Proceedings of the 2014 Winter Simulation Conference
A. Tolk, S. Y. Diallo, I. O. Ryzhov, L. Yilmaz, S. Buckley, and J. A. Miller, eds.

AN APPROACH TO EMBODIED INTERACTIVE VISUAL STEERING: BRIDGING SIMULATED AND REAL WORLDS

Denis Gračanin, Timothy Eck II, Rochelle Silverman, Alexander Heivilin and Sean Meecham

Virginia Tech
Department of Computer Science
Blacksburg, VA 24060, USA

ABSTRACT

Interactive visual steering of a complex simulation is often limited by our inability, due to the cognitive overload, to fully grasp the data presented on a computer screen. Our cognitive processes are dependent on how our body interacts with the world (affordances) and how we off-load cognitive work onto our physical surrounding (embodied cognition). We present an approach to embodied interactive visual steering that takes advantages of affordances and embodied cognition in a large physical space. The initial implementation of the proposed approach uses augmented reality and motion tracking to display the simulated system on a scale that can benefit from embodied cognition. Embodied interactions support visual steering, i.e., changing the simulation system parameters, by using physical devices and device-embodied tasks.

INTRODUCTION

We use many visualization techniques and data views to understand the simulation results and relate those results to the underlying model. However, there is still a gap, both cognitive and visual, that needs to be closed (in the context of interactive visual analysis) (Matković, Gračanin, Jelović, Ammer, Lež, and Hauser 2010). More sophisticated approaches use immersive virtual environments (Renambot, Bal, German, and Spoelder 2000), game engines (Bijl and Boer 2011) and augmented reality (Dong and Kamat 2011).

All those approaches focus mostly on the visual aspects without taking into account the importance of the body's interactions with the physical world. Embodiment cognition (Wilson 2002) builds on the notion of affordances, potential interactions with the environment, to support cognitive processes. Embodied interaction (Dourish 2001) and embodied user interfaces (Fishkin, Moran, and Harrison 1998) lead towards invisible user interfaces and move the computation from computer desktop to physical space and place (Williams, Kabisch, and Dourish 2005).

APPROACH

Recent advances in sensor, tracking and visualization technologies make it possible to move interactive visual steering from computer desktop or immersive virtual environments to larger physical spaces. The data views are mapped to the physical space where users freely navigate and investigate the data as well as manipulate the simulation system parameters. The simplest case is where a single 3D data view is mapped onto the 3D physical space using the scale that supports embodied cognition (e.g, a building simulation and 3D visualization that is scaled to the proportion). We can use Coordinated Multiple Views (CMVs) where data views are simultaneously presented and co-located in the physical space.

The initial implementation of the proposed approach leverages Virginia Tech's Cube facility (http://www.icat.vt.edu/facilities/living_labs) that provides an enclosed space 50×40×40 feet with real-time tracking capabilities. The simulation model is first developed and visualized using a standard desktop based simulation or modeling tool and then presented in Cube (illustrated in Figure 1). Several users can simultaneously move in the physical space and use a tablet (or augmented reality glasses) to view

978-1-4799-7486-3/14/$31.00

the simulation results from different points of view The physical location and orientation of a viewing device is used to determine the corresponding 3D data view. The viewing device is also used for embodied interactions, i.e., device-embodied tasks. The user can also observe other users and collaborate to change the simulation. The changes are sent back to the desktop simulation tool.

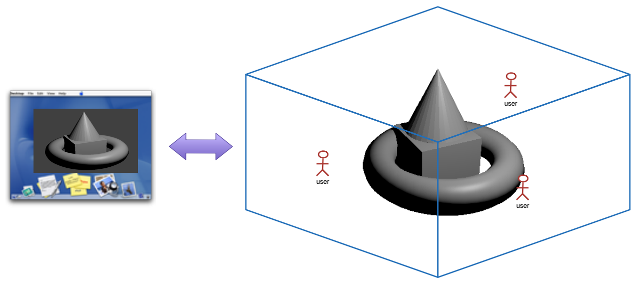

Figure 1: The illustration of the proposed approach.

DISCUSSION

The current implementation demonstrates the feasibility of the proposed approach. The users can experience the 3D data view of the simulation results while navigating and interacting in the physical space. The ongoing work proceeds in several directions. First, we are preparing user studies to compare the effectiveness of the proposed approach by comparing task performance and cognitive load with the traditional desktop approach. Second, we are implementing CMVs to support simultaneous data views. Finally, we are exploring likely application domains, such as building design, manufacturing systems, and training.

REFERENCES

Bijl, J. L., and C. A. Boer. 2011. "Advanced 3D Visualization for Simulation Using Game Technology". In *Proceedings of the Winter Simulation Conference*, 2815–2826: Winter Simulation Conference.

Dong, S., and V. R. Kamat. 2011. "Collaborative Visualization of Simulated Processes Using Tabletop Fiducial Augmented Reality". In *Proceedings of the Winter Simulation Conference*, 828–837: Winter Simulation Conference.

Dourish, P. 2001. *Where the Action Is: The Foundations of Embodied Interaction*. Cambridge, Massachusetts: The MIT Press.

Fishkin, K. P., T. P. Moran, and B. L. Harrison. 1998. "Embodied User Interfaces: Towards Invisible User Interfaces". In *Proceedings of the IFIP TC2/TC13 WG2.7/WG13.4 Seventh Working Conference on Engineering for Human-Computer Interaction*, 1–18. Deventer, The Netherlands: Kluwer, B.V.

Matković, K., D. Gračanin, M. Jelović, A. Ammer, A. Lež, and H. Hauser. 2010, November-December. "Interactive Visual Analysis of Multiple Simulation Runs using the Simulation Model View: Understanding and Tuning of an Electronic Unit Injector". *IEEE Transactions on Visualization and Computer Graphics* 16 (6): 1449–1457.

Renambot, L., H. E. Bal, D. German, and H. J. W. Spoelder. 2000, 1–4 August. "CAVEStudy: an Infrastructure for Computational Steering in Virtual Reality Environments". In *Proceedings of the Ninth International Symposium on High-Performance Distributed Computing*, 239–246.

Williams, A., E. Kabisch, and P. Dourish. 2005, 11-14 September. "From Interaction to Participation: Configuring Space Through Embodied Interaction". In *Proceedings of the Seventh International Conference on Ubiquitous Computing (UbiComp 2005)*, Volume 3660 of *Lecture Notes in Computer Science*, 287–304: Springer.

Wilson, M. 2002, December. "Six views of embodied cognition". *Psychonomic Bulletin & Review* 9 (4): 625–636.