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OnSight: Multi-platform Visualization of the Surface of Mars

Stewart P. Abercrombie[1*], Alexander Menzies[1], Victor Luo[1], Alice Winter[1], Matthew Clausen[1], Benjamin Duran[1], Marijke Jorritsma[1], Charles Goddard[1] and Alana Lidawer[2]

(1) Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, United States
(2) Massachusetts Institute of Technology, Cambridge, MA, United States

* Corresponding author: parker.abercrombie@jpl.nasa.gov

National Aeronautics and Space Administration
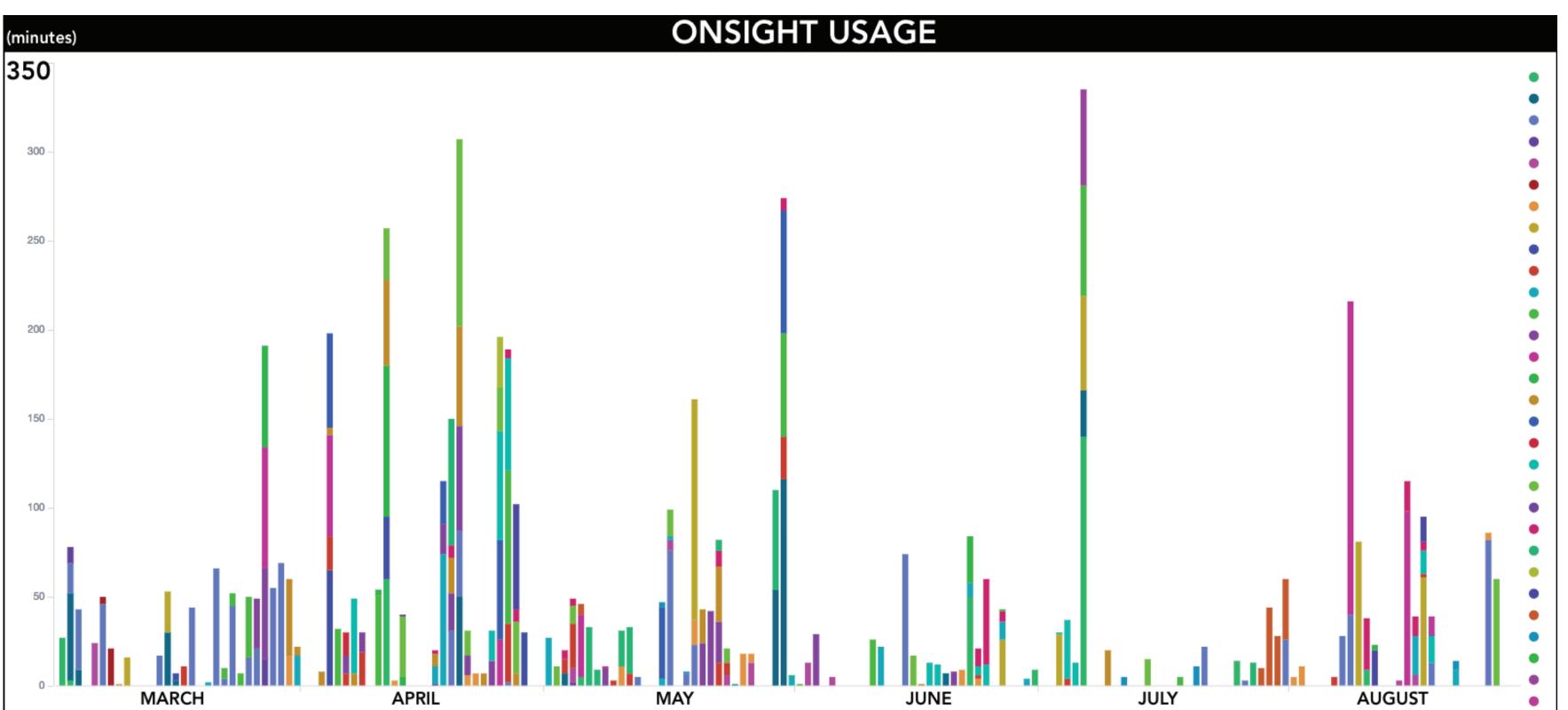
Introduction

A key challenge of planetary geology is to develop an understanding of an environment that humans cannot (yet) visit. Instead, scientists rely on visualizations created from images sent back by robotic explorers, such as the Curiosity Mars rover. OnSight is a multi-platform visualization tool that helps scientists and engineers to visualize the surface of Mars. Terrain visualization allows scientists to understand the scale and geometric relationships of the environment around the Curiosity rover, both for scientific understanding and for tactical consideration in safely operating the rover.

OnSight includes a web-based 2D/3D visualization tool, as well as an immersive mixed reality visualization. In addition, OnSight offers a novel feature for communication among the science team. Using the multiuser feature of OnSight, scientists can meet virtually on Mars, to discuss geology in a shared spatial context. Combining web-based visualization with immersive visualization allows OnSight to leverage strengths of both platforms.

Conclusions

OnSight (immersive version) was released in August 2016, and the web version followed in October 2017. Forty-six HoloLens units have been distributed to scientists (geologists) on the mission team. The team analyzes usage patterns using telemetry and user interviews.

- OnSight has received consistent use, and become a widely accepted part of the Curiosity mission.
- Used both for scientific understanding (e.g. how is this feature spatially distributed?) and to inform vehicle operation (e.g. is this a safe drive path?).
- Most usage is single-user, short duration (< 20 min).
- Scheduled "Meet on Mars" sessions are popular, and longest periods of use (~1 hr).

OnSight immersive usage from 3/2017 to 8/2017. Colors indicate individual users. Tall stacked bars indicate "Meet on Mars" multi-user sessions.

Immersive Visualization

Using an immersive display (the Microsoft HoloLens), OnSight renders a reconstruction of Mars at full scale, and allows users to navigate the model by simply walking and looking around. Users can interact and annotate the terrain using gestures.

The immersive display enables field scientists to access the skills and intuition that they have developed while exploring environments on Earth[1]. OnSight provides the closest experience to working on Mars without physically being there. By enabling users to utilize all of their spatial reasoning ability, users gain improved spatial comprehension of the environment, which enables them to efficiently plan safe rover operations and make new scientific discoveries.
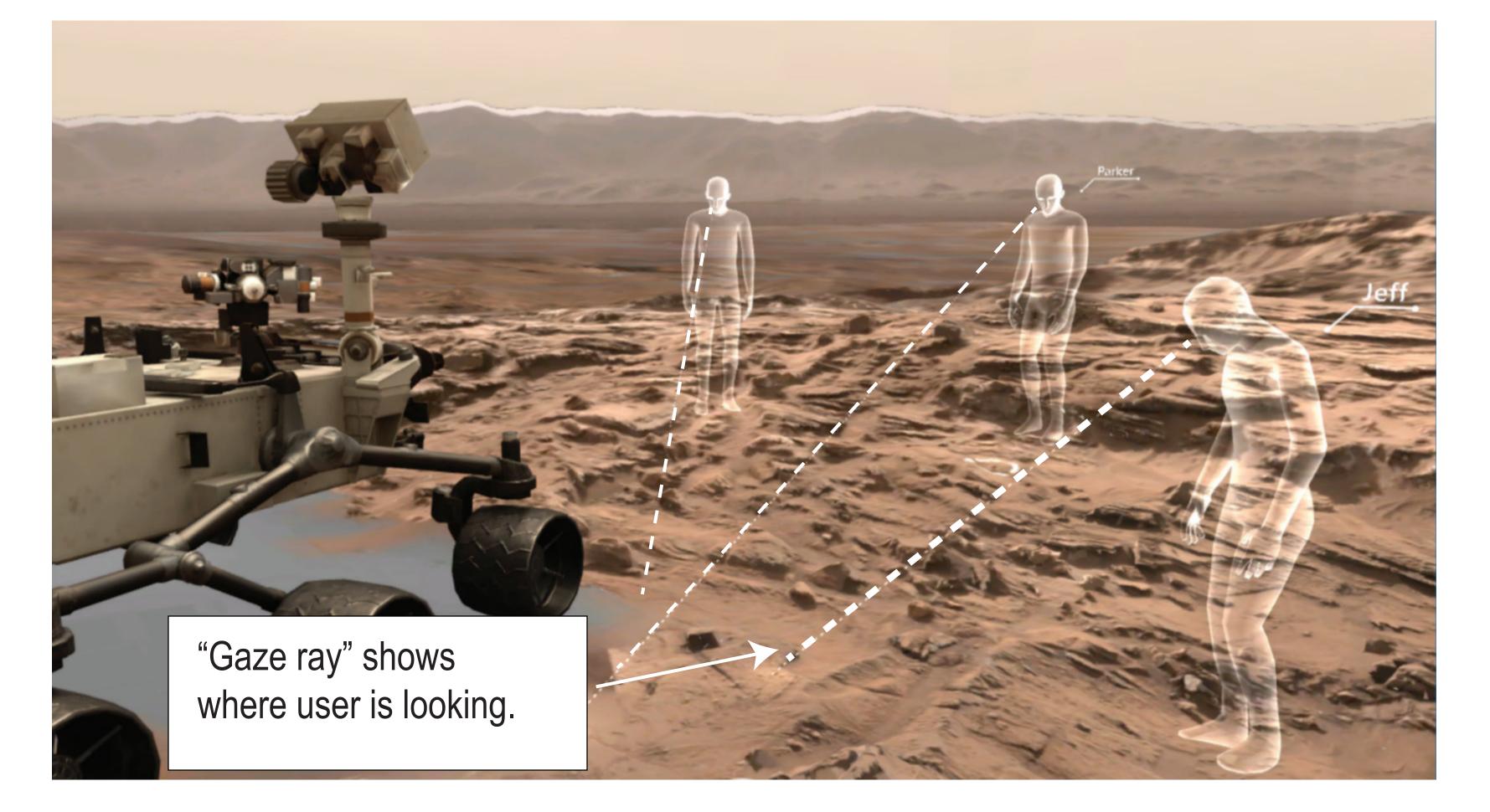
Advantages
- Little to no training – navigate by simply looking around and walking.
- Engage spatial reasoning abilities that humans develop instinctively.
- Display the environment at full scale.
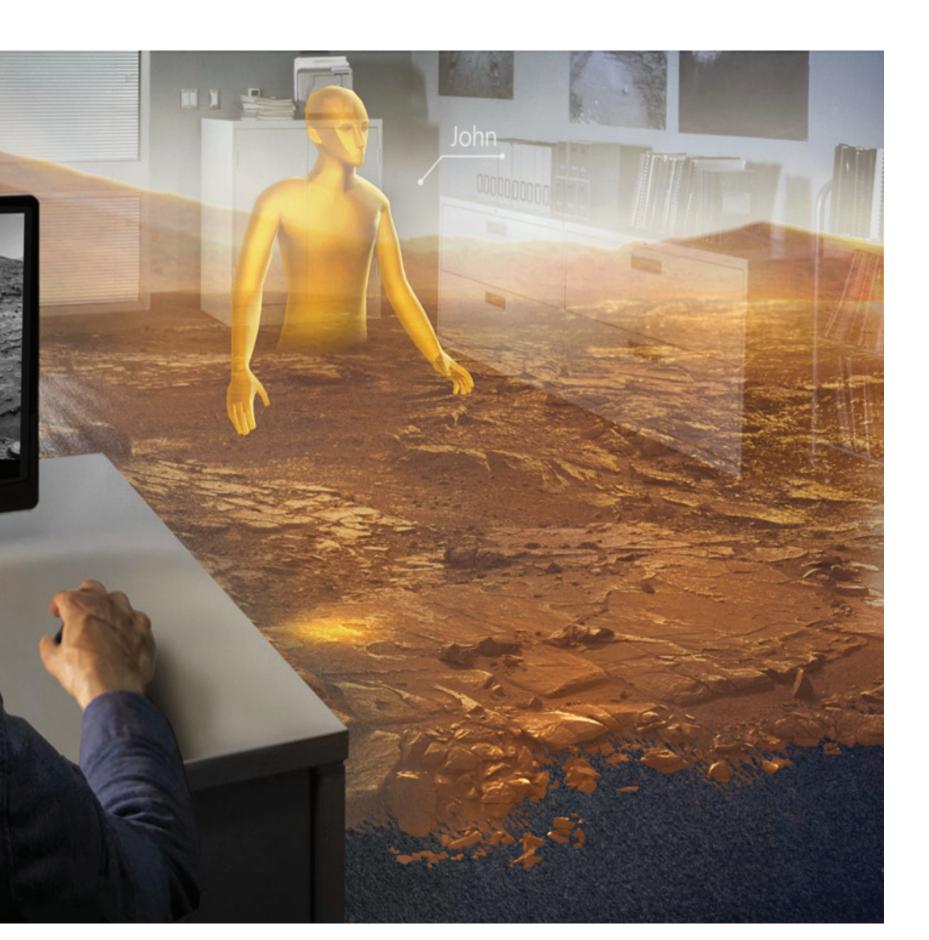
Disadvantages
- Text input is difficult.
- Immersive display is lower resolution than computer monitor.

Multi-user Collaboration

OnSight includes a collaboration feature which allows users to meet together on Mars. Users in different parts of the world can join a multi-user discussion, in which users see each other as avatars. OnSight tracks where each user is looking, and renders this information as a "gaze ray" projecting out from the avatar's head. This allows users to see where their colleagues are looking. Users can also annotate the terrain with point-of-interest flags or quick line sketches to communicate their thoughts.

"Gaze ray" shows where user is looking.

Human size avatars shows where users are standing, and give scale clues.

The OnSight team coordinates regular "Meet on Mars" sessions, which gives users an opportunity to discuss a particular place on Mars with their colleagues. This allows the distributed Curiosity science team to meet together in the environment that they are studying.
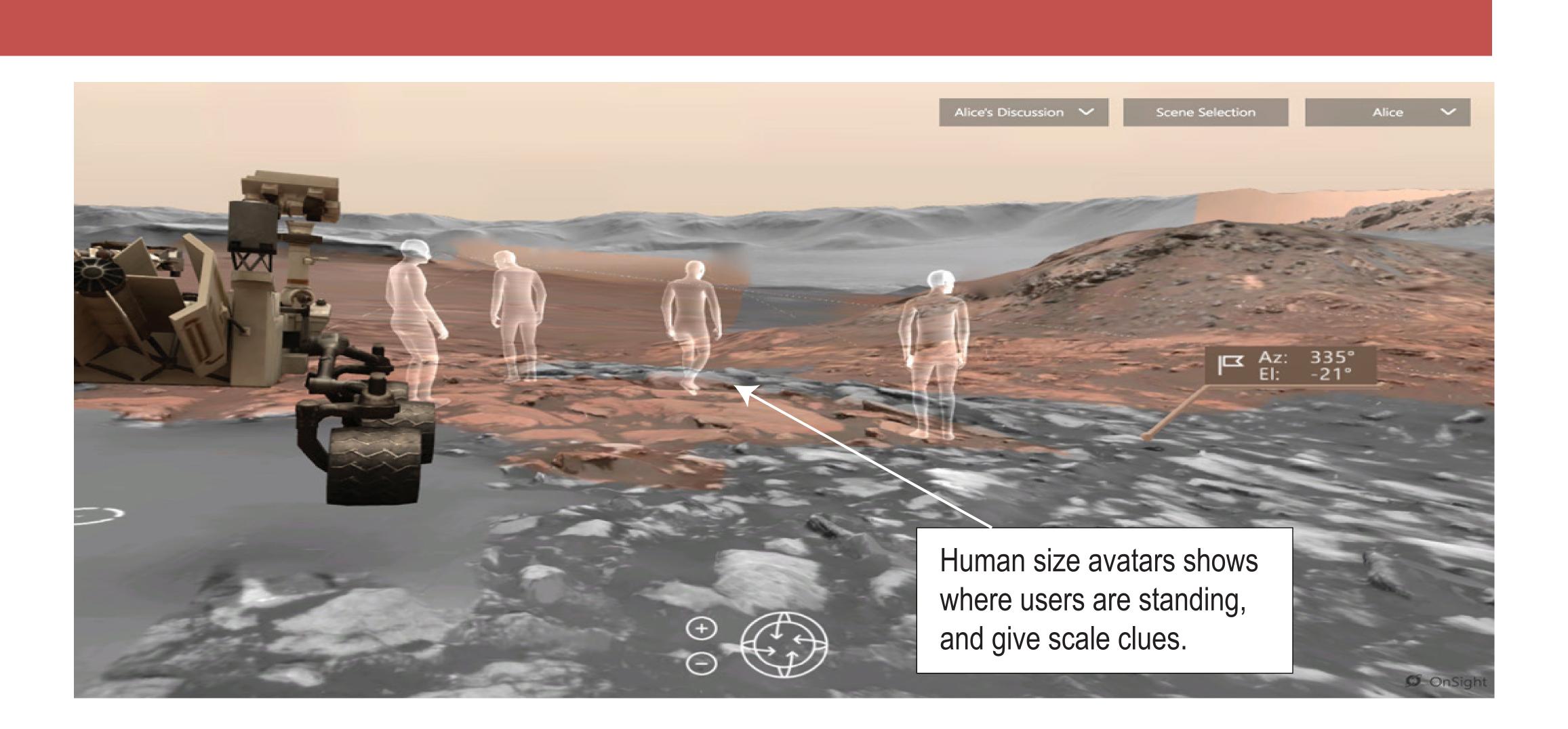
Web Visualization

Like the OnSight HoloLens application, the web application provides an interactive 3D model of the terrain around the Curiosity rover, but runs as a WebGL application in any modern web browser. The user can click on the 3D terrain to find all of the rover images that capture that position.

Advantages
- Browse and search 2D rover images.
- Familiar keyboard and mouse interface.
- No special hardware required.

Disadvantages
- No inherent sense of scale in the display.
- Navigation in 3D interface is difficult for some users to learn.

Image gallery shows images of selected point.

Flag indicates selected point on terrain.

2D image is displayed over 3D terrain, to show how image fits into context of environment.

References

1. C. Donalek et al., "Immersive and collaborative data visualization using virtual reality platforms," 2014 IEEE International Conference on Big Data (Big Data), Washington, DC, 2014, pp. 609-614.