Brahma: an Open Source Library for Cross-platform Social XR and Scientific Visualization

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Abstract

In this position paper, we present Brahma, an open source library used for cross-platform social XR. This library leverages the WebXR standard and is purpose-built for custom virtual environments such as scientific visualizations, providing appropriate locomotion systems and extensibility to custom shared interaction techniques. It includes methods of telemetry for analytics. We discuss the landscape of existing methods for novel social XR, and position this library in the context of FAIR (Findable, Accessible, Interoperable, and Reusable) principles.

Keywords

Open source, Social XR, WebXR, Scientific Visualization

1. Introduction

To assist the HCI community in rapidly creating multi-user VR prototypes, we created Brahma, an open source WebXR library. Unlike traditional methods using proprietary engines that necessitate costly development rigs and game development expertise, development using Brahma requires only standard web development practices on ordinary computers with web browsers. It features substantially faster iteration time between builds that are easily shareable through URLs. It is cross-platform, meaning that the library's outputs are accessible through many 2D and VR devices (Table 1).

While there are computational limits, Brahma's implementation leverages cloud services and custom shaders to contain high-performance datasets such as communally navigable geospatial terrain meshes and Gaussian splats. This repository is in an alpha stage, and by presenting this at the Social Augmentation through XR Technologies Workshop at CHI '26, we aim to contribute to the discussion around the theme "Tools and frameworks for designing, prototyping, and deploying Social XR applications", and also hope to relate the affordances of this library to other workshop themes related to privacy, methods, scalability, and interface design around social augmentation.

This open source library aims to help the creation of FAIR (Findable, Accessible, Interoperable, and Reusable) artifacts.

- **Findable** — Outputs of Brahma are shareable with web URLs, and do not involve proprietary app stores, removing barriers for researchers who would like their work to be findable.
- **Accessible** — Since the output application is accessible on phones and desktop computers, this library aims to increase the accessibility of shared virtual environments by providing alternate, flatscreen ways of access.
- **Interoperable** — As the WebXR protocol is implemented on a variety of headsets, the same application build can be accessed from a variety of VR devices.
- **Reusable** — Often, engine version changes make older VR codebases harder to re-use. Brahma is designed modularly for extensibility and resistance to code rot.

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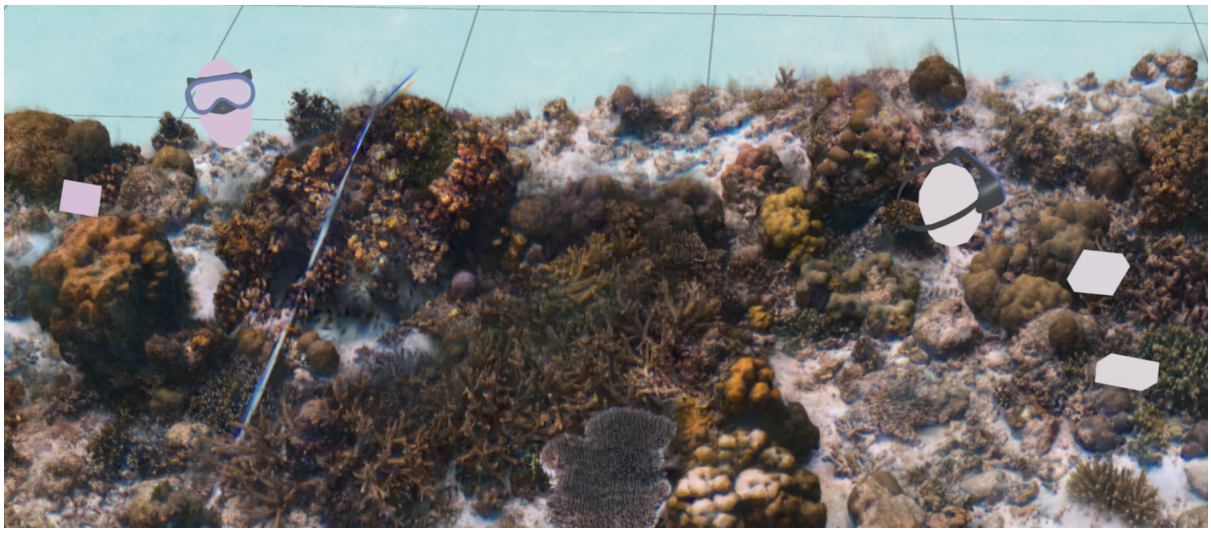

Figure 1: In a shared virtual environment implemented with the Brahma library, two avatars navigate a Gaussian splat of a coral reef in immersive virtual reality. This image was taken from a laptop user's view.

Table 1
Example devices with WebXR support. Users of these devices can access the same shared virtual environment.

3D Devices	2D, Flatscreen Devices
Meta Quest, Apple Vision Pro, Valve Index, Varjo	Mobile smartphones, tablets, laptop and desktop computers

The project is located at github.io/smrghsh/brahma, where we intend to provide implementation and usage details, alongside example applications.

2. Related Work

Open source tools enable scientists to iterate on analyses faster, distribute their work more widely, and access larger scales of computation. These factors are facets of why open source tools revolutionize science and enable breakthroughs [1]. These codebases are the product of immensely collaborative community efforts [2]. However, XR development poses unique development challenges; communities have been constantly re-creating XR frameworks over the last decades due to rapidly changing hardware and interface ontology.

In XR development, one can take proprietary approaches to development using engines such as Unity or Unreal Engine. (The open source engine Godot (godotengine.org/) seems like a promising alternative, but XR support is nascent and codebases aren't fully cross-operable). In the context of creating shared, collaborative virtual environments, there is a necessity for networking code, which can be harder to develop, not only because of a smaller pool of development competency, but also because of barriers of access to cloud computing. Ubiq [3], created and maintained by the Virtual Environments and Computer Graphics group at University College London, is an open source networking library for Unity-based development. While this approach is based on a proprietary engine, it represents an important step in making networked Unity-based applications available to HCI researchers. However, these solutions lack interoperability, require licensing fees, and are susceptible to code-rot as versioning changes of engines and dependent libraries render older versions of apps obsolete. As our work aims to support FAIR principles, it is important to commit to open source— mitigating these issues of obsolescence and access.

Open source approaches to collaborative WebXR-based HCI research were previously facilitated by Mozilla Hubs [4, 5], an open source platform for the creation and use of collaborative virtual environments. As this used the web browser and the WebXR protocol, environments on this platform

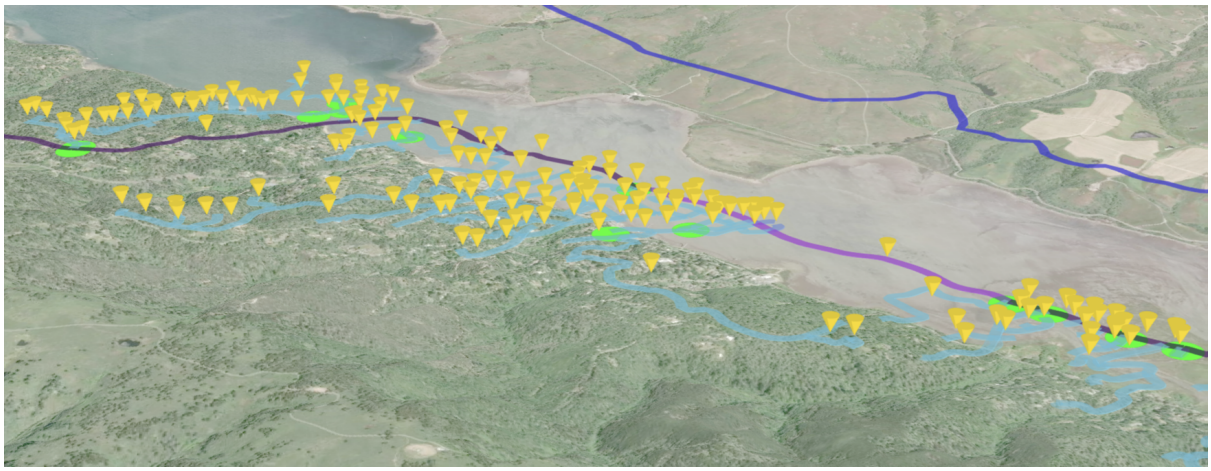

Figure 2: The core functionality of the library, the shared management of avatar positions and interface states, was prototyped during a prior work in collaboration with civil engineering researchers. This image depicts a terrain dataset and roadway datasets related to wildfire mitigation.

could be accessed from a variety of XR and flatscreen devices. However, in 2024, Mozilla Hubs support was discontinued, and the codebase was handed over to community stewards. This transition was not successful, as Mozilla Hubs was built to run exclusively on a complex, bespoke configuration of Amazon Web Services products—leading to a vacuum in WebXR frameworks for collaborative XR development. Furthermore, while Mozilla Hubs offered Spoke, a web browser based virtual environment design application, this tool was limited in allowing for custom datasets or interaction techniques.

3. Implementation Details

> All this universe was in Brahman, and it was, as it were, projected out of Him, and has been moving on to go back to the source from which it was projected, like the electricity which comes out of the dynamo, completes the circuit, and returns to it. —Swami Vivekananda [6] (originally delivered c. 1893).

Brahma takes its name from a Hindu deity of creation. Echoing Swami Vivekananda's metaphor, Brahma's software is responsible for creating a loop of real-time data that flows between clients and a server. The code provides four main networked functionalities: 1) Joining a WebSocket based connection to a server and getting a unique user ID and color via a RESTful API, 2) Maintaining avatar embodiment among users at a rate of about 30 times per second using WebSocket messages, 3) Maintaining shared interface state using a mix of RESTful APIs and WebSocket messages, and 4) Telemetry code to log user poses to a CSV file for later analysis.

There are key limitations to the library. These include a lack of robustness of leaving and maintaining intermittent connections, no customization with user avatar selection, glitchiness with shared interface state, and a proxemics database that would rapidly expand to inordinate filesize (although we used a similar approach as prior research [7]). Such issues inhibit quality research, and are being addressed through ongoing development efforts.

4. Future Efforts

We are currently in the process of documentation and sharing prior works as example code. During this process, we anticipate updates and shifts according to the current state of the art. By bringing this work to SAXR, we hope to find out what kinds of questions SAXR participants have around this library and XR development practices. As the project needs feedback on implementation and usage for scoping a beta release, we are also seeking collaborators who would like to use scientific datasets as

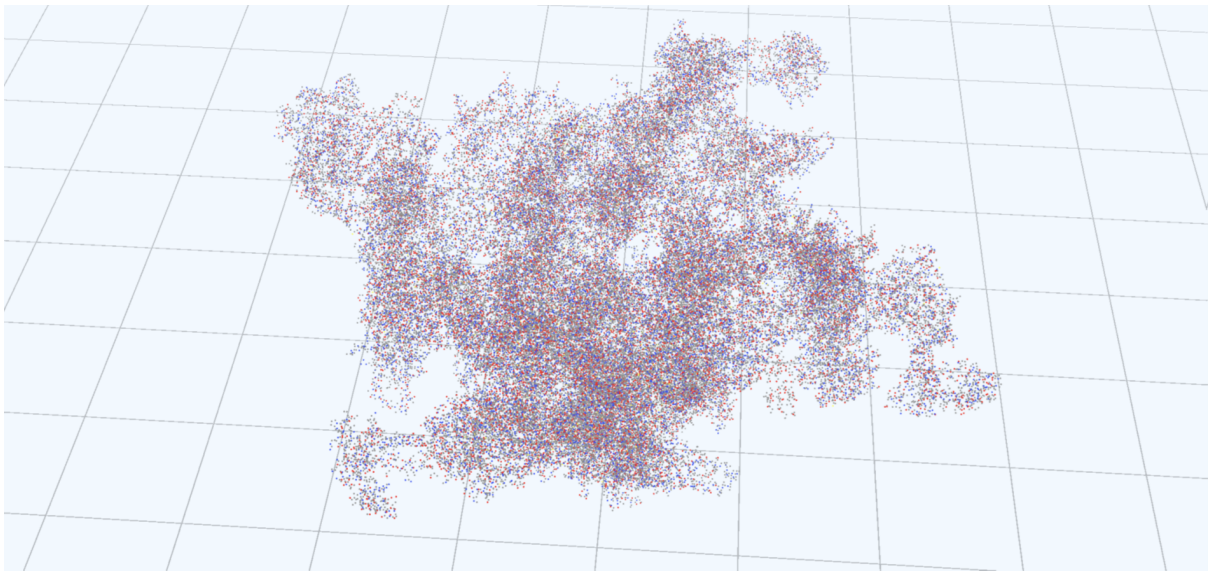

Figure 3: While our ongoing development has related to geospatial datasets, Brahma has the potential to support social augmentation around the sensemaking of other domains; this screenshot depicts the molecular structure of a protein used in a bioinformatics analysis.

part of ongoing HCI research. As part of guiding the development of this library, we are also interested in collaborators who would like to perform a meta analysis of current tools and practices in social augmentation in XR development.

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Declaration on Generative AI

The authors have not used any Generative AI tools.

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