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SPACE WALK – VISITING THE SOLAR SYSTEM THROUGH AN IMMERSIVE SONIC JOURNEY IN VR

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ABSTRACT

Space Walk is a navigable virtual planetarium designed for the Oculus Quest VR headset. It provides an educational yet accurate representation of the Solar System, including visualizations of scientific data, such as magnetic field lines and atmospheric phenomena, and accompanying explanatory text. A navigational interface allows the visitor to travel between planets. As a complement to the visual content, an ad hoc modular soundtrack has been composed, meant to characterize sonically each celestial object and to offer an audio counterpart for each of their possible data visualization layers. Each sound layer could work both in isolation and together with all the other layers, still keeping coherence of the musical discourse. It is also meant to pay tribute to a vast network of literature from Sci-Fi film and video game music, remaining appropriate within a rigorous scientific context. Finally, it integrates both stereophonic and immersive sound spatialization techniques. A fixed rendering through the interactive sound journey can be found online [1]. The full VR experience is freely available on the Oculus AppLab and can be played on Oculus Quest 1 and 2 devices [2].

1. INTRODUCTION

Space Walk is a virtual planetarium application designed for the Oculus Quest standalone VR headset [3]. It accurately represents the Solar System, including all major celestial objects and several extra elements such as comets and natural and artificial satellites. In the present iteration, five of these objects can be visited: Sun, Mercury, Venus, Earth, Mars, and the comet 67P/Churyumov-Gerasimenko.

The Space Walk project is based on research and educational needs at Aalto University to investigate results from our 3D numerical space weather simulations. Virtual Reality provides a new approach for researchers to do so immersively as well as valuable teaching supports. The 1st version of the Aalto Virtual Planetarium (AVP) was developed for the HTC Vive headset to present a visually attractive, but also scientifically relevant, research based virtual Solar System visualization tool. The AVP was one of the main attractions of the Space Truck space science and technology exhibition tour in September-October 2017 when Finland celebrated 100 years of independence [4]. Space Walk, the 2nd generation version of the AVP, was initiated at the beginning of 2020 in order to include an advanced sound design and a stand-alone VR platform, see Fig. 1. In addition to a new holistic visual and sound experience, another outreach goal of Space Walk is to widen its potential audience by the use of a cheaper, up to date VR headset including individual users, schools, libraries, universities and exhibitions.

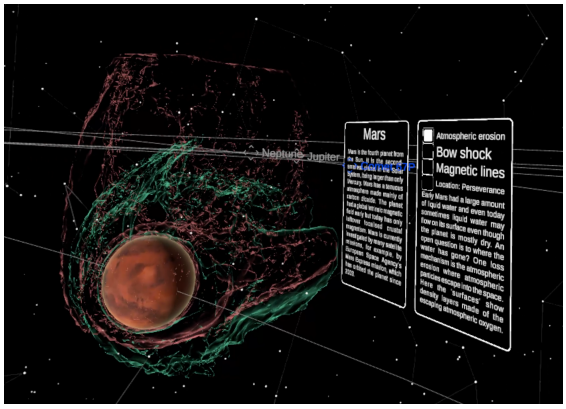

Figure 1. Screenshot from the Space Walk experience. In view is planet Mars with a surface visualization of atmospheric erosion, which is one of three data layers. An info panel explains details about the scientific data and simulations.

2. DESCRIPTION OF THE EXPERIENCE

In Space Walk, each planet is associated with a description text box and individual UI controls to select which elements are visible and audible, which can be operated by the visitor using handheld controllers. In the current release, the key physical parameters visualized near different Solar System objects include streamlines of the solar wind plasma, interplanetary and planetary magnetic field lines

[1] https://www.sebastianjiroschlecht.com/publication/SpaceWalkSound/
[2] https://space.aalto.fi/software/
[3] https://www.oculus.com/quest-2/
[4] https://research.aalto.fi/en/publications/space-truck

and equal density surfaces of the solar wind and the gases escaping from the Venusian and Martian atmospheres and from the comet 67P, a temporal evolution of the Sun's interior magnetic field, and a propagation of the radio waves in the Earth's ionosphere. The VR visual elements were constructed from 3D data cubes outputted from the scientific model runs such as those analyzed in our studies of Mercury [1], Venus [2], Mars [3] and the comet 67P [4]. Finally, the 3D space weather simulations are from scientific models developed interpreting observations from several European Space Agency's spacecraft missions to, for example, Mercury (BepiColombo mission), Venus (Venus Express mission), Mars (Mars Express mission) and the comet 67P (Rosetta mission) as well as observations around the Earth made by Aalto University's own nanosatellite (Suomi 100).

3. THE MUSIC

3.1 Artistic Ideas

Designing the musical content for such an application offered several challenges to be resolved. First and foremost, its nature of a navigable open-ended world, where it is possible to quickly move from an overview of the whole Solar System to a detail of a single planet, required each planet's musical character to fit within the overall musical context. The dynamic positions of the planets, as well as the unknown time each visitor would spend in each possible observation point, made it necessary to work with looping fragments in a compromise between thematic musical material and static soundscape-like elements that could be interrupted and remixed at will. Lastly, the biggest challenge was to wisely construct the various thematic fragments to accompany the multiple data visualization options layers being switched on and off by the user.

It has been decided thus to compose, for each of the observation points, a modular music characteristic of the corresponding celestial object. This is made of several specific sonic layers (containing, for example, harmonic, timbral, melodic, or rhythmic materials), each linked to a corresponding visual element and it is thus audible or not, depending on the visitor's choices. If no other visible layer than the planet's "naked" surface is enabled (which is the planet's default state) only one simple sonic material is audible. The choice of enabling all possible data overlays thus produces a sort of "orchestral tutti," and every combination in between is also possible, as each layer is designed to fit and intersect musically with every other.

The musical choices were guided by the wish to fuse recognizable musical elements inspired by Sci-Fi musical imaginary and popular culture around Space at large, with elements taken from more experimental music genres, such as contemporary, electronic, and noise music, in a way to render the fist one more abstract and timeless, and at the same time to also allow it to play a role in between music and sound design. This was often achieved through a mixture of "traditional" orchestral instruments' passages combined with synthetic elements, bridged together using electronic music techniques such as looping, transforming effects, and spatial treatment of the sound sources.

The orchestration choices were aimed at rendering and sonify not only the physical properties of each planet but also more poetic interpretations drawn from popular and literary sources. For example, the Sun, propelling energy core of the Solar System, was rendered by using mainly percussive instruments and poly-rhythmic patterns. To underline the human presence, Earth is the only planet where humane voices are used as sonic materials, and Mars, traditionally connected to war themes, is characterized by a limping funeral march, dominated by brass instruments, see Fig. 2.

To connect each observation point with the next one, the short transition moment needed to change position, is also accompanied by a sonic transition that elaborates on thematic materials belonging to the planet of destination.

3.2 Technical Implementation

The VR experience employs the Unity game engine and the native XR Interaction Toolkit for enabling the VR display and interaction for Oculus Quest. The experience allows room-scale movement of the visitor; however, it is designed to be comfortably watched with a narrow range of motion.

The sound layers for each planet are pre-binauralized stereo tracks. This choice carries limitations and practicalities. Pre-binauralization does not allow adaptation to visitor's head position and rotation in the way, for instance, Ambisonics or sound objects would. On the other hand, this choice maximizes control over the spatial fidelity and sound mix. However, when the visitor leaves the direct vicinity of the planet, the stereo mix is dynamically rendered as a stereo sound source spatially located closely to the planet. Thus, leaving or approaching a planet is enhanced by a sound zoom effect, where the sound object's apparent width corresponds to the planet's changing visual size. The real-time sound spatialization is performed by the spatializer included in the Oculus integration toolkit [5].

The pre-binauralization is processed with two research-based tools, the SPARTA plugin suite [5] and the 3D artificial reverberator based on work on feedback delay networks (FDNs) [6]. The majority of sound objects in the layers have static positions and are placed to maximize the immersive extend of the space. Some sound sources are automated to emphasize the rotating nature of the planetary rotation. The 3D reverberator allows rendering position-dependent room acoustics with a dense late reverberation tail for multi-channel speaker layouts. The reverberation times were set generally high, to about 3 to 7 seconds, in reference to the empty character of outer space. The multi-channel reverberation is binauralized into the resulting mix.

While most of the musical material was composed with virtual orchestral instruments, some sound samples from space research were included, e.g., the landing sound of the Philea lander on the Comet 67P [6]. To transform such

[5] https://assetstore.unity.com/packages/tools/integration/oculus-integration-82022

[6] https://sci.esa.int/web/rosetta/-/55036-the-sound-of-touchdown

VISUAL LAYER	MUSICAL ELEMENT
Planet Surface	low drone
Suomi 100 Satellite	voices melody
Ionosphere	percussions (crotales)
Magnetic Field	spoken voices (whispers and space history comment)
Magnetosphere	string chords (tremolos)

VISUAL LAYER	MUSICAL ELEMENT
Planet Surface	percussions (bass drum + snare)
Rover Perseverance	strings (overtones and bow scratching sounds)
Atmospheric Erosion	low brass countermelody (trombones tuba + horns)
Bow Shock	brass melody (trumpets)
Magnetic Lines	brass fx (triple tonguing + glissandos + runs)

Figure 2. List of sonic and data layers for Earth and Mars.

short sound samples into long sound texture, we have employed the endless sound algorithm [7]. For this, the sound file is convolved with a sparse noise sequence called velvet noise. The density of the velvet noise balances the temporal structure of the sound sample versus the smoothness of the resulting texture.

4. THE INSTALLATION IN KUUTIO

The 1st implementation of Space Walk was presented in September 2021 in the Kuutio space, a black box exhibition space with fully projectable walls, in Helsinki Central Library Oodi. The room offered the occasion for a broad range of visitors to try the application in a public environment, arranged to comply with recent restrictions for the Covid-19 pandemic. The space, besides explanatory panels illustrating Aalto Space research activities, was equipped with five headsets ready to be worn and a few doubles that cyclically were replacing used ones while these were disinfected and put back in operation.

Two of the four walls of the space presented a video projection loop of cinematic material also extracted from the Space Walk application. At the four corners of the room, a four-channel PA system was installed to diffuse a quadraphonic soundscape, a musical equivalence of the universe background noise, where thematic fragments for each of the themes present in application's soundtrack would rotate around the audience with trajectories mimicking the planets' actual movements.

5. FUTURE DEVELOPMENTS

Future development of Space Walk is already in course. The next iteration of this application will allow visiting all the celestial objects, such as Jupiter, Saturn, Uranus, and Neptune, each with the associated data visualization layers. A way to add new sonic layers or modify existing ones for each planet is also under development, so to offer a sonic equivalent to wide data variations such as temperature changes on the planet surface in the various phases of the day, and similar sonifications that could provide intuitive ways to understand otherwise abstract scientific data.

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