Cognitive Psychology and Human Factors Engineering of Virtual Reality

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Abstract

This position paper summarizes the author's research interest in Cognitive Psychology and Human-Computer Interaction in the imseCAVE, a CAVE-like system in the University of Hong Kong. Several areas of interest were explored while finding the thesis topic for the Ph.D. research. They include a perception research on distance estimation with proposed error correction mechanism, neurofeedback meditation with EEG in VR and the effect with audio and video, the study of training transfer in VR training, the comparison and research of cybersickness between HMD and the imseCAVE, and comparing VR gaming in TV, HMD, and the imseCAVE by performance, activity level and time perception. With a broad interest, the exact direction is still in the search and requires future exploration.

Keywords: Virtual environment, cognitive psychology, HCI.

Index Terms: H.1.2 [Models and Principles]: User/Machine Systems—Human factors; H.5.1 [Information Interfaces and Presentation (e.g., HCI)]: Multimedia Information Systems—Artificial, augmented, and virtual realities; J.4 [Social and Behavioral Sciences]—Psychology

1 Research Interest

The research interest of my Ph.D. study started with the notion of incorporating and exploring Psychology in Virtual Reality (VR). The study of the human using scientific methods of experiments and models, Psychology and Human Factors Engineering, are fascinating. With the VR system, the imseCAVE at the University of Hong Kong [2], it is possible to incorporate Psychology theories into the virtual environment (VE) for testing.

After some narrowing of the scope, the area of Cognitive Psychology, and its application and validity in VR, and Human Factors Engineering were selected as they collide with the research interest. Cognition refers to the mental process including attention, language use, perception, thinking, learning and memory, aspects that link external sensory with the brain process. It would be valuable to understand if psychological processes are in fact, different in the virtual or technological realm. On the other hand, Human Factors Engineering, or Human-Computer Interaction (HCI), focuses on the interaction between human and technology and attempt to improve it by design and the use of technology. Integrating two fields together makes research not only theoretical (rooted in human psychology) but also applicable (by applying to human interaction).

As the technology of VR is getting more popular, the need for understanding the usefulness and effect of technologies have with the human is increasing crucial. Proactive research on VR can be highly informative and impactful to the application of technology [13]. It can aid mobilizing research to the general public and in specific application domains.

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2 Trial Projects

Several projects in the area of interest were explored and initiated; they are currently ongoing in the imseCAVE lab.

2.1 Depth Perception and Corrective Feedback

Distance estimation is found to be underestimated in VE. My undergraduate Final Year Thesis Project was to investigate the possible variables that could improve the perception accuracy in the imseCAVE by comparing the 2D and 3D objects; allowing the user to see all the screens in the imseCAVE, using only the front screen, or enabling users to walk around in the imseCAVE [9]. Only 2D and 3D objects were found to be significantly different regarding the accuracy.

Newer research is now carrying out based on the previous results. Photos, 2D, and 3D objects were presented as the target object. A novel corrective feedback training based on previous successful research in the head-mounted display (HMD) [6] was also modified and tested in the CAVE-like system context. As there is a physical constraint in the imseCAVE environment, interactive walking with visual feedback is not possible. The current verbal corrective feedback mechanism was proposed so that users receive the correct numerical answer on the distance estimation after he/she perceived the distance.

Part of the pilot study is finished and results shows that the feedback methodology is also useful in the imseCAVE although there maybe an overestimation problem with some closer distance objects [11]. It was speculated that participant simply learns that the estimations were incorrect and underestimated, and so future errors in answers are explicitly corrected by using cognitive adjustment and that such correction is valid across different objects and distances [10].

The asymmetrical transfer after the training is also measured between different VEs. Kelly et al. [6] reported a significant transfer of distance perception from VE to the real environment. Yet, as scene changing frequently happens in VR systems, it is more worthy to study in such context.

2.2 Cybersickness in HMD and imseCAVE

The study of cybersickness is a cooperation with the Department of Psychology, the University of Hong Kong, the aim of the research is to find out why human is more prone to cybersickness in HMD and compare to that in the imseCAVE. The current focus of the investigation is on the lack of surrounding information in HMD, and that all scene updates have to be instantly calculated when the user moves their head around, which may cause delay; while in a CAVE-like systems, the surrounding image of the previous scene is always provided that users can look at until the scene is recalculated. The research is ongoing, including the search for other possible factors such as sensory conflict theory and postural instability theory, and comparison of different interaction and navigation methods in VR.

2.3 Neurofeedback EEG Meditation in VR

The project tries to develop an EEG Neurofeedback system in VR and evaluates its usefulness with audio and visual instant feedback to aid meditation. A lightweight wireless EEG device, Muse (RRID: SCR_014418) by Interaxon Inc., measures the alpha brain wave signal of the user and feedbacks the meditation state to assist the user to concentrate on their meditation state. The aim is to find out if visual feedback in VE could be another type of useful medium for users to immerse in and mediate. The research is ongoing but currently still in the development process as there are coding issues with signal processing.

2.4 VR Gaming in TV, HMD vs. imseCAVE

Motion-sensing video game platform and HMD are getting more popular for gaming nowadays. As HMD devices are getting more popular in the gaming realm, it will be informative in comparing various kinds of gaming systems and VR systems in gameplay.

2.4.1 Performance and Activity Level

Questions are now being asked if VR gaming can help increase the activity level of users and if different kinds of VR systems provide different accuracy in performance and user experience. Currently, it is hypothesized that since the imseCAVE provides an observable size of space the user can interact with, the motion in that system should be more than that for HMD where users may have higher inertia to stay in their standing location and use their hand at arms-length only. Such result will have a significant in future VR gaming design on how to encourage users to be more active.

2.4.2 Music on Time Perception and Performance

While gaming is an interesting thing to compare across the three systems, the effect of music on time perception and performance of tasks is also an area of research [1]. Different variations of music, such as different arousal level, are tested to investigate which one creates the biggest impact on the user in performance. Effects on game play to time perception can also be compared between the three systems. The result can help improve the selection of background music for gameplay, and method to use for users to perceive time pass faster, for example, using VR gameplay during waiting or queueing as entrainment.

2.5 Training Transfer in VR Training

One of the major applications in the imseCAVE is training and simulation [7], for example, a new training system is developed to train workers for docking airbridge in the airport [3]. Steps in the procedure and spatial location can be taught using a VE instead of the real world. Real world training involves a real airplane parked on the apron for practice which would induce operation cost and involves risk. It is hoped that the operator, after learning the process in a realist VE on the procedure and spatial knowledge, the set of operation can be performed in the real world without any or only a little extra training or adaptation. This effect is termed training transfer. However, the evaluation of such effectiveness and the factors that related to such transfer are usually focusing on medical-surgical simulation, such as [4], and training related to rehabilitation patients, such as [12].

The current directions of assessment are the procedural memory, declarative memory, spatial cognition and situational awareness that are in line with the industrial training provided by the imseCAVE. Their performance in VE will be measured while they are learning with different methodologies or variables and after they have completed the training in VE, an additional test is provided to them in VE or real world to evaluate the effectiveness of training transfer and testing methodology.

Different studies had examined various factors that could affect factual memory during a VR training. For example, in a compared experiment of driving, participants that choose their route and/or control the navigation in VE with a steering-wheel shows better in memory function [5]. A physical touch with sterling-wheels and gas peddle may also be one of the factors that improve memory recall. However, the experiment is performed using a single screen-based VR system that does not provide full-immersion.

Another study found immersion VR systems such as HMD provides better memory recall than desktop system if the VE can provide a great immersion to the user [8]. Hence, immersion maybe an important aspect to consider in designing VR training. The above factors are seen as some relevant points that can be tested in imseCAVE for training transfer.

3 Thesis Topic?

As covered in this paper, different kinds of projects within Cognitive Psychology and Human Factors Engineering of VR are currently in progress. The thesis topic for the Ph.D. study requires further narrowing and exploration within or around the aforementioned areas for a concentrated study.

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