Designing a mixed-initiative multi-user VR interface for wildfire mitigation

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Abstract

Climate change has led to increased occurrence of wildfires, calamitous natural disasters that pose threats to personal property, civil infrastructure, and human lives. Mitigation of these threats involves the use of predictive modeling for risk assessment to allocate firefighting resources and to direct evacuation. Recent research in Social VR environments shows promising results towards technical collaboration, but there are still existing limitations in navigating simulations. To address these limitations, we are engaging in participatory design in collaboration with civil engineering researchers to leverage HCI research towards needs in wildfire resilience. We discuss ongoing work on a prototype of a mixed-initiative interface for wildfire risk assessment that uses object detection algorithms to identify flammable material in immersive social VR environments generated from geolocated Google Street View images.

1 Wildfire Impact and Mitigation

Due to climate change, North America is predicted to incur wildfires at greater frequency and acreage. These calamitous events are devastating and pose a danger to personal property, civil infrastructure, and lives.[6]

One part of risk mitigation strategy involves predictive modeling of the spread of wildfires surrounding critical areas. According to a report [3] for California's Fourth Climate Change Assessment, these efforts have benefited by

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methods that provide increased ability to identify, represent and inventory elements such as vegetation, roads, and buildings to support data-driven strategies for stakeholders involved in risk mitigation.

We are a cross-disciplinary team of civil engineering and interface researchers embarking on a participatory design approach to leverage HCI research to build novel tools to address this need. In this workshop paper, we show preliminary work on an immersive, multi-user application that leverages an object detection system to identify elements for fire modeling, aimed at users who are involved with wildfire resilience. While explaining aspects of this work, we discuss how research into social VR, multi-user interfaces, and mixed initiative models are used to inform this ongoing process.

2 Prototype Design and Considerations

Social VR applications permit multiple concurrent users to join a Virtual Environment (VE) that contains a 3D scene and shared networked graphical user interfaces. These applications commonly feature avatar embodiment, transversal using locomotion systems, and interactivity with shared virtual objects and interfaces. In addition to these methods of engagement with a VE, social VR environments such as Mozilla Hubs, VRChat, and Horizon Worlds contain communication affordances such as voice and text chat, screen sharing, and affect signaling. While Social VR is promising for scientific collaboration, Olaosebikan et al. point out limitations in existing applications that necessitate novel approaches.[2]

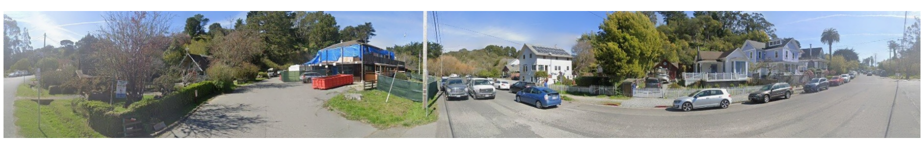

Figure 1: Equirectangular image of Bolinas, CA, USA an area with wildfire risk, for use for an immersive, 360 image in VR stitched using OpenCV (`https://github.com/aneangel/scrying`).

Using the Google Maps Street View API and OpenCV we have created a process to create geo-located 360 degree equirectangular projections for use as part of the VE of a social VR application, permitting users to remotely examine and discuss objects of a real-world location.

VR Researchers have already established through the analysis of concurrent body positions and orientations that proxemics (the tendency for people to arrange themselves in group formations during conversations) also seem to be a factor in VR [7]. We intend to examine how proxemics in VR among scientists unfold as they make use of the spatialized visualizations we have created. We can use this in combination with other metrics to better understand where and how these tools offer value.

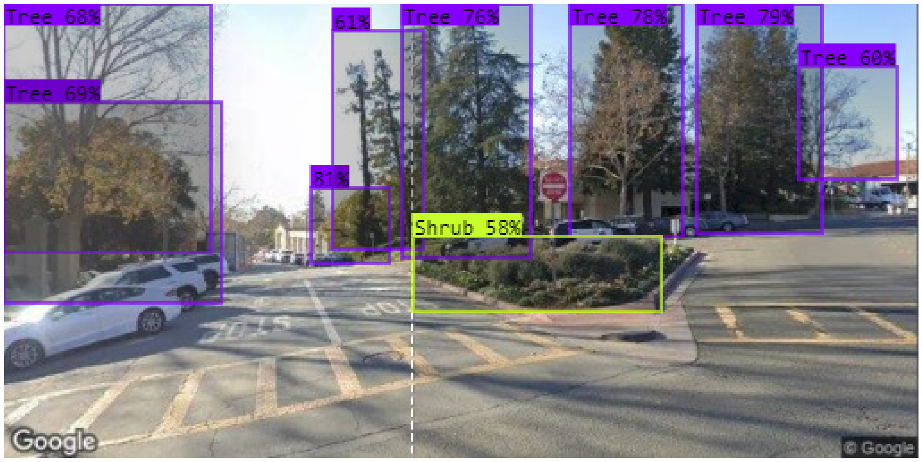

Figure 2: Testing a computer vision model on identification and classification of vegetation on a source image from Google Maps

In order to aid with the classification of objects, we are testing computer vision models, such as YOLOv8, trained on a small dataset of images annotated with vegetation and evaluated on equirectangular projections. Although we are testing this model with basic categories such as ”tree” and ”shrub” as seen in Figure 2, we hope to achieve types of identification related to surface fire spread models [5]. Further work must be done to verify accuracy, and to optimize an evaluation and overlay time for use in a VR interface.

Integrating an object recognition model into an interface is a mixed-initiative problem, where both human actors and AI processes have the prerogative to modify the state of a graphical user interface. [1] Due to these AI-based computer vision models having execution time on the order of seconds, there is a pressing need to validate interface design surrounding group object selection in a timely manner for relevance to a verbal conversation. Rahman et al. have demonstrated a novel method for indicating co-located gaze in the context of pedagogical instruction[4]; this interface option may be viable for civil engineering discussion in service of collaborative sensemaking.

3 Conclusion

As we are in the early stages of creating a novel tool that leverages HCI research to mitigate threats due to climate change, this workshop would provide an invaluable opportunity to solicit advice from the SIGCHI community. Using object detection models on immersive environments is only one application of multi-user virtual reality; creative speculation and critical discussion may lead to applications of these processes for other issues related to climate change in our global community. As a cross-disciplinary team trying to work across disciplines to advance HCI research, our perspective represents researchers who are pragmatically applying research in service of communities that are presently withstanding damage from climate change.

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