Extended Reality 3D Model Application in Space Exploration and Planetary Habitation

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Abstract:

This proposed project incorporates the use of data science, astronomy, and VR to create a visually **interactive learning tool** for students, academics, enthusiasts, and professionals alike to learn about areas of space exploration that will be easily accessible to anyone with a VR device such as an Oculus Quest 2. The application will include an **accurate mapping** of different celestial bodies such as planets and stars, and the model will be **fully interactable** through functions such as scaling, time manipulation, and highlighting. The uses of this proposed application range from basic elementary applications (e.g. learning about our solar system in astronomy courses) to astronomical data research (e.g. viewing spectra of celestial objects found by Gaia).

Intro:

Why?

- Combine multiple **interdisciplinary** skills, such as data science, XR technologies, software development, astronomy/astrometry to create an interactive space education application.
- Current 3D models exist, but **not** to this proposed scale, accuracy, or interactivity; Example: NASA's "Eyes on exoplanets" contains around 1000 exo-planets.[1]
- Databases exist but are **too difficult** to understand for non-professional individuals. (see *Figure 1*)
- 2D Diagrams often don't present the **scale** of distances and objects (see *Figure 2*)

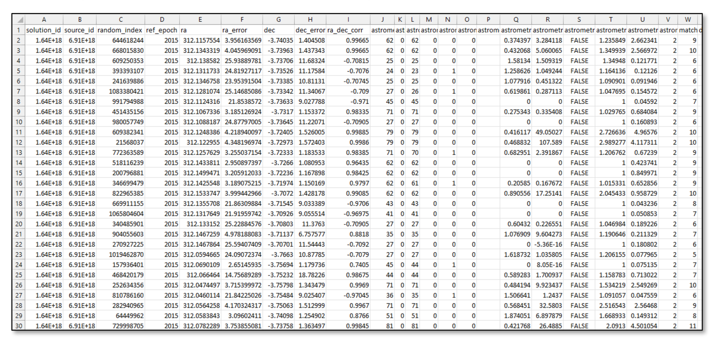


Figure 1. CSV File containing Gaia Release 3 data

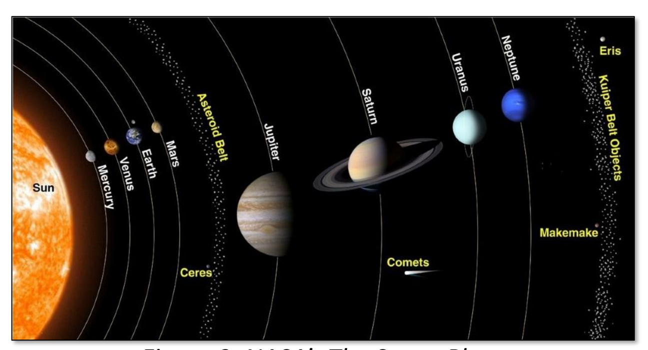


Figure 2. NASA's The Space Place

Methods:

Software:

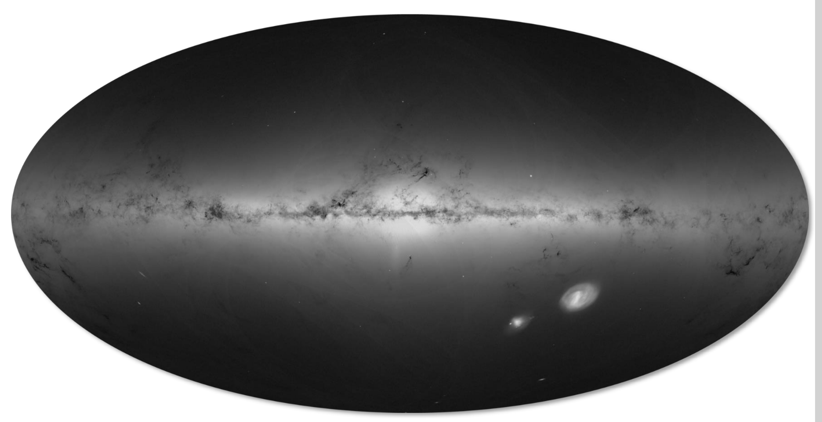
Unreal Engine 5 (UE5): Commercially known as a game engine, used for many applications involving real-time visualizations, simulations, video-games, VR development, etc.. This project primarily used this software with the combination of custom C++ and Blueprint programming techniques, algorithms, and data manipulation techniques.

Unreal Engine 5, Epic Games

Nasa SPICE Toolkit: Used for many applications in astronomy, astrometry, and other disciplines. Contains information on many celestial objects in our solar system including planets, stars, asteroids, comets, and satellites. Data from this software was programmatically extracted using the MaxQ Plugin with the combination of C++ coding and imported into Unreal Engine 5.

NAIF, creator of SPICE

Gaia Database: The largest, most accurate mapping of the Milky Way Galaxy created by the *European Space Agency*. This database contains information on distant celestial objects via the Gaia Satellite. Data was programmatically extracted using the ADQL language into a csv file, then imported into Unreal Engine 5



Gaia Release 3 constructed image, European Space Agency

Hardware:

Oculus Quest 2, Meta

Oculus Quest 2: VR HMD (headset) with controllers is used for many applications involving gaming, 3D visualization, virtual reality, etc.. The Interactivity of this hardware was programmed using C++ and UE5's Blueprinting system to create an interactive and functional application.

Process:

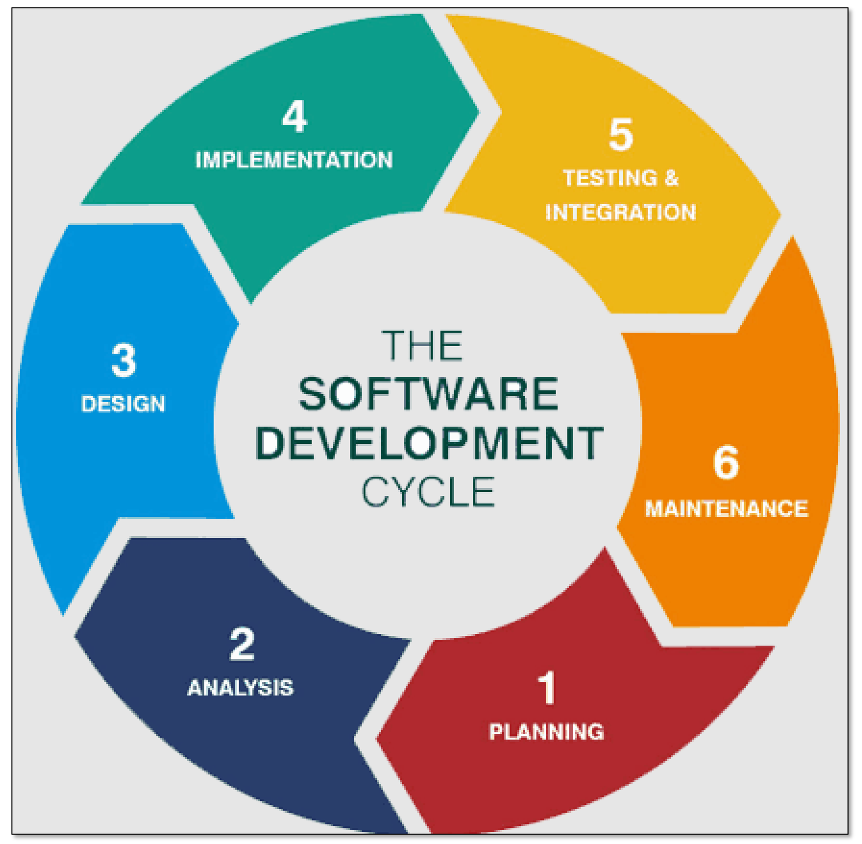


Figure 3. The Software Development Cycle

Protocols:

Throughout the research process, it was **vital** to follow the software development cycle alongside the research cycle to ensure proper delivery of this application. (See *Figure 3*)

Planning & Analysis:

1. Database Analysis
   - Investigate different databases containing celestial object data and their metadata and how that data can be **extracted**.
2. Preliminary Research (literature review, existing research/projects)
   - Review **existing** projects/research developments in this area.
   - Understand current software, databases, and their limitations.

Design & Implementation:

1. Design Project Aspects
   - Data **import** software from researched databases (*NASA* Spice, Gaia).
   - 3D Environment (Unreal Engine 5) including object design, textures, etc..
   - Interactive **methods** and tools for functionality
2. Implement designs
   - Use MaxQ Plugin and C++ to **map** solar system data including celestial object's location, orientation, and scale.
   - Use ADQL to **pull** celestial Object data into csv file, then import into Unreal Engine 5. Includes location only.
   - Program **interactive methods**, including teleportation, scale/time manipulation, object highlighting, and teleportation using UE5's Blueprinting system and C++.

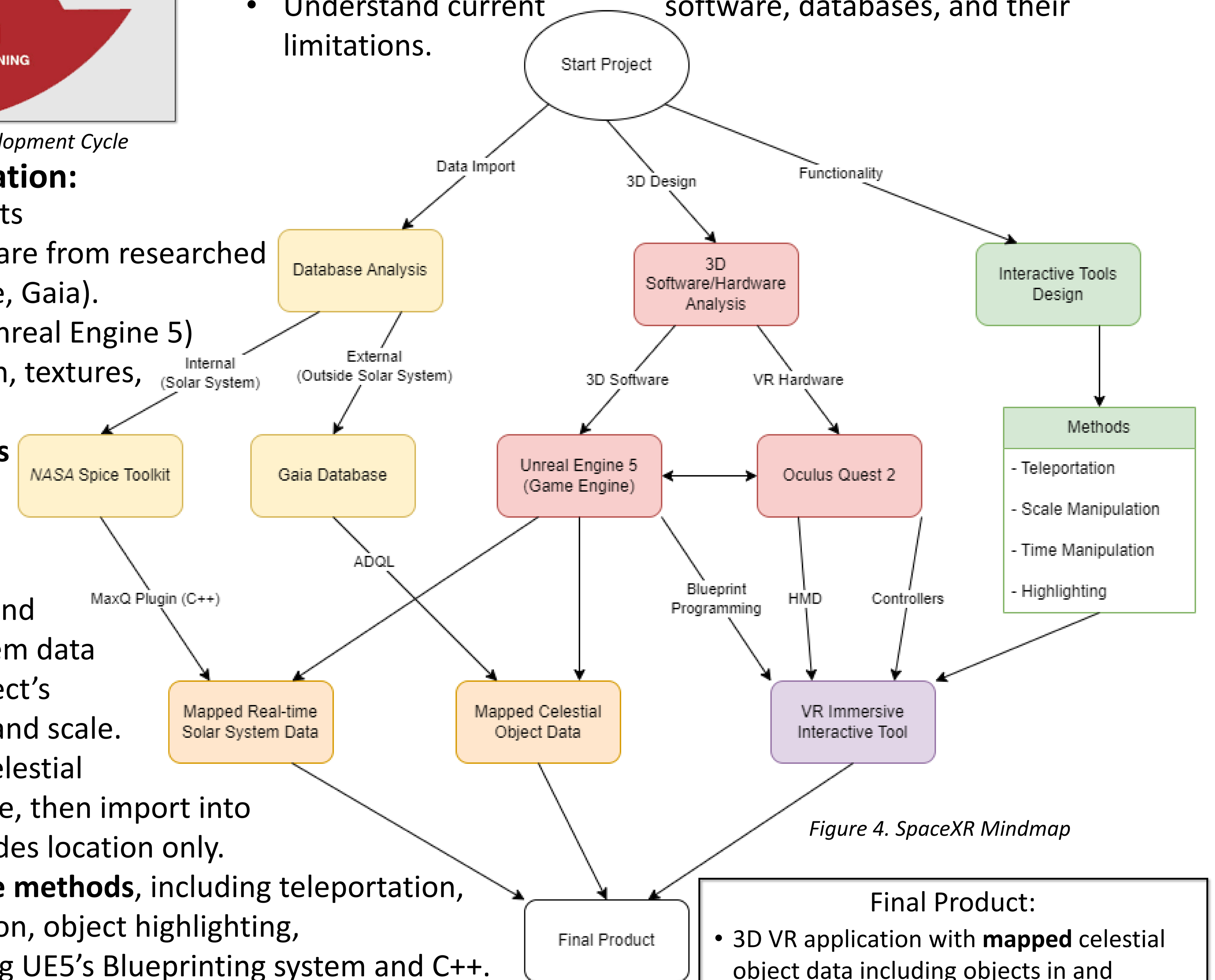


Figure 4. SpaceXR Mindmap

Final Product:

- 3D VR application with **mapped** celestial object data including objects in and outside of the solar system. User can **interact** with the model in multiple ways to enhance their learning/curiosity.

Testing, Integration, & Maintenance:

1. Test Project Aspects
   - Ensure data uploaded is **accurate** and **relevant** to the application.
   - Test different cases of **interactivity** in multiple combinations to ensure intended functionality.
2. Maintain Program Integrity
   - Polish bugs, details, and overall look of the application.
   - Move onto the next software development cycle step to **complete** the cycle.

Results:

Outcome:

- 3D VR Application that runs on Oculus Quest 2.
- Incorporates **data** on different celestial objects in and outside of the solar system.

Figure 5. Imported Gaia Stars, SpaceXR

- Includes multiple **interactive tools** such as teleportation, scale manipulation, and time manipulation.
- Base software allows for **new data** to be pushed into the application.

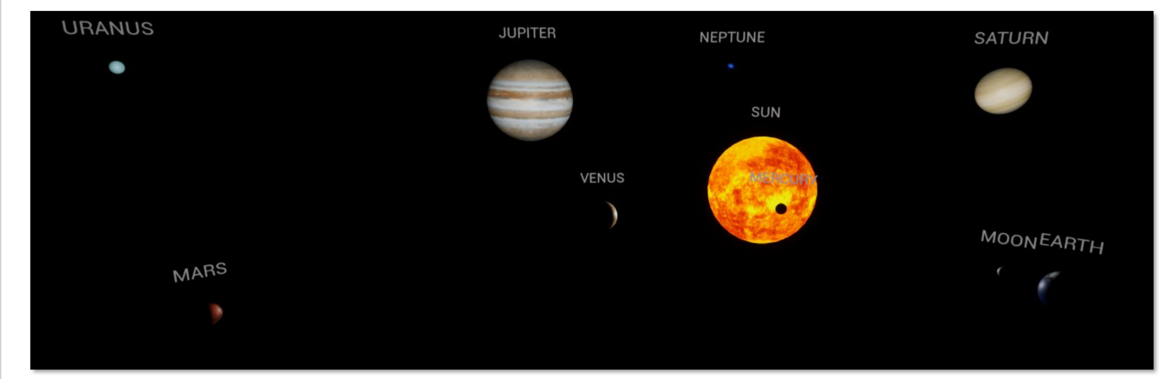


Figure 6. Solar System, SpaceXR

Conclusion:

Findings:

- Data on celestial objects exist and can be accurately modeled in a 3D software if **given** proper metadata, such as inclination, declination, and parallax.
- Modern game engines such as Unreal Engine 5 with custom programming can **handle** thousands of objects with metadata in real-time.

Future Directions:

- Expanding current solar system model to **other** celestial objects other than planets and the sun.
- Incorporating other **databases** for external objects, such as the Dark Energy Survey
- Incorporating **artificial intelligence** to determine habitability and/or other factors associated with celestial objects.

References & Acknowledgments:

Acknowledgements:

Project Advisor: *Dr. Ming Tang, tangmg@ucmail.uc.edu*

Research Funding Source: *University of Cincinnati Space Research Institute for Discovery and Exploration*

External Celestial Data: *This work has made use of data from the European Space Agency (ESA) mission Gaia (https://www.cosmos.esa.int/gaia), processed by the Gaia Data Processing and Analysis Consortium (DPAC, https://www.cosmos.esa.int/web/gaia/dpac/consortium). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the Gaia Multilateral Agreement.*

Internal Solar System Data: *Acton, C.H.; "Ancillary Data Services of NASA's Navigation and Ancillary Information Facility;" Planetary and Space Science, Vol. 44, No. 1, pp. 65-70, 1996. DOI 10.1016/0032-0633(95)00107-7*

Charles Acton, Nathaniel Bachman, Boris Semenov, Edward Wright; A look toward the future in the handling of space science mission geometry; Planetary and Space Science (2017); DOI 10.1016/j.pss.2017.02.013

References & Sources:

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