

A Science-Enabled Virtual Reality Demonstration to Increase Social Acceptance of Prescribed Burns

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Abstract—Increasing social acceptance of prescribed burns is an important element of ramping up these controlled burns to the scale required to effectively mitigate destructive wildfires through reduction of excessive fire fuel loads. As part of a Design Challenge, students created concept designs for physical or virtual installations that would increase public understanding and acceptance of prescribed burns as an important tool for ending devastating megafires. The proposals defined how the public would interact with the installation and the learning goals for participants. This poster provides an overview of the virtual reality (VR) pipeline created to develop working prototypes of the immersive experiences and VR games that were proposed by the finalists in the design challenge.

1. Objectives

In a wildfire, it is the vegetation that burns. It is a bit counter intuitive, but a decades-long policy of wildfire suppression has created a wildland fire deficit that contributed to the increased risk of severe wildfires during fire season because of an accumulation of fuels. Putting these ecosystems back into balance requires important shifts in policies and public understanding of the role of wildfires.

Nature needs fire in fire-adapted ecosystems to thrive. Prescribed burns - the controlled use of fire under appropriate weather conditions to benefit ecosystems - are an important tool for wildfire mitigation because they reduce the future risk of uncontrollable and highly destructive wildfires by reducing dangerous fuel loads. Increasing social acceptance of prescribed burns is an important element of ramping up these controlled burns to the scale required to effectively mitigate destructive wildfires.

As part of a Design Challenge hosted by the WIFIRE Lab (wifire.ucsd.edu) at the San Diego Supercomputer Center and the Design Lab at UC San Diego, students cre-

ated concept designs for physical or virtual installations that would increase public understanding and acceptance of prescribed burns as an important tool for ending devastating megafires. The proposals defined how the public would interact with the installation and the learning goals for participants. This poster provides an overview of the virtual reality (VR) pipeline created to develop working prototypes of the immersive experiences and VR games that were proposed by the finalists in the design challenge.

2. Setting up a VR Pipeline for Wildland Fire

The design challenge lead to five projects with requirements to integrate observational and simulation data with immersive and gaming experiences. For standardization between these projects, a generalizable data pipeline involving data ingestion, simulation and visualisation was developed.

2.1. VR Scenarios for Increasing Social Acceptance

Three design challenge finalists envisioned immersive experiences where participants would plan and carry out a prescribed burn with a qualified burn boss to understand the steps taken to achieve ecosystem goals in a safe and effective manner. They further imagined that participants would be able to see the healthy regrowth of the forest after the prescribed burn. Two design challenge finalists envisioned immersive games that would give youth an understanding of the relationship between forest health, weather conditions and wildfire risk by letting participants build homes in the game and experience how their neighborhood is impacted by different wildfire scenarios under varying combinations of weather conditions and forest health.

2.2. Science to Virtual Reality Pipeline

Figure 1 illustrates the data pipeline supporting the VR demonstration from data generation to multimodal end user

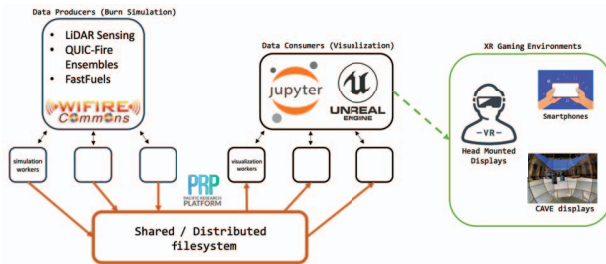


Figure 1. The architecture supporting the science to VR pipeline.

experiences. For this demonstration, the data was generated using Terrestrial LiDAR Scans (TLS) scans, Aerial LiDAR Scans (ALS), FastFuels [2] and outputs from QUIC-Fire [1] ensembles. This data is made available to clients through the WIFIRE Commons [3].

The data is moved to a distributed, shared file system managed by the NSF-funded Nautilus cluster (portal.nrp-nautilus.io), which uses Kubernetes to orchestrate containerized applications, leveraging state-of-the-art high speed science networks to link hundreds of Graphics Processing Units (GPUs). Nautilus provides several possible ways to store and move data. We will explore TMPFS, CephFS, and SeaweedFS (S3) solutions for best performance. Fast access to the distributed data is an essential aspect of this pipeline, as it allows us to visualize large quantities of data at interactive frame rates.

The Unreal Engine (unrealengine.com) by Epic Games and the data mentioned previously made it possible to create the kinds of VR experiences that the students from the design challenge imagined for their installation prototypes. An experience included imports of the point cloud object of the TLS scans from before and after a prescribed burn in the New Jersey Pine Barrens to Unreal Engine with the aid of the LiDAR Point Cloud Plugin from the same program as a .laz file. Another experience was realized by making use of the ALS and TLS data from the Studhorse 5 burn unit in Yosemite. Employing the ALS scans, the user moves over the burn unit to see vegetation and topography from a birds eye view and use the TLS scans when it jumps down into the forest at specific locations to see the forest from a human perspective.

A separate experience was created using QUIC-Fire prescribed burn simulations and FastFuels 3D vegetation data from WIFIRE. To generate fire simulations, QUIC-Fire ingests the FastFuels vegetation model and sets environmental conditions for each burn, including fuel moisture, wind speed, wind direction and time of day. A point cloud was generated from the QUIC-Fire outputs for each one minute timestep in the model so that the player can visualize the development of the prescribed burn both from the birds-eye view and from the human perspective at specific locations.

The same machines used to compute the fire simulation time steps are used for visualization leveraging their GPUs to generate VR experiences using the Unreal Engine. The various types of data and metadata generated at each time step can be loaded and visualized in an environment where a

user, or set of users, can explore the scene at various scales and levels of detail. Asset loading and management is done with the native plugins available in Unreal, in addition to our application logic wherever necessary.

The use of a computing environment like Nautilus allows for the scaling of our visualization jobs to multiple GPUs, and provides the opportunity for the integration with AI-driven analysis tools, Jupyter-based programming and visualization environments, and cross-platform compatibility. The pipeline takes advantage of Unreal's open-source code base and cross-compilation toolchain and use the same source code to produce games for a multitude of platforms. We focus on experiences developed for the desktop computer and mobile phone, plus VR-specific builds for head-mounted displays (HMDs) and CAVE environments.

3. Conclusion

We summarized a demonstration effort for using a VR environment to translate scientific models into experiences by non-expert audiences. The novelty of the presented approach lies in its unique integration of data from observations and scientific simulations with a scalable computing environment that couples AI libraries, Jupyter notebooks and the Unreal Engine to multimodal VR and gaming platforms.

This approach is scalable to many simulations in a repeatable fashion and integrates parameters from science simulations to control the VR experiences. It also can enable both VR and mobile gaming through Unreal and can be replicated to other types of simulations and science to VR projects. The use of PRP allows for integration of AI-based microservices into the VR experience through Kubernetes. Future work includes extending the simulations with many locales and scenarios with an ability to automatically ingest and create a VR scene for any new QUIC-Fire simulation ensemble as well as automatic updates to ingest the latest fuel data and LiDAR scans.

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