ExpTrialMng: A Universal Experiment Trial Manager for AR/VR/MR Experiments based on Unity

A Preprint

Jinwook Kim
Graduate School of Culture Technology
Korea Advanced Institute of Science and Technology
South Korea, Daejeon
jinwook.kim31@kaist.ac.kr

Yee Joon Kim
Institute for Basic Science
South Korea, Daejeon
joon@ibs.re.kr

Jeongmi Lee
Graduate School of Culture Technology
Korea Advanced Institute of Science and Technology
South Korea, Daejeon
jeongmi@kaist.ac.kr

September 8, 2022

ABSTRACT

Based on the improvement of recent virtual and augmented reality (VR and AR) Head Mounted Display (HMD), there have been attempts to adopt VR and AR in various fields. Since VR and AR could provide more immersive experimental environments and stimuli than 2D settings in a cost-efficient way, psychological and cognitive researchers are particularly interested in using these platforms. However, there is still an entry barrier for researchers who are not familiar with Unity programming, and current VR/AR HMDs could also cause unexpected errors during the experiment. Therefore, we developed a Unity library that can be adopted in various experiments universally and assist researchers in developing their own. Our library provides functions related to trial assignment and results saving. That way, researchers can easily implement the essential functions of their psychological experiments. We also made a function that enables proceeding with the experiment from a specific trial point to handle unexpected errors caused by HMD tracking loss issues during the experiment. We expect our library could invite researchers from various disciplines and help them acquire valuable insights in VR/AR environments.

Keywords cognitive psychology experiment · Trial Management · Unity · 3D Environment

1 Introduction

With the development of immersive devices such as virtual reality and augmented reality, research is being attempted from a psychological and design perspective rather than a technical point of view. Kim et al. [2022], Peng et al. [2020], Tregillus and Folmer [2016]. The virtual environment and interactions are mostly developed with 3D programming tools, such as Unity or Unreal. Compared to PsychoPy, which is a python library that provides GUI programming for developing psychological experiment Peirce et al. [2019], these tools require high proficiency in programming skills to develop the whole experiment structure. These features could act as an entry barrier for researchers who conduct user experience or experimental studies based on the design or cognitive science perspective, who are mostly not familiar with 3D programming tools.

In order to assist these researchers, various frameworks and tool-kits provide source codes on Github that could reduce the effort of implementing experiments or stimuli in Unity Brookes et al. [2020], Zenner et al. [2021]. However, those frameworks include heavy functions, such as server connection, which are unnecessary for some experimental
Figure 1: The operation flow of ExpTrialMng. Based on the pre-generated CSV file that includes all trial information, it delivers each trial setting to the experiment manager. After a trial is completed, it saves the data to an additional CSV file and loads the following trial information. In addition, it starts the trial from the point where the results are not filled.

circumstances. Sometimes this makes it harder to implement experiments from zero bases. Excluding unused functions could cost more time and effort and lead to serious compatibility issues later. In addition, those frameworks do not provide functions that resume the experiment from a specific point. For virtual reality (VR) experiments, various components could cause errors (i.e., tracking, power and connection issues, etc.) in the middle of the experiment, and in that case, it needs to be restarted at that specific point of error, instead of starting from the beginning again.

Therefore, we developed a Unity library\(^1\) that provides essential functions for most Human-Computer Interaction (HCI) studies. It could be adapted universally to VR/AR-based experiments easily. Our Library includes a restart function from a specific trial number where an error stopped an experiment, and the trial randomization process is separated by reading the pre-generated CSV file. Also, we implemented a function that saves results from each trial into a single CSV file. We expect that this library could help researchers focus on their experiment and stimuli design and ease the burden on those who are not familiar with Unity programming. Eventually, it could invite researchers from various disciplines into VR/AR and achieve a broader perspective. We propose that our library makes the following contributions:

- It lowers the barriers to conducting HCI experiments within VR/AR environments for researchers who are unfamiliar with Unity programming.
- It provides a general-purpose package that can be applied to diverse experiment settings with minimized lines of code.
- It minimizes data loss due to unexpected errors and allows easy resumption by modifying the pre-generated trial data file based on the point of interruption.

2 Stimuli Presentation Library

Most psychological and design user experiments commonly require functions that present stimuli in a randomized order and save the data into a specific format for analysis.\(^2\) Therefore, we focused on these functions and tried to make them universal in various experiment settings. Also, we minimized the effort of adapting it to user experiments. Our library's requirements and operation flow are as follows (see Figure 1).

2.1 Pre-generated Trial Data

Before starting the experiment, the researcher needs to generate a CSV file containing stimuli information for each trial and place it in the Asset folder (see Figure 2). We separated this part due to the various methods for randomization.

\(^1\)https://github.com/jinwook31/Unity-Experiment-Trial-Manager

\(^2\)Kim et al. [2022], Wang et al. [2022], Bae and Luck [2018], Gehrke et al. [2019].


2.2 Experiment Manager

As Figure 3, researchers need to import the Experiment Manager prefab to their Unity project and set the appropriate parameters in the TrialData tab. After setting the parameters, the researcher needs to link the code that activates and manages stimuli (e.g., visual, audio, haptic, etc.) with the trial information in the 'ExperimentManager.cs' script. We wrote an example code that could get the trial settings from a pre-generated CSV file and iterate the trials until it is ended. Researchers do not need to look into the code in detail and easily adapt these functions by using a few lines of code. When the experiment is done, they can find the results recorded in a CSV file format in the Asset folder.

3 Discussion & Conclusion

In ExpTrialMng, we implemented a Unity library that includes only the core functions for psychological and design user test experiments and enables researchers adopt it to their experiment easily and universally. The library delivers the trial information from a pre-generated CSV file and saves the experiment results into an additional file. Also, it includes a function that enables the experiment to restart from a specific trial in case of unexpected errors (i.e., HMD controller battery issue, tracking loss issue after a rest phase). However, several features need to be improved in the future. For instance, we could add functions that manage the trial process, such as inter-trial interval (ITI) and stimuli presentation time.

Our library could contribute to inviting researchers from various backgrounds to virtual and augmented reality domain research. By relieving their burden on programming in Unity and helping them focus on experiment design, we expect the research that utilizes VR/AR environments will be expanded and new perspectives and improvements in the academic field could be gained.
Figure 3: The connected scripts in ‘Experiment Manager’ Unity prefab. Users need to configure the appropriate pre-generated CSV file name, the number of input and output features in the CSV header, and startFrom index indicating the trial position where the experiment will start in TrialData tab.

References

Jinwook Kim, Seonghyeon Kim, and Jeongmi Lee. The effect of multisensory pseudo-haptic feedback on perception of virtual weight. *IEEE Access*, 10:5129–5140, 2022.

Yi-Hao Peng, Carolyn Yu, Shi-Hong Liu, Chung-Wei Wang, Paul Taele, Neng-Hao Yu, and Mike Y Chen. Walkingvibe: Reducing virtual reality sickness and improving realism while walking in vr using unobtrusive head-mounted vibrotactile feedback. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, pages 1–12, 2020.

Sam Tregillus and Eelke Folmer. Vr-step: Walking-in-place using inertial sensing for hands free navigation in mobile vr environments. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, pages 1250–1255, 2016.

Jonathan Peirce, Jeremy R Gray, Sol Simpson, Michael MacAskill, Richard Höchenberger, Hiroyuki Sogo, Erik Kastman, and Jonas Kristoffer Lindeløv. Psychopy2: Experiments in behavior made easy. *Behavior research methods*, 51(1):195–203, 2019.

Jack Brookes, Matthew Warburton, Mshari Alghadier, Mark Mon-Williams, and Faisal Mushtaq. Studying human behavior with virtual reality: The unity experiment framework. *Behavior research methods*, 52(2):455–463, 2020.

André Zenner, Hannah Maria Kriegler, and Antonio Krüger. Hart-the virtual reality hand redirection toolkit. In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems*, pages 1–7, 2021.

Liu Wang, Mengjie Huang, Chengxuan Qin, Yiqi Wang, and Rui Yang. Movement augmentation in virtual reality: Impact on sense of agency measured by subjective responses and electroencephalography. In *2022 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*, pages 832–833. IEEE, 2022.

Gi-Yeul Bae and Steven J Luck. Dissociable decoding of spatial attention and working memory from eeg oscillations and sustained potentials. *Journal of Neuroscience*, 38(2):409–422, 2018.
Lukas Gehrke, Sezen Akman, Pedro Lopes, Albert Chen, Avinash Kumar Singh, Hsiang-Ting Chen, Chin-Teng Lin, and Klaus Gramann. Detecting visuo-haptic mismatches in virtual reality using the prediction error negativity of event-related brain potentials. In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, pages 1–11, 2019.