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A Unity Framework for Conducting Virtual Reality Experiments

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Abstract

Research concerning Virtual Reality (VR) is notably broad, with a considerable volume of user-based studies in the literature. As VR research is often cross-disciplinary, it is not uncommon for non-technical researchers to struggle building a VR experiment from scratch. In this paper we propose a framework, currently in development, to aid in building and running VR experiments. Our proposed framework intends to aid researchers with limited technical expertise to design and conduct VR-based studies in the Unity engine.

CCS Concepts

• ***Applied computing*** → ***Computer games;*** • ***General and reference*** → ***Performance;*** • ***Computing methodologies*** → ***Real-time simulation;*** *Computer graphics;*

1. Introduction & Background

Virtual Reality (VR) research has grown to encompass a large volume of articles over the preceding years. With a considerably diverse number of works, a significant portion of these papers explore VR effects through user-based studies and experiments, across several subtopics. Many of these choose to utilise the *Unity*[†] games engine in their implementation of VR-based experiments, as virtual reality development is well-supported.

Many of these user-based studies are built from scratch, for the purposes of the experiment. However, most of work in developing VR experiments is not specific to a particular study, e.g. recording data from in-VR questionnaires, or the recording of head-mounted display (HMD) telemetry data. Furthermore, VR research finds applicability in a diverse range of fields: its application is inherently cross-disciplinary [AGMG*24]. However, building VR-based studies remains a challenge for researchers with limited prior experience. A framework which simplifies the process could provide a valuable resource in this case.

Therefore, the motivation for such a framework which facilitates VR study creation is evident, especially targetting non-expert users. Despite the need for such a toolset in the literature, only a handful of relevant frameworks exist. Ugwitz et al. [UŠŠ*21] review a broad range of previous frameworks built in Unity for facilitating experiments. They additionally propose a simplistic framework for running experiments, but fundamentally, do not consider VR projects. Other frameworks exist in the literature adjacent to VR studies, e.g. in developing digital twins [YVA*24], but do not cater specifically to VR experiments. Some frameworks exist which consider virtual reality experiments [AQPTPO22], but are not considered in the context of the Unity engine. Other frameworks exist for Unity, but largely consider contexts outside of VR, e.g. Augmented Reality (AR) [NSW*20] or Mixed Reality (MR) [SIB*22]. To date, one of the only purpose-built VR experimental frameworks for the Unity engine is in the work of Brookes et al. [BWA*20]. The authors propose the *Unity Experiment Toolkit (UXF)*, an experimental framework offering several boilerplate assets which have utility in running VR studies. However, the framework is largely a starter project and still requires significant expertise with the Unity engine.

We propose a work-in-progress Unity framework to address this gap in the literature, especially catering to non-expert users. Our proposed toolkit will aid in the management and undertaking of VR-based studies. We intend to develop and publish our framework as an open-source toolkit to facilitate a collaborative development effort.

2. Proposed Framework

With these objectives in mind, the following goals will inspire the design of the proposed framework:

1. To aid in the administrative tasks associated with running VR studies, e.g. management of participants, assignment of groups/conditions, etc.
2. To assist in the collection of user-based data, e.g. recording Presence and Sickness metrics via questionnaire, or recording telemetry data.

[†] https://unity.com/

3. To offer a low-code approach to developing experimental procedures, offering an accessible tool to researchers with limited programming experience.

The framework will be developed as an in-engine package for the Unity games engine, which can be installed directly within the engine. It will primarily be developed as an importable set of tools, in which researchers can manage participants, virtual scenes, data collection methods and experimental procedures. In its current form, the framework has the ability to create, assign and manage participants for a study. Development is still in its incipient stages and the design of the framework has yet to be finalised. As such, it remains a work-in-progress which we intend to expand on in future work.

2.1. Participant Management

A key drawback of existing frameworks is the lack of support for participant management in studies. Instead, similar frameworks primarily focus on providing a starter project from which experiments can be developed, e.g. [BWA*20, YVA*24, AQPTPO22]. There are no in-built tools, for example, to track a participant's progress through multiple exposures, or assign them to experimental groups. Instead, only boilerplate and reusable assets are typically supplied in which the developer can use for a variety of purposes; e.g. in recording presence and sickness scores. In our proposed framework, participant management will be possible throughout the lifetime of the study. This includes tracking the progress of a participant across several sessions or conditions, and managing experimental groups.

2.2. Utilities & Boilerplate VR Assets

Our framework intends to build atop of functionalities offered by previous frameworks, especially concerning the range of utilities and boilerplate assets. There are several features we intend to supply to fit a wide range of VR-based studies. For example:

- A plethora of common questionnaires found in VR studies, e.g. Presence (PQ), Simulator Sickness (SSQ) and Fast Motion Sickness (FMS), as some examples. These will have the ability to be completed immersively in VR.
- A range of tools for recording time series telemetry data, such as headset or controller movement.
- An extensible set of utilities for custom tooling, such that the framework can be extended easily by researchers for a variety of purposes.

By providing common utilities which can be used across a wide range of studies, we intend to aid in the rapid development of VR experiments. In addition, the framework will leverage the Unity engine to provide support for a variety of VR platforms. This will be primarily achieved through Unity's *XR Interaction Toolkit*, a platform-agnostic package for building cross-platform VR projects.

2.3. Non-Expert Support

At its core, we plan to develop a low-code solution which leverages Unity's visual scripting system [Uni25] for developing custom studies. Researchers will be able to build node-based graphs which represent the experimental procedure of the study. An illustrative mock-up of such an interface can be found in Figure 1. This procedure can then be run with a sample of participants and the stages of the study can be edited with relative ease.

This enables a rich feature-set for creating a wide array of different experiments, whilst simultaneously making the authoring process code-free. This enables non-expert researchers unfamiliar with the C# scripting language to build custom functionality into their studies with little difficulty.

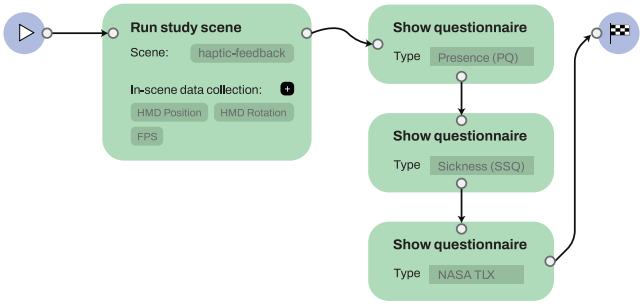

Figure 1: *A mock example of the planned node-based interface, for developing experimental procedures. An example study procedure is shown here, in which a study scene is shown to the user followed by three questionnaires. We specifically plan to utilise Unity's visual scripting functionality to achieve this.*

3. Validation

To validate the proposed framework's efficacy, we intend to run a small focused study with non-expert audiences. Participants will be tasked to develop an experimental procedure using the framework, with limited guidance. Following this, participants will be interviewed about the experience, and will fill out questionnaires to provide valuable data. In particular, we intend to assess the framework's usability via the System Usability Scale (SUS) and mental workload of participants with the NASA Task-Load Index (TLX). Semi-structured interviews will additionally provide valuable qualitative data.

We plan to analyse the results and infer its utility in aiding the development of VR studies. Furthermore, we intend to examine qualitative feedback to further strengthen the toolset and its utility.

4. Conclusion

In this paper we have discussed our proposed framework for facilitating the undertaking of virtual reality studies. The framework primarily intends to cater to non-expert users who wish to develop VR experiments utilising the Unity games engine. It is our intention to significantly reduce the difficulty of developing VR studies, and make the task of development more accessible to fields with a limited technical background. Furthermore, this paper intends to spur further interest and attention to this underexplored area. We welcome collaborative interest in developing a experimental framework suitable for the wide cross-section of VR research.

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