EVE: A Framework for Experiments in Virtual Environments

Jascha Grübel❖, Raphael Weibel❖, Christoph Hölscher❖, Daniel A. Hackman⚬, Victor R. Schinazi❖
❖Chair of Cognitive Science, ETH Zurich; ⚬Department of Population Health Sciences, University of Wisconsin-Madison

1. Introduction

EVE is a framework for the setup, implementation and evaluation of experiments in virtual reality (VR). The framework aims at reducing repetitive and error-prone steps during experiment-setup while providing data management and evaluation capabilities in later phases of an experiment. The framework is based on the popular platforms of Unity3D and MiddleVR. Database support, visualization tools and scripting for R make it a comprehensive solution for research using virtual environments.

Gaggioli[1] outlines four motivations why running experiments in VR can benefit research in experimental psychology. First, VR can provide for better ecological validity by allowing for naturalistic behaviour within a simulated environment. Second, VR systems are flexible and can be customized to the needs of researchers. Third, new VR technology can provide accurate sensorial feedback that can be difficult to manipulate using traditional methods. Fourth, VR systems can facilitate the accuracy and reliability of data recording helping to speed up the experimental process. Indeed, there is now growing evidence that a correspondence may exist in the aesthetic experiences and navigation behaviours of participants in VR and the real-world[2,3] (but see Taube[4]).

In short, EVE offers a variety of functions for the most common components necessary for conducting studies in VR.

2. Framework Overview

EVE is not a middleware framework that focuses on the abstraction of hardware. Instead, it provides a comprehensive work environment that gives researchers control over 3 different stages of an experiment.

In the **setup phase**, external environments are loaded and populated with virtual sensors to keep track of the virtual experiment state. In this phase, questionnaires can also be prepared and physical sensors added. In the **runtime phase**, EVE gathers data from all specified sources and stores them in a database. In the **evaluation phase**, data can be reviewed in replays, map plots, analysed by running R scripts and exported for further processing.

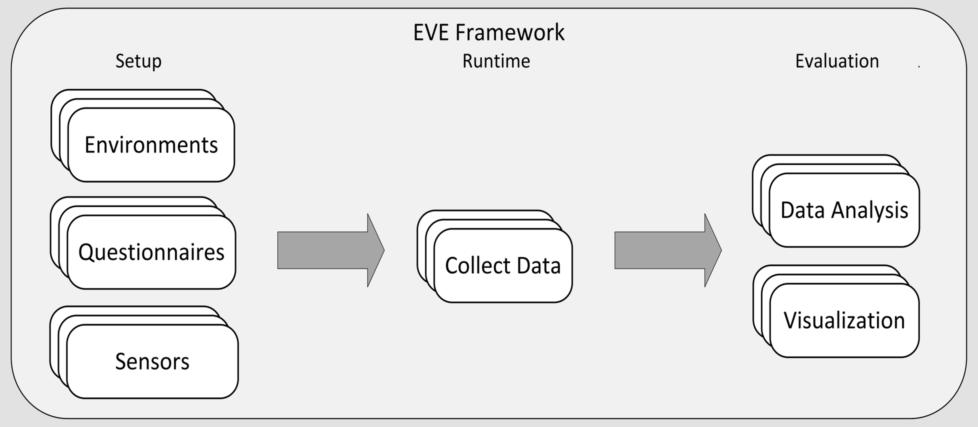

Fig. 1. Overview of the three experiment phases supported by EVE

3. Framework Features

The framework runs on Unity3D, MySQL and MiddleVR to facilitate modelling, data storage and hardware interaction.

Another aspect of the framework, is to provide access to commonly used features such as standard questionnaires (SBSOD[4]) or useful scenes such as training environments, fixation screens or baseline measure scenes.

Acquisition and data processing are at the core of the framework. The framework simplifies the interaction with different physical and virtual sensors. It also manages data gathering during and after the experiment is complete. Integration with the R scripting language is provided to compute a set of common statistics as well as user-defined R-scripts.

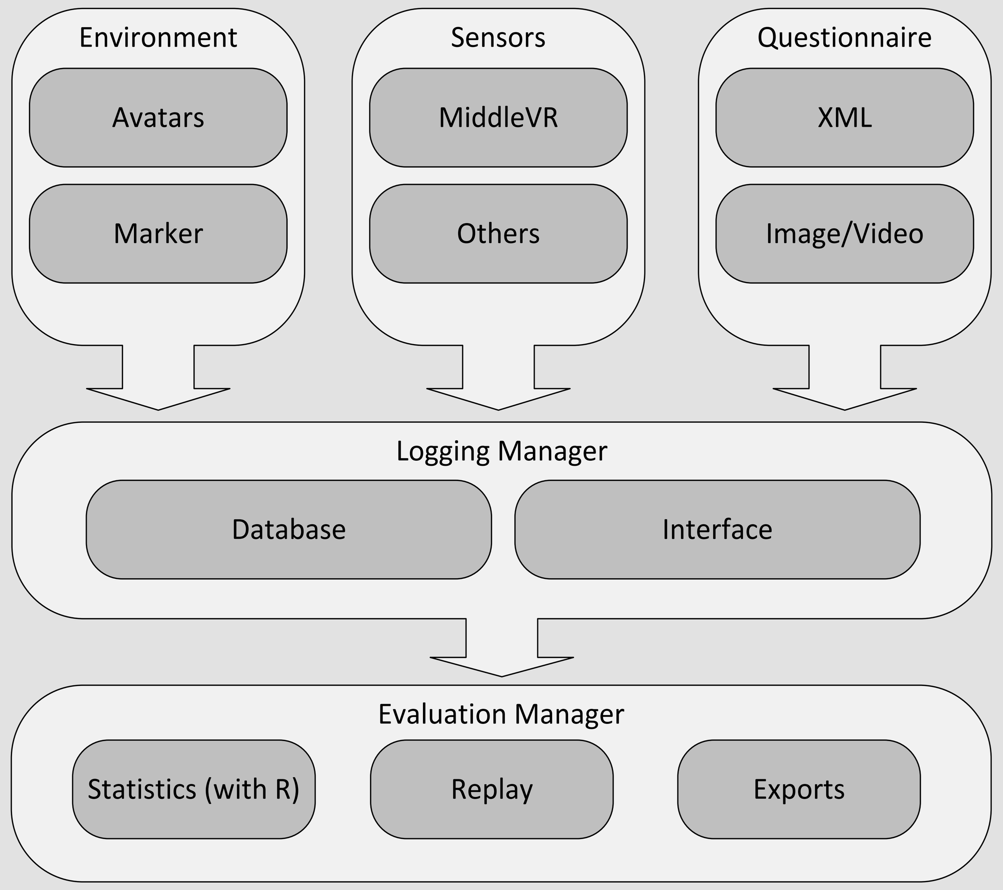

Fig. 2. Flow of data through the framework during and after an experiment

4. Example: Neighbourhood characteristics

In a collaboration between ETH Zürich and the University of Wisconsin-Madison, we are currently developing and validating an experimental variation of neighbourhood characteristics in a virtual reality environment.

Neighbourhood socioeconomic status is an important predictor of health, mental health, and cognitive performance, independently from an individual's socioeconomic status[6,7,8]. However, assessing causality in such investigations is challenging. As a complement to existing observational and experimental approaches, we seek to develop an experimental model of neighbourhood disadvantage in virtual environments that can be deployed to investigate the causal effects of acute exposure to advantage versus disadvantaged neighbourhoods on cognition, emotion, behaviour, and physiology.

The city is designed with two distinct neighbourhoods, which are differentiated by building types, layout, signals of social and physical disorder and other features (e.g., noise, pollution) that are routinely observed to differ between neighbourhoods[9,10].

Heart rate and skin conductance are measured throughout the experiment as indicators for stress in the respective neighbourhoods.

Fig. 3. EVE's training maze

Fig. 4. Disadvantaged route

Fig. 4. Affluent route

Fig. 5. Top-down view on the route

5. Example: Stress and Navigation

The aim of the present study is to investigate how experimentally induced stress affects navigation performance. The study overcomes some of the shortcomings of previous research[11,12,13] by using a large-scale virtual environment and by measuring multiple physiological stress parameters (EDA and ECG).

During the learning phase, participants are asked to navigate to 4 distinct locations in a city with help of a pop-up map. During the testing phase, participants are asked to retrieve these locations under time pressure and without the help of the map.

Fig. 6. Pop-up map with goal locations

Fig. 7. Visualisation of a goal location

6. Conclusion

We describe the basic features of a new framework to run experiments in virtual environments. The EVE framework allows researchers to setup, execute and evaluate experiments in virtual environments. The inclusion of sensors (virtual and physical) make it an option for a variety of experimental designs. By automating different steps, EVE greatly reduces the time and costs associated with the setup and evaluation of experiments in virtual environments.

The Unity platform allows for EVE to be custom expanded. Future developments of the framework will include a simulation package for AI agents (avatars). In addition, the evaluation manager will support data imports from real-world experiments allowing for systematic analysis within the virtual environment. This procedure will not only speed up the analysis of external data, but also provide for a more precise comparison between real-world and virtual data.

7. References

[1]Gaggioli, A.: Using Virtual Reality in Experimental Psychology. Towards cyberpsychology: Mind, cognition, and society in the Internet Age 2, 157{174 (2001)
[2]Kort, Y.A.W., Ijsselsteijn, W.A., Kooijman, J., Schuurmans, Y.: Virtual laboratories: Comparability of real and virtual environments for environmental psychology. Presence: Teleoperators & Virtual Environments 12(4), 360{373 (2003)
[3]Kuliga, S.F., Thrash, T., Dalton, R.C., Hölscher, C.: Virtual reality as an empirical research tool - Exploring user experience in a real building and a corresponding virtual model. Computers, Environment and Urban Systems 54, 363{375 (2015), http://dx.doi.org/10.1016/j.compenvurbsys.2015.09.006
[4]Taube, J.S., Valerio, S., Yoder, R.M.: Is Navigation in Virtual Reality with fMRI Really Navigation? Journal of Cognitive Neuroscience 25(7), 1008{1019 (2013)
[5]Hegarty, M., Richardson, A.E., Montello, D.R., Lovelace, K., Subbiah, I.: Development of a self-report measure of environmental spatial ability. Intelligence 30(5), 425{447 (2002)
[6]Diez-Roux, A. V., & Mair, C. (2010). Neighborhoods and health. *Annals of the New York Academy of Sciences, 1186*(1), 125-145.
[7]Kawachi, I., & Berkman, L. F., Eds. (2003). Neighborhoods and health. New York: Oxford University Press.
[8]Robert, S. A. (1999). Socioeconomic position and health: The independent contribution of community socioeconomic context. Annual Review of Sociology, 25:489–516.
[9]Odgers, C. L., Caspi, A., Bates, C. J., Sampson, R. J., & Moffitt, T. E. (2012). Systematic social observation of children's neighborhoods using Google Street View: a reliable and cost-effective method. *Journal of Child Psychology and Psychiatry 53*(10), 1009–1017.
[10]Sampson, R. J., & Raudenbush, S. (1999). Systematic social observation of public spaces: A new look at disorder in urban neighborhoods. *American Journal of Sociology, 105*(3), 603-651
[11]Richardson, A. E., & VanderKaay Tomasulo, M. M. (2011). Influence of acute stress on spatial tasks in humans. *Physiology & Behavior*, *103*(5), 459-466.
[12]Silverstein, N. J., Collaer, M. L., & Richardson, A. E. (2011, November). The effects of acute stress on human performance in a virtual reality navigation task. Poster presented at the Society for Neuroscience Meeting, Washington, DC.
[13]Thomas, K. G., Laurance, H. E., Nadel, L., & Jacobs, W. J. (2010). Stress-induced impairment of spatial navigation in females. *South African Journal of Psychology*, *40*(1), 32-43.