A Virtual Reality Experience of the California Faults

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Abstract

In recent years, the use of Virtual Reality (VR) has opened new possibilities for the visualization and analysis of scientific data. Earth sciences and specifically the field of Earthquake Science would greatly benefit from the use of VR. More specifically, the physical mechanisms and tectonic structures behind the generation of earthquakes are among the most difficult to represent and communicate to the general public. Here we present a virtual reality experience based on the geometry of faults represented in the Uniform California Earthquake Rupture Forecast (UCERF3). With a foundation from a previous representation in Paraview (.org) visualized in the HTC Vive Pro system, a process was initiated to improve the VR experience with new layers of information. This new information includes the California counties’ administrative limits, major city centers, the California system of highways, hydrologic information, quaternary fault lines, seismicity, and a digital elevation model of the state of California. In the last phase of our work, we used both the HTC Vive Pro system and Oculus Rift S to test the resulting VR experience. Both VR systems use the software SteamVR to communicate through Paraview.

Based on our preliminary experience with the Oculus Rift S, we see that the three-dimensional renderings of the material are displayed smoothly and are comparable to the previous version implemented with the HTC Vive Pro. To make the project more accessible to the general public we are writing a manual composed of step-by-step procedures on how to operate the files on personal systems. Moving forward with the project, we aim to utilize a multiplayer mode for the VR experience which allows users to explore through the map in remote locations alongside a trained guide. In the specific case of the California faults, we envision a joint exploration between students and professors and the possibility to explore dynamic ruptures models together. The above work was supported by SCEE through the SURE internship program. The project is based out of the Center for Earthquake Research and Information (CERI) Visualization Lab at the University of Memphis.

The COVID-19 pandemic created significant disruption to our activities. Consequently, we reorganized our lab work to be online and adapted accordingly to our remote working conditions. In the coming months we are planning to proceed with the same work arrangements and use a “mobile” VR setup (laptop + goggles) that will allow the students to work safely from home. In case access to the lab is required we will follow University policies.

Virtual Reality

Our virtual reality (VR) experience works with different VR systems that interface with SteamVR (.com). For the VR goggles to connect with Paraview they first must interact with SteamVR (.com). The Oculus Rift S (pictured right) as well as the HTC Vive Pro (pictured left) were both supported and connecting with Paraview. Using Paraview we were able to explore our datasets using both systems interchangeably. The two sets of goggles offer a similar experience however they have a different setup. More specifically, the HTC Vive Pro requires a set of sensors that can be installed on tripods or the wall, while in the Oculus Rift S the sensors are installed directly on the goggles.

HTC Vive Pro

OCCULUS RIIT S

Images modified from the HTC Vive user guide

As our work was disrupted by the COVID-19 pandemic, we primarily relied on the Oculus Rift S to do most of our testing in VR. We hope to be able to continue our work with both systems and to expand the experience to allow for “multiplayer” capabilities in the future.

Preparation of information layers

Using a series of scripts developed in MATLAB (.com) we were able to interpret open-source shapefiles found online (mostly from https://gis.data.ca.gov/). We collected different types of geographic information such as state lines, rivers, roads, etc. After processing the data we created Paraview compatible file formats. The Paraview visualization software gave us the capability to create some of the images shown below which can also be accessed in virtual reality.

- Figures made using ParaView
- Using Paraview, we overlaid the California county lines on top of the fault network.
- After visualizing the collected geographic data we overlaid them on top of the UCERF3 based network of California faults.
- Another important set of coordinate data we included in our VR experience is California's road system (pictured right in neon yellow).
- The roads system includes California's highways which are important to travel throughout the state. Compared with the faults this gives us the ability to see which roads run alongside faults.
- Visualizing topographic data give us the possibility to observe changes in elevation and how these changes could be related to the faults.

Widgets & Tools

The widget Paraview integrated into the VR experience (pictured right) gives the option to turn OFF or ON a layer, change the opacity of a layer, measure the distance between faults, and many other features.

Displayed to the left is the “distance” option within Paraview’s widget for the VR. The distance option measures the length from one point to another—this is most useful for measuring faults.

Virtual Reality Testing

Due to the COVID-19 pandemic, our work had to be altered. Continuing the work at home, we began using a new virtual reality headset system to test the experience. This gave us the ability to go into virtual reality and see how new data looked when using the Oculus Rift S.

Photo: Intern Dianne Pham combining Paraview (right screen) and SteamVR (left screen) to test the VR experience at home. Remote work has become necessary because of the COVID pandemic. The students developed their projects from home. In this photo Dianne uses the Oculus Rift S.

The fault geometry is based on UCERF3 (Field et al., 2013)

The topographic layer is extracted using GeoKapapp.org

When we overlay the topographic layer above the faults, Paraview allows for changing opacity which helps the user easily view the faults underneath the topography.

References


Citation:

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