ReRun: Enabling Multi-Perspective Analysis of Driving Interaction in VR

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ABSTRACT

Rerun is a software system to support post-facto analysis in simulation research. In this submission, we show it working inside a multiplayer driving simulator. Rerun is built in Unity 3D and captures the virtual behavior of participants and their interactions with virtual objects. These recorded behaviors can then be played back from any perspective in the virtual space. This is useful in multi-agent interaction studies because researchers can sift through scenarios carefully from each participant's perspective or even from an outside observer's perspective. This enables a fine-grained understanding of implicit and explicit signaling between participants and other human or AI-controlled agents.

CCS CONCEPTS

• **Human-centered computing** → **User studies**; **Mixed / augmented reality**;

KEYWORDS

driving simulation, HRI, virtual reality, automotive, user studies, interaction studies, multi-perspective, post-analysis

1 INTRODUCTION

Virtual reality simulation studies are increasingly used by HRI researchers to conduct studies about how people will perform in a variety of interaction scenarios with robots and machines, so that
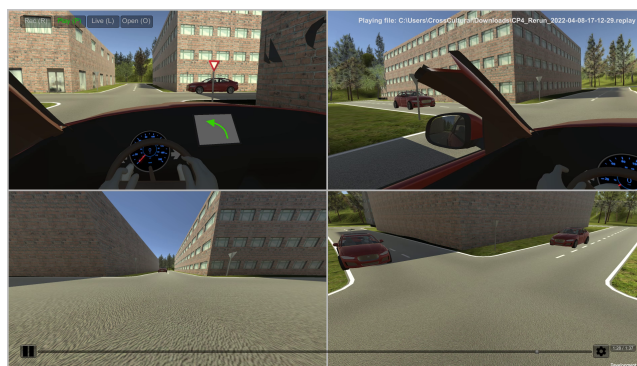
Figure 1: Screenshot of the Rerun system.

we might anticipate user behaviors in a variety of contexts. [2, 5, 8, 9] VR driving simulation studies, for example, allow researchers to study how drivers will respond to dangerous scenarios, novel technologies such as autonomous vehicles, or chance situations (like cars being broken down on the road) without the risk or trouble of staging these situations in the real world. [7] One of the additional benefits of virtual reality simulation is that it can enable lightweight simulation of multi-person scenarios. [3] The advent of multi-person simulation, however, raises the question of what viewpoint studies should be analyzed from post-facto.

We have developed a system, Rerun, which supports post-facto analysis of simulated driving. It is built in Unity 3D, and captures virtual driving behavior so that it can be played back. A unique feature of Rerun is that the playback can be rendered from any perspective in the virtual space. This enables fine-grained understanding of implicit and explicit signalling between participants, enabling research to reconstruct what factors are pertinent to driving communication.

2 SYSTEM

For this project, we added the functionality of being able to replay simulation runs to the StrangeLand simulator[3]. Because the Strangeland simulator enables multi-person interaction, the ability to replay driving interactions from different perspectives gives us

greater ability to perform qualitative analysis of driving interaction, and to explore the role that viewpoint plays on perceptions of traffic interaction.

Rerun extends the Ultimate Replay 2.0 asset, which is publicly available on the Unity Asset Store[1]. This asset is primarily used by game developers for in-game event replays, and offers efficient storage and playback of state-based event data. Rerun is built on top of this asset, without modifying its existing code base. This allows for sharing of Rerun code with the research community, which can then be run within projects containing the purchased asset. Rerun implements custom-made features for conveniently recording and playing back VR interactions. The key features from this abstraction layer are ready-to-use prefabs enabling recording of head pose and hand tracking data, a virtual camera rig for flexible multi-view playbacks, handling of session metadata, and a decoupled desktop UI not visible to the VR participant. The updated version of the StrangeLand [3] simulator that integrates tightly with Rerun can be found on GitHub[2]. Rerun is published on GitHub under the MIT license[3].

3 RELATED WORK

Replaying actions and motions from a virtual environment are a common feature found in many video games such as Activition's Call of Duty, and Codemasters' Grid2. Often, game replays are used to recap important events or even offer players an opportunity to review gameplay from different perspectives.

Recording the entire game state, then, is feature common to many commercial game engines. Outside of gaming, virtual reality playback has been used to help athletes review their sports performance [1], dentists to gain sensimotory skill [4], public speakers to understand how their speaking performance might be perceived [10], and VR experience designers to understand the first-person experience that viewers may have of their systems [6].

However, the ability to playback driving simulation experiences is novel. For the most part, driving researchers use event data and virtual telematics data from the simulation environment to determine driving activities and performance. To our knowledge, no previous work has been published demonstrating the ability to playback driving simulation runs for post-facto analysis; this work demonstrates how it enables researchers to revisit interactions from different perspectives, so that the effect of say, distracting events or field of view might have influenced driving interaction outcomes.

4 DESCRIPTION

To experiment and develop the features, we extend the StrangeLand simulator[3] to allow for recording and playback of the vehicle behaviors (car motion, wheel and steering wheel motion, on-screen driving instructions, indicator lights) as well as the driver's position and hand gestures.

In the video, we demonstrate how we are able to record and play back these scenarios with different perspectives to form a

Figure 2: Participants using the StrangeLand simulator.

more complete picture about how interactions take place in this simulator.

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[2]**Updated StrangeLand simulator:** https://github.com/FAR-Lab/CrossCulturalDriving2021
[3]**Rerun:** https://github.com/FAR-Lab/Rerun