
ANFA 2014
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ACADEMY OF NEUROSCIENCE FOR ARCHITECTURE

Virtual Environments to Assess Facility Design for the Cognitively Impaired

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It is difficult to assess the impact that architectural designs have on individuals with age-related cognitive problems, such as Alzheimer's disease and mild cognitive impairment. We have developed an immersive virtual reality system to assess the behavioral and physiological conditions of subjects while interacting with a realistic virtual environment, assisting clinicians in cognitive evaluation and architectural designers in designing for cognitive difficulties.

1. ABSTRACT

It is difficult to obtain solid evidence of how aspects of a built environment affect the inhabitants of that environment. It is particularly difficult to do so for facilities designed for habitation by or service for individuals with age-related cognitive problems. While designing for the gradual impairment of navigation abilities and route learning widely documented in normal aging (Yamamoto 2012, Moffat 2009, Harris 2012) is challenging, designing for age-related dementias, such as mild cognitive impairment (MCI) and Alzheimer's disease (AD) is even more so. Designing such facilities well and understanding their effects on their inhabitants is becoming increasingly important, as the population ages and more individuals develop dementia, with over 5 million current diagnoses in the USA, and the number increasing inexorably (National Institutes of Aging Website - nia.nih.gov)

Classically, testing the effects of such facilities is done by analyzing aspects of existing architecture and implementing them into a new building, followed by behavioral observation, a system which is both expensive and cumbersome. More recently, virtual reality (VR) environments, such as the StarCAVE at CalIT2, have allowed individuals to experience a virtual incarnation of a building in an immersive and interactive way while allowing monitoring of the subjects position and head orientation (Zhang et al., 2011; Macagno et al., 2012). Unfortunately, such systems are geared towards research and development, rather than broad testing of subjects' responses to designs of the built environment in VR. Due to their developmental nature, these systems, while capable of implementing software for such tests, are expensive, difficult to use by untrained individuals, and require specialized technical support.

Based upon these existing technologies we have developed a more cost-effective, immersive VR system for use by clinical researchers at the UC San Diego Center for Neurodegenerative Diseases. This modified mini-WAVE system, is a more portable VR system incorporating an easy-to-use interface, such as a steering wheel and pedal, virtual sound, and integration of sensors for determining the state of subjects in real time. These sensors may include motion capture, eye tracking, and non-invasive physiological sensors (such as EEG, EOG, ECG, etc.), allowing researchers to evaluate the cognitive state of patients with dementia as they interact with the virtual environment. The adaptation and integration of these technologies is vital for the assessment of behaviors within a virtual environment similar to the behaviors such subjects would have with an actual environment, especially allowing maximally natural movements of the subjects' body and unimpeded visual feedback of actions both within the VR environment and with the physical interfaces.

We have also developed experimental paradigms for testing features of the environment, cognitive function of patients navigating the environment, and software for real time evaluation of sensors during the testing. Existing systems have been used to perform experiments in virtual environments (Flynn '03, Cushman '08) and realistic models of actual (or proposed) built environments have been displayed in our existing facilities. These new paradigms, however, are adapted from classic neuroscience experiments, specifically geared towards the evaluation of cognitive processes and integration of monitoring sensors. These paradigms are implemented using a baseline virtual model we have developed, able to be customized to test aspects of spatial memory, orientation skills, navigation, and structural cue recognition. One of the key aspects of this model is its versatility; allowing an experimenter to easily place visual and auditory objects in the virtual environment, set experimental parameters, define basic interactions, while collecting information about the experiment and subject. This allows our system to be used (1) by clinicians working on dementia, looking

for environmental biomarkers related to disease progression, and (2) by architectural designers to better inform the design of assisted care facilities and hospitals.

ACKNOWLEDGMENTS

Support has been provided by HMC Architects and CSRO grants from Calit2.

2. REFERENCES

Yamamoto, N., DeGirolamo, G.J. (2012) Differential effects of aging on spatial learning through exploratory navigation and map reading. Front Aging Neurosci. Vol. 4, article14, June, 2012..

Moffat, S.D. (2009) Aging and Spatial Navigation: What Do We Know, and Where Do We Go?7 Neuropsychol Rev 19:478-489.

Harris, M.A., Wolbers, T. (2012) Aging Effects on Path Integration and Landmark Navigation. Hippocampus 22:1770–1780.

Zhang, L., Joachim Gossmann, Cory Stevenson, Michael Chi, Gert Cauwenberghs, Klaus Gramann, Jurgen Schulze, Peter Otto, Tzyy-Ping Jung, Randy Peterson*, Eve Edelstein, Eduardo Macagno. Spatial Cognition and Architectural Design in 4D Immersive Virtual Reality: Testing Cognition with a Novel Audiovisual CAVE-CAD Tool. In Bhatt, Holscher & Shipley (Eds). Epub. Nov 2011.

Macagno E.R., Zhang L., Edelstein E., Schulze J., Stevenson C., Cauwenberghs G., Jung T.-P., Gossman J., Otto P. & Townsend J. Next-Gen Wireless Monitoring of Electrical Activity and Movement in Virtual Reality: Evidence-based Analysis/Diagnosis in Realistic Environments Presentation Code: 138.02 Abstract Number: 4538 Poster Board Number: G2. FENS 8th Forum of Neuroscience. Barcelona, Spain. July 17, 2012

Flynn D, Van Schaik P, Blackman T, Femcott C, Hobbs B, Calderon C (2003) Developing a Virtual Reality–Based Methodology for People with Dementia: A Feasibility Study. Cyberpsychol Behav 6:591-611.

Cushman LR, Stein K, Duffy CJ (2008) Detecting navigational deficits in cognitive aging and Alzheimer disease using virtual reality. Neurology 71:888-895.

3. AUTHOR BIOS

Cory Stevenson is currently a PhD student in the Department of Bioengineering, at UC San Diego, where he previously graduated with a BS in Bioengineering: Biotechnology. His research focuses on the control of human movement in space.

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