Virtual Reality and Visualization in Research and Cultural Preservation

Kari Noe

Senior Honors Project (Computer Science)
Mentors: Jason Leigh and Daniel Boulos

Visualization as a field can be defined as the process of turning data into interactive images to provide insight or knowledge to a user. New innovations in virtual reality hardware open up new opportunities in the field of visualization, rather than merely for entertainment. My research portfolio and poster highlight two visualization projects that I have created that utilize current virtual reality hardware, the HTC Vive and the University of Hawai'i at Mānoa's Laboratory of Advanced Visualization and Applications (LAVA) Destiny-class CyberCANOE. The At-Risk Artifact Visualization System will allow users to view and study 3D models of archaeological artifacts and sites that are considered "at-risk" within the cyberCANOE. "At-risk" in this case is defined as: an archaeological artifact or site in danger of destruction by either human or environmental influences. Kilo Hōkū, optimized for the HTC Vive, is an immersive virtual reality simulation to aid in the visualization and education of Hawaiian star navigation practices. The goal of this portfolio is to demonstrate the possibilities virtual reality and visualization have for the field of cultural preservation.

Introduction

All of my work revolves around Hawai'i in different ways. Born and raised on Kaua'i, I use my knowledge of visualization and design to create tools that help preserve Hawai'i-centric knowledge. Through this portfolio, I will present my best works that involve research and educational topics in Hawai'i. Through these projects, I would like to demonstrate the benefit of utilizing virtual reality for cultural preservation.

Virtual and augmented reality (VR and AR) have gained mainstream popularity since the release of affordable hardware such as the Oculus Rift. Due to the introduction of VR headsets intended for entertainment, VR is more accessible than it ever has been before. VR has the advantage of immersing the user in scenarios and environments that may not be possible to experience in reality. Both of my projects, the At-Risk Artifact Visualization System and Kilo Hōkū will be implemented in a VR environment and utilize this advantage.

Traditionally Hawaiian knowledge is taught through oral

This portfolio was created to fulfill my Honors program requirements with the help of my mentor Jason Leigh. I wanted to study in what ways virtual reality could be used to help in the preservation of Hawaiian knowledge. It is typical to think immediately of video games when discussing virtual reality, but I wanted to see what else could be created for Hawai'i's benefit with virtual reality's current advantages and limitations.

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traditions. Today cultural knowledge is preserved through *mele (*song*), oli (*chant*),* and other oral traditions. These traditions can be implemented within the virtual environment while the user is immersed in a space that will give them the best context for what they are learning. In this way, virtual reality has the ability to replicate traditional Hawaiian methods of teaching better than through typical written media.

Of course virtual reality cannot compare to learning from a *kumu* (teacher) in person. However, the main advantage of virtual reality is that it can make a world accessible to those who are not in Hawai'i. Hawaiians living in diaspora often grow up not learning their culture or feeling that they do not have a right to their culture because they are not in the islands, which can cause various problems and identity issues (Lee, 2003). Through the accessibility and immersiveness of virtual reality, Hawai'i and access to cultural knowledge can be attainable wherever one may happen to reside.

Project Descriptions

At-Risk Artifact Visualization System

For this project I designed an interactive visualization system for at-risk archaeological artifacts. The analysis of artifacts is integral to archaeology, but due to problems such as the artifacts own fragility, ethical disputes over ownership of artifacts, and natural and anthropogenic factors, many artifacts are considered to be at-risk of being damaged, destroyed, or inaccessible to researchers. Currently, there are techniques to preserve these at-risk artifacts, however, degradation is unavoidable at every stage of the archaeological process. However, with the increasing affordability of 3D scanning technologies, the ability to create 3D data products has become available to archaeologists. With this advantage, I produced a VR visualization prototype that created an intuitive user experience for archaeologists through lessons I learned through archaeological experience and research.

The visualization system itself will be developed in the Unity3D Game Engine. Unity has the ability to import .obj files that were acquired through 3D scanning. The method to collect 3D image data was through the Structure Scanner, a portable 3D scanner that attaches to an Ipad. Through an app, one can use the iPad-scanner combination to create 3D point data of a desired object. The hardware that displays this visualization system is the University of Hawai'i at Mānoa's Laboratory for Advanced Visualizations and Applications' (LAVA) Destiny Cyber-CANOEs (Cyber-enabled Collaboration, Analysis, Navigation, and Observation Environment). With its large screen and capability for multiple users to interact with the visualization system, it allows for collaboration when studying the 3D artifacts.

To collect relevant data, I volunteered at the Department of Anthropology Archaeology Lab at the University of Hawai'i Mānoa to scan Hawaiian artifacts. Many Hawaiian artifacts can be considered at risk due to the remote locations they are found in, their age, and conflict between taking or leaving artifacts from where they lie. Through 3D scanning, artifacts can be left in peace, but archaeologists will still be able to study their relevance and context through the 3D model.

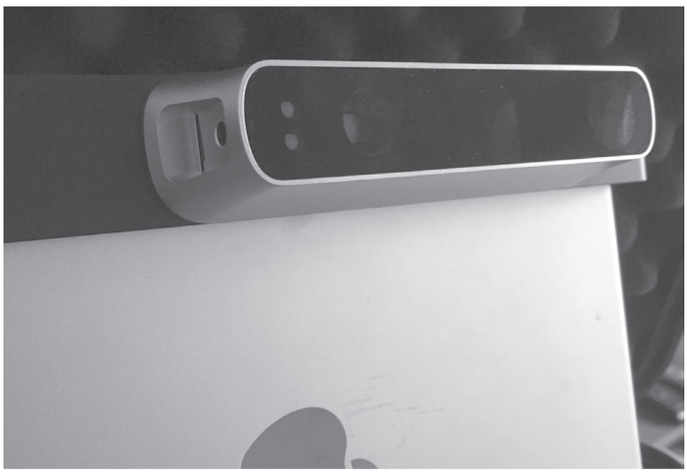


Figure 1 The Structure Scanner

Figure 2 Myself, using the At-Risk Artifact Visualization System in the Destiny cyberCANOE

Kilo Hōkū

Development for the Kilo Hōkū project started in ICS 691-Virtual Reality, a course taught by Jason Leigh. Kilo Hōkū is developed by a team of four including myself, Patrick Karjala, Anna Sikkink, and Dean Lodes.

The night sky offers a map to those who know how to read it. During the time of the Hawaiian Renaissance, in the year 1973, the practice of traditional navigation was brought back to Hawai'i with the founding of the Polynesian Voyaging Society (Low, 2013). Through the efforts of the crew and affiliates of the Polynesian Voyaging Society, the knowledge of non-instrument wayfinding has been recovered. A large part of

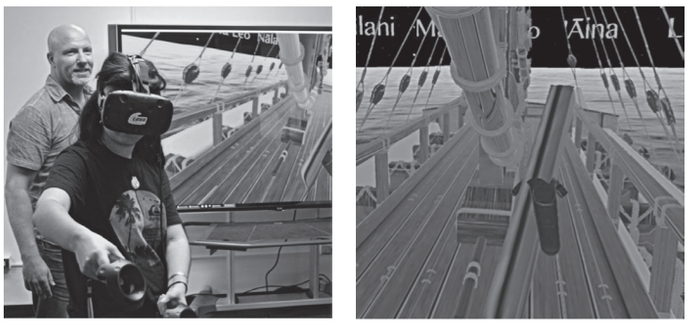


Figure 3 Myself, using Kilo Hōkū (left), and what it looks like from my perspective (right).

the technique for traditional navigation is to be familiar with particular stars and constellations, and their movement in the night sky. Kilo Hōkū, literally "To observe the stars," is a VR application to help teach users about the important stars and constellations in the night sky in a Hawaiian context. Kilo Hōkū allows users to control and investigate the night sky with the use of a HTC Vive. Through the unique experience VR creates for the user, the user is able to learn to become familiar with the sky in a more natural way, as they are immersed in a VR star dome, than they would studying a typical paper star map.

The project is developed using the Unity3D Game Engine and is specifically built to be used with the HTC Vive, however, other hardware may be considered in the future; such as porting the project to a mobile app so it can be viewed with accessible virtual reality hardware such as the Google Cardboard. This project will continue to be developed past my graduation as an undergraduate student as a tool for introductory Hawaiian Navigation classes.

Relations to Prior Work

To create the At-Risk Artifact Visualization System, I did research to see what others have done utilizing VR with archaeology research. It was interesting to find that most papers I found were published by European researchers. The paper, "A Versatile Large-Scale Multimodal VR System for Cultural Heritage Visualization" (Christou, 2006) describes the development of a VR experience in a CAVE-like display to allow users to appreciate and learn about European cultural heritage sites. As the Destiny CyberCANOE is a descendant of the first CAVE system, I thought that I could utilize the available technology to build upon the idea of using a CAVE-like environment. Although within the project, they also included haptic technology to try to make the experience more immersive. I did not go through with that approach. Instead I developed my project with the expectation that the users would be archaeologists who use the tool to do research, rather than the user be the equivalent of an average museum-goer using it for entertainment or education.

For Kilo Hōkū, we found that there are multiple VR simulations that revolve around research on old sailing vessels. One in particular is an 18th-century French merchant ship, the *Le Boullongne* (Barreau, 2015). The goal of this particular research was to recreate the boat at a 1:1 scale and put it within a VR simulation to better understand the living conditions on such vessels. There are features within the simulation that are similar to Kilo Hōkū, such as user controlled sailing, however Kilo Hōkū is unique in that we are developing our experience on a Polynesian vessel while teaching non-instrumental navigation. Also, since Kilo Hōkū's focus is in celestial navigation, we had to develop features that have not been implemented in other similar research such as controls for the night sky and the implementation of a star compass.

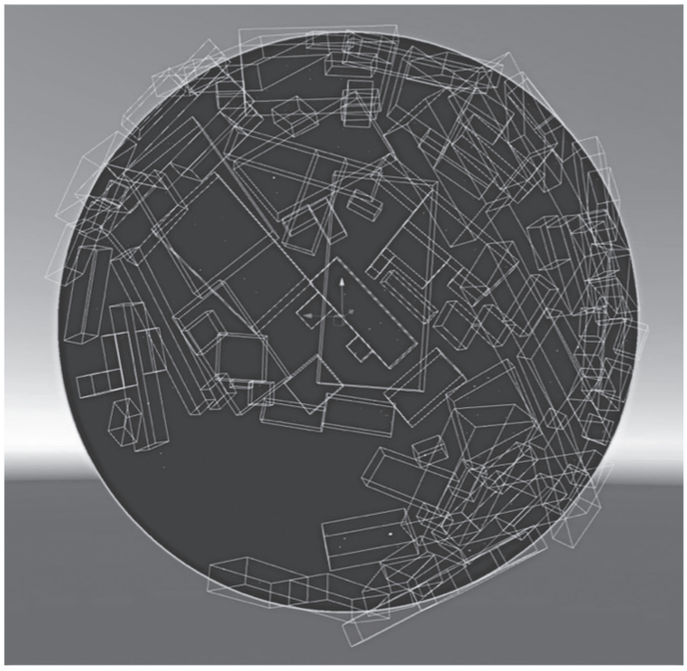


Figure 4 Full view of sky-dome like night sky object that is user-controlled. Each bounding box contains a constellation.

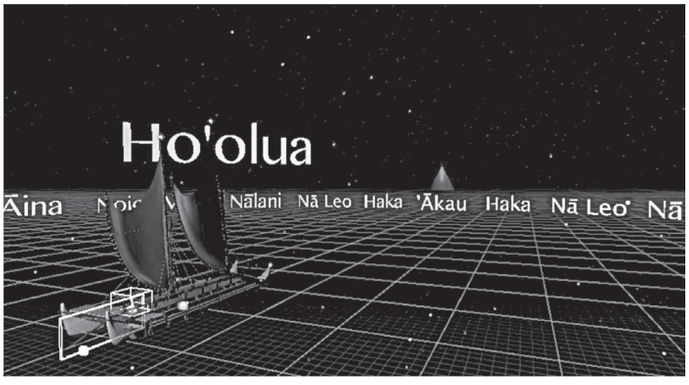


Figure 5 Example of the star compass that surrounds the Hōkūle'a.

Methods

Virtual reality research tends to use headsets or other experimental virtual reality or augmented reality setups that do not allow for multiple users to share the same physical space while experiencing the same virtual space. It was for this reason I decided to develop the prototype for the Destiny CyberCANOE (Kawano, 2017). Housed in LAVA, the Destiny CyberCANOE allows users to share the same physical space while immersed in a virtual environment in a 13-foot wide cylindrical structure. In this way, users are able to fly around and observe virtual scans of various artifacts, or if the data is available to upload, larger immersive LIDAR scans of different archaeological environments so they can compare scans of artifacts and relate them to where they were found in-situ.

To develop a program to be used in the Destiny cyberCANOE, it must be developed in the Unity3D Game Engine. Within the Unity program, before the Unity project folder is uploaded to Destiny's server, a folder containing the .obj information must also be uploaded in a subfolder within the Unity project folder.

Kilo Hōkū was created first as an experience, but grew into becoming a learning tool. It is developed in Unity3d, but is designed for the HTC Vive. The Vive was chosen for the superior headset tracking and resolution that it had over its competitors at the time when we started development. We wanted to be sure that users could move around freely without breaking the experience, and the Vive's main competitor, the Oculus Rift, could not track the user if they turned their back to the sensors.

Most assets in Kilo Hōkū are created by our team, the only exceptions are the ocean asset, which is the Ocean Community Next Gen package, and the model of the Hōkūle'a. The Ocean Community Next Gen package is a set of ocean assets which allows for the manipulation of various variables such as wind, swell, and current strength, as well as buoyancy effects. The Hōkūle'a model was created by 3D artist Mike Pai. Permission for the model was given to us for educational purposes as the model was created under the Bishop Museum's US Department of Education Native Hawaiian Education program grant S362A110069, "All Together Now: A Model Partnership for Improving Native Hawaiian Middle School Education," in partnership with the Polynesian Voyaging Society and the University of Hawai'i College of Education.

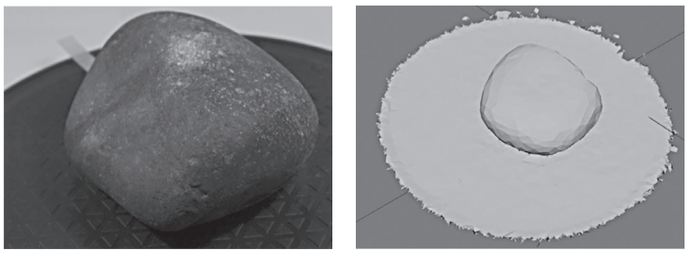


Figure 6 Hawaiian Artifact (left) and its 3D scan (right).

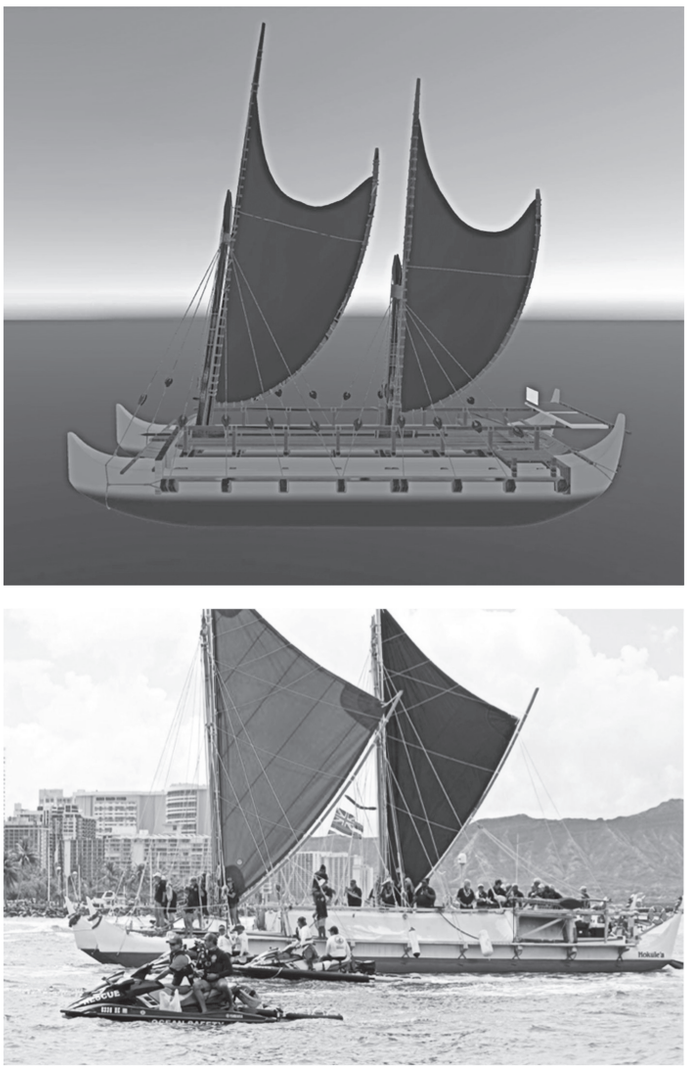


Figure 7 Comparison of 3D model and photo taken during the 2017 Hōkūle'a Homecoming

Discussion and Future Work

Both projects within this portfolio can act as the foundation to future feature additions to make each respective project more effective.

For the At-Risk Artifact, since it is a prototype, it is able to save different note taking sessions, but there are other tools that would be useful for archaeologists to have while in the virtual space. The ability to record and playback camera movement and audio would allow users to create notes more effectively. At this time, users can only type in notes, which can be a bit cumbersome considering the mobility a user has in the

Destiny CyberCANOE. Allowing the user to create audio-visual notes will allow collaborating users to understand the note's creator easier than finding and reading through written notes on large screens.

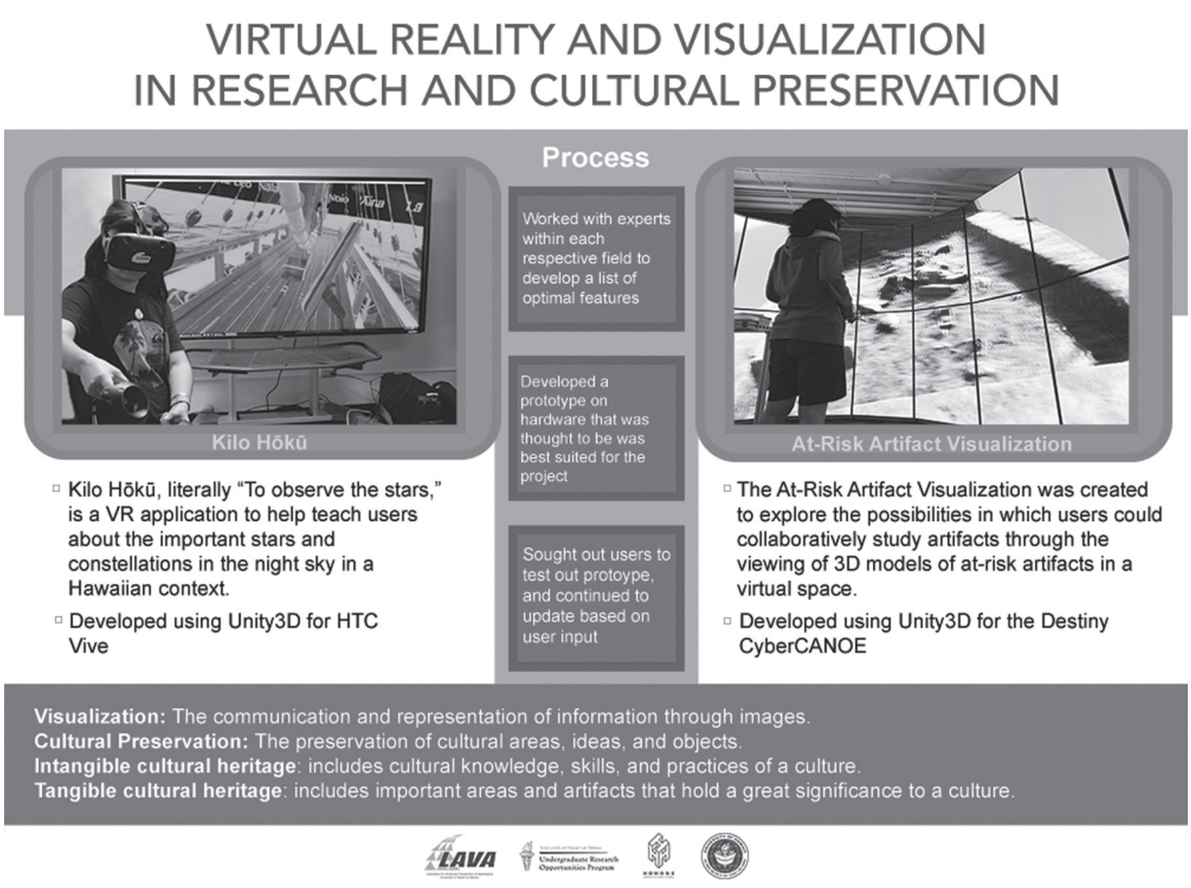
The ability to draw boundaries and highlight an area of interest would also help in clarifying what each user is taking note of. In its current version, users can only drop a pin on the point of interest. The ability to draw and specify the exact area of interest, along with implementing a highlighting organizational system will allow users to define and categorize particular points of interest, and with a search system, easily review them in the virtual space.

As for Kilo Hōkū, the project is still under development. However the work was substantial enough to be accepted to a special issue of the Presence Virtual Reality journal-the longest standing journal of virtual reality. Future features of Virtual Cultural Heritage will include, as mentioned earlier in the paper, making it more accessible to the general public by porting it to mobile devices so they can be used with cheaper virtual reality hardware such as Google Cardboard. Before this happens, however, a more guided experience needs to be created within Kilo Hōkū. Currently, there is no guide for the user other than a menu that appears at the beginning of the experience. However, we usually omit that and guide the user through the different controls personally and let them do whatever they would like in the virtual space. In future versions of Kilo Hōkū, we will put in tools to help guide the user through different scenarios in hopes that it can be used to teach and test a user's knowledge.

To do this, we have discussed various options from implementing "teacher controls," in which the teacher can sit at the computer while the user is using the headset, and from the computer manipulate the virtual environment as the user is experiencing it. In this way, the teacher may do actions such as rotate the sky, hide the star compass, and track certain variables such as the time it takes for a student to identify certain celestial objects.

Also discussed is the possibility of adding in a virtual agent, a virtual character that will guide a user through the experience. In this way, we can add in a virtual teacher that can bring in different cultural aspects of sailing in a more natural way. There are certain cultural protocols that must be adhered to while sailing, and a virtual agent could provide this knowledge in a friendly and relatable way (Champion, 2015).

We hope to initiate these sorts of features and intend to test the new educational features in a study that would test its efficacy of teaching wayfinding students in an educational setting in the near future.



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The name Hōkūle'a and the sailing vessel Hōkūle'a are trademarks of and are owned by the Polynesian Voyaging Society, and are used within the Kilo Hōkū simulation with permission.

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