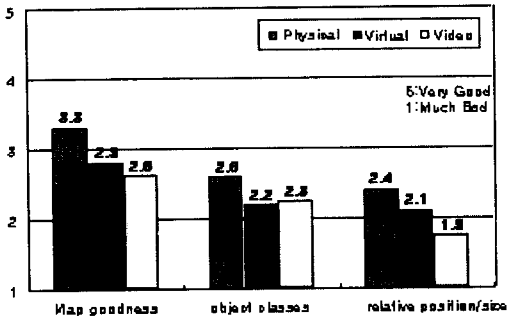


Figure 5. Result evaluated for sketched maps

objects show similarity between location of objects and size of objects. The rate of reality in virtual environment compared to physical environment in drawing-map measure resulted 0.86, $p<0.01$. The difference between virtual and physical data seems to be caused by narrow FOV that provided a little information on environment. Lower result was showed in video environment because participants experiencing environment with video screen lacked for interactivity.

5-point ordinal scale was also employed in questionnaire (Figure6). Result notices that the performance of visual part of VAEG was evaluated mid-level and the presence of VAEG did not increase after some minutes. The Correlation between map goodness and some results of a questionnaire was calculated (Figure7) to select the factors that affected participants' cognitive map more seriously.

4.3 Searching object

Every Participant found the designated object. But some participants in virtual environment chose the longer path because they did not recognize small ways. Milestones are needed to reduce these cases.

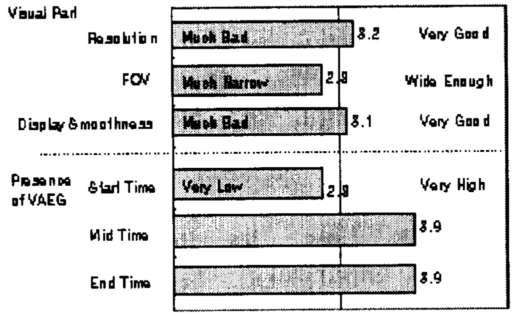


Figure 6. Some results of questionnaire on VAEG

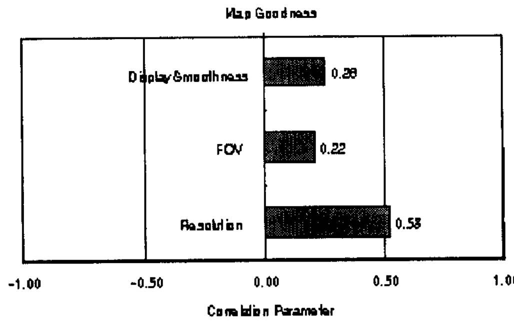


Figure 7. Correlation between Map Goodness Scale and questionnaire items

5. Conclusion

Various measuring methods, such as estimating size/distance, drawing map and searching objects, was employed for comparing differences between visual reality of virtual environment and that of real environment.

In this study, we used variable perceptual keys such as a sense of distance, comparison with the relative size between other object and comparison with perceived object to the exclusion of factors such as lighting, color. There was difference in each person, but we got meaningful result of experiment through statical analysis of correlation between size and distance when the size of object was less than 2 meters.

The participants in virtual environment displayed with VAEG experienced 83% (size), 60%(perceived distance), 86% (drawing-map) visual reality compared to those in physical environment. Companies using VAEG have to consider the difference rate between virtual products and physical products.

The rate of correlation between visual factors and map-goodness will be studied as varying scale of visual factors in order to find economic level support same performance.

These studies are merely a starting point in the research regarding evaluating of virtual environment system, and further studies are needed to test and extend the framework.

So further research is currently under way based on these results to develop a standard of virtual environment interfaces. The present study merely applied the Emotive Engineering methodology to the evaluation of a few visual factors in virtual environment.

In future studies, the design factors identified in this study will be actually incorporated into the human factors (presence, performance and motion sickness) of a standard interface design for virtual environment systems.

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가상환경에서의 Visual Reality에 대한 평가

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Abstract 본 연구는 3D Visual and Auditory Environment Generator(VAEG)에 의해 표현되는 가상환경에서 시각적 현실감의 정도를 평가하고자 하는데 그 목적이 있다. VAEG는 인간의 감성과 일치하는 제품을 설계할 수 있는 prototyping simulator의 일부이다. 계층적인 가상환경을 구성하는 요소로써 size, length, distance 세가지 요소를 선정하여, estimating size/distance, sketching map, 그리고 searching objects와 같은 다양한 방법을 통해 가상환경과 실제환경에서의 시각적인 현실감 차이를 비교하고자 하였다. 실험은 피험자들이 가상환경을 항해하고, 과제를 수행한 후에 설문에 응답하도록 하는 방식으로 진행되었으며, sketched map과 설문서 간의 상관관계를 통해 가상현실시스템의 현실감을 향상시킬 수 있는 보완요소들을 추출할 수 있도록 설계되었다.