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Sensorial (In)verse: Charting your own Skies

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Sensorial (In)verse translates the data derived from the European Space Agency's Gaia Mission in the form of an interactive installation and represents it in a multimedia framework in order to make astronomical data accessible to a broader audience. This astrometry representation enables a better understanding of the mapping of trajectories of the star clusters and provides insight into the Earth's positionality within our galaxy.

Introduction

Astrometry, the science of charting the sky, is one of the oldest branches of astronomy and a discipline in which Europe excels. The European Space Agency (ESA) pioneered space astrometry with the HIPPARCOS Mission (launched in 1989) and, more recently, with the Gaia Mission (launched in 2013). Gaia is a project initiated by ESA to produce a three-dimensional map of our Milky Way galaxy by charting the motions of a thousand million stars, their luminosity, composition, and temperature. This mission aims to provide a more in-depth knowledge about the origin of the universe as well as the evolutionary history of our galaxy. The data derived by Gaia provides novel positional and radial velocity measurements and enables us to fathom our positionality in this vast cosmos.

There are a plethora of theories and data that remain two dimensional, all stacked on top of each other, unreachable to the public. The main question that inspired the development of Sensorial (In)verse was: how can astronomical data be accessible for a broader audience?

Sensorial (In)verse intends to bridge this distance and produce an immersive experience of the novel astronomical observations visible for all. It is an interactive installation that allows users to explore the movement of stars in the Orion constellation over time. It does this through gestural control and produces an interactive audio-visual representation of the data.

Charting your own skies

The work of ESA scientists is important and impactful, but much of it is complex and technical, making it difficult for non-specialised audiences to understand and appreciate. This can be a significant barrier to the broader dissemination and uptake of scientific knowledge. In this project the intention was to create an interactive installation, visually and sonically translating the data derived by the European Space Agency into an immersive experience in order to make astronomical data more accessible for the general audience. Additionally, this work sought to address the lack of accessibility of experiential works for visually impaired individuals. Many visualisations are created with a focus on visual aesthetics and are not designed with accessibility in mind, meaning that they can be difficult or impossible for visually impaired individuals to understand and engage with. Given the relevance of both approaches, an opportunity to create an installation emerged that would address these concerns and make knowledge about our planet's positionality in relation to the known universe, more accessible to non-specialised audiences, including those who are visually impaired.

Astrometry Multimodality: Design Philosophy

In order to develop Sensorial (In)verse, a design methodology was devised to translate the data collected by ESA in the form of a multimedia output; this multisensorial work employs three elements: visualisation, sonification, and interactivity.

The universe is not static; there is constant motion and change. Therefore, visualisation enables us to view the dataset in a more comprehensive form. In the domain of visualisation, it is considered that the majority of existing visual representations of the known universe are viewed from the northern hemispheric perspective. Taking that into consideration, the representation of the dataset takes place from a non-Earth-based perspective. To accomplish this, a space shuttle is personified as it navigates the constellation. The visual experience of the work concerns what is taking place on the screen, the star (colour, texture, hue, etc), the background, HIPPARCOS identifiers, the visual movement of the star, or the

Visitor interacting with Sensorial (In)verse through gestural control at Space Expo. [Jasper van den Ende]

travelling of the camera/spaceship. As the user moves closer to the objects in the visualisation, the HIPPARCOS identifiers appear.

Sonification makes astronomical data accessible to visually impaired individuals, inviting them to explore space through sound, creating an immersive astronomical soundscape. Through this medium, different sounds are produced based on the colour of the star, it also varies based on the position and trajectory of the camera/spaceship within the visualisation.

Furthermore, the interaction component is integrated into the Kinect, enabling one to engage with the installation and navigate through the trajectories of the stars over time. This occurs as a result of the gestural-control guidelines provided to the audiences, facilitating their ability to modify the auditory as well as visual cues of the installation. For instance, placing one hand in front of the Kinect and performing a panning gesture moves the stars around. As two hands are placed in front and moved horizontally in opposite directions, one can advance further into the constellation, and as the hands move towards each other, one can return to their initial position. The velocity at which the stars move increases or decreases as the hands move vertically.

Dataset and Software

The dataset encoded in this work was acquired by the ESA and comprised information of two hundred stars in the Orion constellation. The dataset includes the positions of all the stars across a thousand steps (each being 10,000 years), allowing for the modelling of the movement of the stars over time. The dataset also included the HIPPARCOS identifiers as well as the R, G, and B values (light intensity in Red, Green, and Blue) of the stars. The HIPPARCOS identifiers were used to retrieve the names of the stars, which were obtained from the SIMBAD Astronomical Database. This additional component contributed to this work as it provided further context and significance, making it more familiar and engaging for the audiences.

The Sensorial (In)verse installation was materialised using a variety of software tools, including the Unity game engine, Kinect SDK v1.8 and Audiokinetic WWise. The dataset was read and interpreted using the Unity game engine. The visualisation was programmed using the C# language, which allowed us to create a dynamic, interactive visualisation that could be controlled through gestural input using the Kinect. The Kinect SDK v1.8 was used to interface with the Kinect sensor, which was used to capture and interpret user gestures in order to control the visualisation. Finally, Audiokinetic WWise was used to sonify the stellar data, which allowed us to create custom sounds for each star based on its colour and other properties. This added an immersive auditory experience to the installation, which enhanced the overall user experience and made the visualisation more accessible to visually impaired individuals.

Prototyping: Material & Methods

The process leading to the materialisation of this work involved challenges, considerations and specific hardware and software tools.

Visualisation: After deriving the data set from ESA, Python was used to transform the data into a readable format. Once the dataset was uploaded to the Unity engine, the following phase was to use the RGB values of the stars and their magnitudes to create the visuals. Furthermore, the positions of the stars were visualised by plotting the stars' positions based on their position in time (referring to the 1001 steps the star is in according to the data set).

Sonification: Three specific tones were produced, each attributed to the R, G, and B values of the stars. Initially the sounds were responding to only the blue value of the stars. However, this resulted in an inaccurate representation of the data as it was repetitive and confusing for the visually impaired users. In addition, the pitch and the volume also represent the data, as the pitch changes based on the RGB value and the volume changes based on the distance between the user and the star(s).

Interaction: Initially the aim was to use the API (application programming interface) which is built for the Unity package, however it was inconsistent and highly imprecise. Therefore, instead of trying to detect certain gestures, the focus became tracking the hands in order to manoeuvre through the visualisation.

Reflections and Results

To analyse the Sensorial (In)verse installation, two different approaches were employed. Initially, a questionnaire-based evaluation was used to assess the user interface design of the installation. Participants reviewed the user interface for usability, intuitiveness, iconography, diverse ways of displaying information, and overall effectiveness. This provided us with knowledge of features of the interface that are ambiguous, challenging to use, and require additional attention,

Left: Karen O'Flaherty interacting with the installation at Space Expo. [Jasper van den Ende].
Right: From left to right – Rick Heemskerk, Karen O'Flaherty and Pragya Jain. [Jiaxin Zhang]

allowing us to make appropriate modifications. Many participants offered recommendations to convey various elements of information more effectively to the user of the installation, encouraging us to identify the most suitable and intuitive methods. Responses from the participants were highly positive, expressing enthusiasm for the installation and its potential to make astronomical data more accessible and understandable.

In addition to the questionnaire, a usability scale test was performed to assess the entire experience of the installation. Participants interacted with the installation and rated their experiences based on a series of standardised scales that measure factors such as enjoyment, ease of use, and perceived effectiveness. In the second user review, participants emphasised the importance of visualisation and recommended that a reference point, such as the earth's position, be given special consideration.

Feedback from early prototyping and testing phases prompted us to consider ways to demonstrate relationships between stars if they travelled in the same direction, both sonically and visually. We also investigated how the years in which the stars traversed could be indicated in the visualisation and create an interface where the user may tap on a star to receive all its information. There was the proposition of incorporating gestural control guidelines to assist users in determining which gestures are appropriate for the installation. Moreover, guidance was also sought in the framework of integrating sound and maintaining the scientific legitimacy of the work. Colour and distance were eventually devised as the variables to be translated into auditory representation in order to make it as accessible as possible for visually impaired individuals. Overall, the interactive experience of the installation was highly valued by both specialists and non-professionals, and we were further encouraged to investigate the potential applications of this installation as a scientific instrument.

Sensorial (In)verse was exhibited during Space Week 2023 at Space Expo, the visitor centre for ESA ESTEC, in collaboration with NL Space Campus. The work was presented in the form of an interactive installation and was welcomed with tremendous enthusiasm and astonishment by the audiences, including scientists and researchers specialising in their respective domains in the fields of optical imaging, geostationary satellites, and more.

Science communication within the field of astronomy is becoming highly significant, as researchers are realising the value of sharing their work with the public. This inspired us to produce a work that is accessible and informative for the audience. We were particularly focussed on ensuring that Sensorial (In)verse is accessible to visually impaired individuals. To this end, we made use of spatial audio to represent the position of stars within the visualisation, allowing users to locate specific stars based on their sounds.

Future Work

For the next steps, we aim to conduct further user analysis with visually impaired individuals and continue developing this work. Currently the visualisation does not highlight the coordinates at which the user is positioned at. In consultation with the scientist, we aim to explore ways to diagrammatically represent the coordinates of the user in the visualisation. Furthermore, we aim to make the sonification element of our installation more unique and immersive by deriving the data regarding the spectral type, age and/or mass as well as the frequency of the stars and synthesising the data with the sound input. We also would like to continue this project by translating a bigger dataset and produce a grander representation of specific coordinates of our galaxy.

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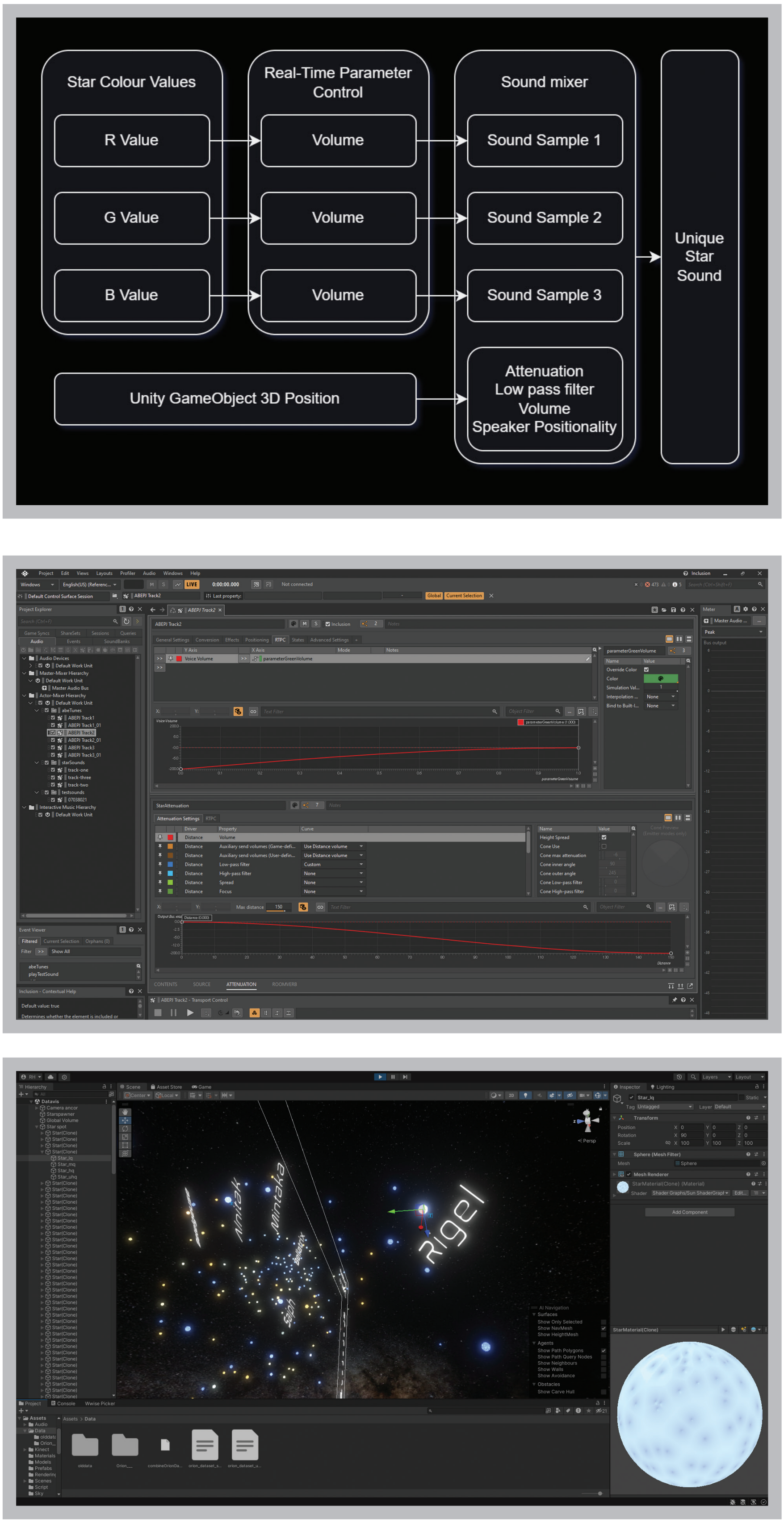
Pragya Jain and Rick Heemskerk are students of the MSc Media Technology programme in LIACS at Leiden University, The Netherlands.

Pragya Jain

Simultaneously with her education, Jain's research revolves around themes that are seemingly distant or opposed to one another. By employing and superimposing scientific insights, cultural knowledge, and artistic strategies, she seeks to highlight their potential points of intersection that are often invisible. Through the lens of transdisciplinarity, she approaches research as a convergence of disciplines with the intention of facilitating an experience and enhancing recognition of one's positionality in relation to others from diverse perspectives. Sensorial (In)verse exemplifies how such unique tangents of knowledge are shared with audiences through multimedia installations as well as (hybrid) publications.

Rick Heemskerk

As a computer scientist and artist, Heemskerk finds passion at the convergence of art and technology. Driven by a keen enthusiasm for interactive media, Sensorial (In) verse stands as a tangible manifestation of these converging domains. Drawing from previous experience in crafting interactive installations and fuelled by a love for stimulating experiences, the aim is to transport participants to a new realm. Heemskerk's fascination with data science further extends to crafting interactive installations, where intriguing datasets become the foundation for creating unique experiences that linger in the minds of participants.



Left: schematic of sonification parameters. Middle: sound synthesis in Audiokinetic WWise software, used to design the sound samples per unique star parameters. Right: visual processing of Gaia data in Unity Engine.