SpaceXR: Virtual Reality and Data Mining for Astronomical Visualization

Abstract

This paper presents a project named "SpaceXR", that harmonizes data science, astronomy, and Virtual Reality (VR) technology to deliver an immersive and interactive educational tool. It is designed to cater to a diverse audience, including students, academics, space enthusiasts, and professionals, offering an easily accessible platform through VR headsets. This innovative VR application offers a data-driven representation of celestial bodies, including planets and the sun within our solar system, guided by data from the NASA and Gaia databases. The VR application empowers users with interactive capabilities encompassing scaling, time manipulation, and object highlighting. The potential applications span from elementary educational contexts, such as teaching the star system in astronomy courses, to advanced astronomical research scenarios, like analyzing spectral data of celestial objects identified by Gaia and NASA. By adhering to emerging software development practices and employing a variety of conceptual frameworks, this project yields a fully immersive, precise, and user-friendly 3D VR application that relies on a real, publicly available database to map celestial objects.

1. Introduction

Astronomical data visualization and analysis have traditionally been the purview of seasoned professionals in the field of astronomy. The existing databases containing information about celestial objects often pose significant challenges for non-specialists to comprehend intricate astronomical and astrometry concepts. However, integrating Virtual Reality (VR) technology reshapes this landscape, making concepts like scale, distance, and spatial awareness more accessible and intuitive. This paper delineates creating a 3D representation of the solar system and harnesses VR's capabilities to enhance the visualization of diverse aspects of space science. This innovative approach can significantly advance education, especially in classrooms, by providing engaging and interactive tools for learning about planets and their properties.

2. VR Application Development

The development of the VR application is structured into three essential modules: data importation, 3D data mapping, and the implementation of interactive elements.

2.1 Data Importation

The initial module revolves around extracting and importing data from databases containing information about celestial objects within and beyond our solar system. This phase leverages multiple data mining methods to extract and preprocess the relevant data.

2.2 3D Data Mapping

The second module focuses on mapping historical data into the Unreal game engine, seamlessly bridging the gap between data sources and the VR environment, resulting in an immersive and informative visualization. For NASA Spice Toolkit data, this involves object position, orientation, and scale, while for

Gaia data, object position alone is utilized for mapping. This module is intentionally designed with extensibility, allowing for customization and adaptation to suit the specific needs of various applications.

2.3 Interactive Elements

The third module centers on incorporating interactive features within the VR environment. This module emphasizes the principles of human-computer interface design while being adaptable to meet the unique requirements of diverse applications. It introduces key interactions, including teleportation, scale manipulation, time manipulation, and object highlighting, all conveniently accessible through a user-friendly menu. Scale manipulation enables users to toggle between "visual" and "realistic" scales, allowing for a more intuitive comprehension of celestial objects. Time manipulation provides users with control over the temporal aspects of the star system model, facilitating dynamic exploration. Highlighting offers an additional layer of engagement by providing users with optional information about celestial objects within the model.

3. Challenges and Future Directions

Developing the SpaceXR application for a vast-scale star system simulation comes with challenges, encompassing constraints on data query, software bugs, and real-time rendering performance issues. However, the potential for future enhancements is promising. These improvements include optimizing the software for higher visual fidelity paving the way for the inclusion of complex, high-polygon budget, and visually stunning models. Leveraging Unreal Engine 5's advanced rendering capabilities holds great potential. Additionally, there is a need to expand the interactive elements to incorporate other databases. Currently, the application interacts exclusively with NASA NST and Gaia data, and extending this capability to other datasets will significantly enhance the application's versatility and value.

This paper illustrates VR technology's transformative potential in space education and planetary visualization. It offers an accessible and interactive platform for diverse audiences to engage with celestial objects and explore the mysteries of our universe. While challenges exist, this VR application's ongoing development and enhancement promise to push the boundaries of space science education and research, making these fields more captivating and comprehensible to all.

Reference

NASA. (2018, December 14). NASA's eyes: Eyes on exoplanets. NASA. Retrieved October 11, 2022, from https://eyes.nasa.gov/eyes-on-exoplanets.html

Owen, T. Chant (2023, March 10). solar system. Encyclopedia Britannica. https://www.britannica.com/science/solar-system

Figures

Framework and It's Modules Diagram

Figure 1: Framework of SpaceXR

Solar System Model, SpaceXR

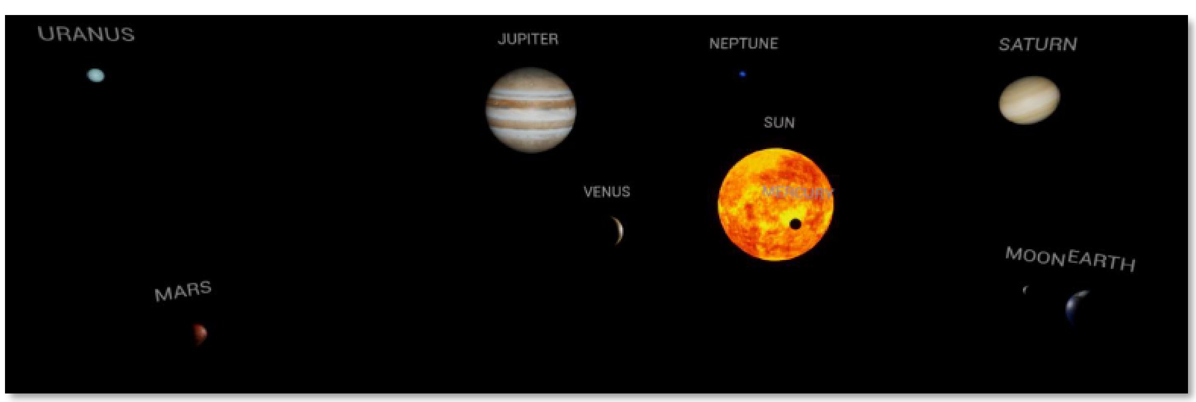

Figure 2: Solar system in VR. Based on the NASA database.

Imported Gaia Stars, SpaceXR

Figure 3: Star system in VR. Based on the Gaia database.

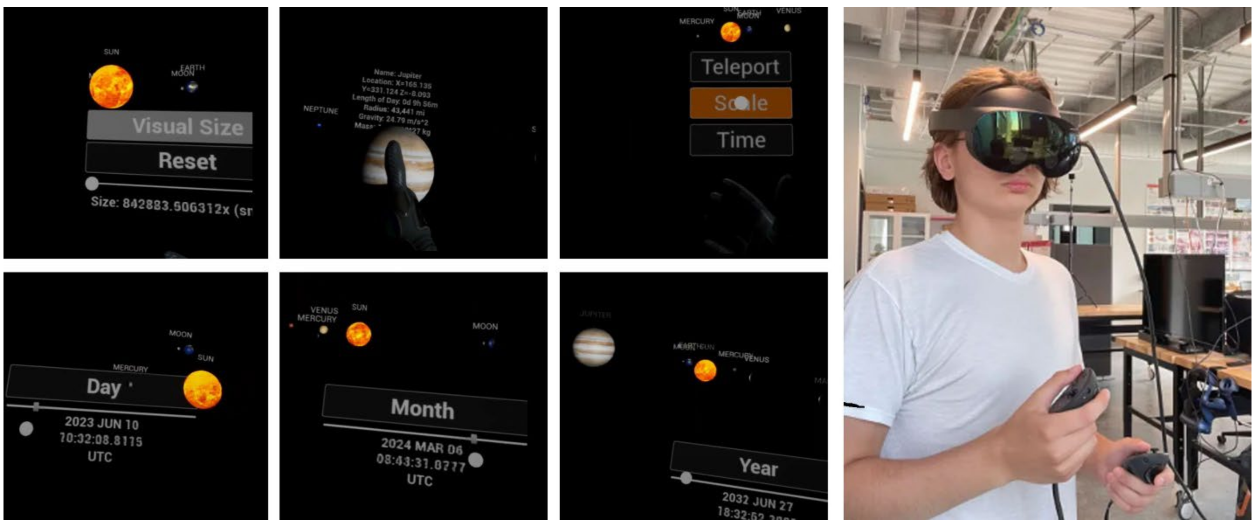

Figure 4: interactions in VR.