Interactive Sonification in OpenSpace

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1 Introduction

There is no sound in space. That is a truth that has discouraged the use of sound when it comes to representing scientific data in outer space. Instead, scientific visualization is the primary method of conceptualizing the information of space, which is the method that is used in the visualization software OpenSpace.

Instead of visually showing data, sonification is a method of conveying information through non-speech audio. It is a method that has been around for several decades, but has not acquired the widespread use that the visualization methods of the same field has. There are however certain advantages of using sonification over visualization. Our auditory perception has a better sense of detecting changes in temporal, spatial, amplitude and frequency domains that can be useful when showing differences of these values. By using these advantages as well as immersing the audience with sound, further understanding of astronomy and space can be acquired.

1.1 Background

Sound relies on vibrations propagating as pressure waves through a transmission medium. On Earth this medium is air which surrounds us with the atmosphere. In space however, there is no transmission medium for sound to travel in. The average density of atoms in space is about one atom per cubic centimeter [1], compared to millions of billions of air molecules by cubic centimeter in earths atmosphere. Even though sound does not exist in space, sound can still conceptualize data collected from space using sonification.

Sonification is a method of conveying information through audio. Something simple as a clock ticking is a form of sonification, as it tells to its surroundings when one second has passed [2]. Another example of sonification is the Geiger counter, which outputs audible clicks in different frequency depending on the concentration of the radiation. This helps the user to locate the highest concentration of radiation in a space, while still being able to look around. Similar to this is also the heart rate monitor found in hospitals, emitting a sound for every heartbeat. These examples shows that sound can perceptulize data in a way that visualization techniques can not.

There are numerous standalone examples of sonification used in astronomy. One example is the sonification of the gravitational waves discovered by the laser experiment facility LIGO [3]. It detected a signal increasing in frequency from 35 to 250 Hz, creating a 3 second audio clip of this pitch increase. Because this frequency is within the human hearing spectrum, the sonification of these waves were straight forward to produce.

OpenSpace is an interactive data visualization software which uses scientific visualization to visualize the known universe in different ways. The software can show the solar system in an accurate relative scale, while also being able to visualize dynamic simulations like the magnetic field of earth and other planets. OpenSpace does not output any sound, which is a missed opportunity to not use sound to explain or compare different astronomical properties. It has been determined that sonification can better illustrate certain things compared to visualization [4], which is what this thesis will explore by implementing sonification in OpenSpace. By combining visualization with sonification an audiovisual experience can be created which can further increase understanding of certain abstract aspects in astronomy. These abstract aspects include for example the scale of space and the solar system, and how fast different objects travel through it.

1.2 Motivation

There are a couple of examples where sonification has been used in planetariums as a demonstration for the public [5, 6]. In these examples sonification has often been used to illustrate the scale of space. There are however no examples of sonification being implemented in an interactive data visualization software such as OpenSpace. Adding interaction would enable an adaptive and immersive experience, which will in turn lead to increased knowledge of astronomy for the users.

1.3 Purpose

The aim of this thesis is to investigate in what ways sonification can be used to increase understanding of astronomy using the software OpenSpace. Specifically, the sonification will be used in the Dome at Visualiseringscenter C in Norrköping [7], which includes sound and visuals in 360 degrees.

An implementation will be made to extract data from OpenSpace which can later be sonified. A user study will be conducted to investigate which type of sonifications are more useful than others.

1.4 Research Questions

The following research questions will be answered in this thesis:

- Which parameters from OpenSpace are more suited to be included in a sonification to give a more comprehensible understanding of space?
- In what scenarios can sonification be used to increase understanding of astronomy by complementing visualization techniques?

1.5 Delimitations

The implementation of sound will increase the accessibility of the software to visually impaired people. However, the work of this thesis will focus on sonification complementing the already implemented visualization, not replacing it.

The size of space will be limited to the solar system, including the sun, the planets and their respective moons.

2 Theory

This section explains more about the theory of the thesis such as sonification, supercollider, OSC and previously done related work.

2.1 Sonificaiton

The strength of sonification lies in how the ear is different from the eyes. It is therefor important to identify specific concepts where sound can perceptulize a topic better than a visual representation. Sound can for example be positioned in a way that visuals can not. Sterne [8] calls this the spherical sound, which describes the multidimensional and multidirectional nature of hearing. It opens up the possibility to position objects in a scene, and also to play several sounds at once as they can be spread out around the listener. The listener also has the possibility to choose what sounds to concentrate on, which creates a sort of innate filtering ability [9]. By presenting both a visual and auditory component to the audience it also increases the chance of them remembering the information presented as they can create associations to either of the two senses [10].

An important step in sonification is to define which scientific data should be represented by which sonification parameter. Should for example the velocity of an object be represented by the volume of a sound or its pitch. By combining basic elements of hearing listed by Levitin [11] with sonification mappings listed by Dubus and Bresin [12], Quinton et al. [5] created a table (figure 1) that shows a possible relation between these parameters. This is however one of many combinations, as there are often subjective preferences of sound.

2.2 Supercollider and OSC

To create and manipulate sound depending on external data, a synthesizer has to be used. SuperCollider [13] is a code environment which enables audio synthesis and algorithmic compositions, suiting well for sonification. The SuperCollider environment consists of a server (scsynth) and a client (sclang). This structure enables the setup of an external software like OpenSpace to act as the server, sending its data to a synthesizer. The communication between the server and client of SuperCollider is done with Open Sound Control (OSC). It is with this protocol that the data from OpenSpace will be transferred to SuperCollider.

Parameter	Sonification Mapping
Loudness	Proximity, size, importance, energy
Pitch	Location, size, orientation, velocity, motion, size, distinction
Contour	This would represent the overall sonification
Rhythm	Intensity, density, speed
Tempo	Velocity, event rate
Timbre	Proximity, intensity, importance
Reverberation	Motion, location, proximity, spatialization

Figure 1: Possible sonification parameters according to Quinton et al. [5].

2.3 Related work

As mentioned in section 1.2, there are a couple of examples where sonification has been used in planetariums. Quinton et al. [5] sonifies the planets of the solar system with focus on testing and demonstrating it for the end user. For this work however, there was no visual component. The reports shows promising results, with the evaluation stating that the audience could discern information from the sound, with some not being told of the sound design at all beforehand. Another use area of their work is to offer sonification to astronomy scientists, where they can possibly explore more findings by listening to their data. The most important knowledge taken from this report is that sonification in a planetarium environment is possible, and that sonification has the potential of being more comprehensible compared to visualization techniques in some cases. The report also shows that the use of surround sound can be especially effective at sonifying the elliptical orbits of the planet, as the planets can orbit around the listener.

The second example is the work done by Tomlinson et al. [6]. It shares many aspects of the previous mentioned report, such as being used for a planetarium by sonifing the solar system. Apart from the previous report there is a visual component as well. At the beginning of their work they asked people teaching astronomy in what aspects it was hard to teach it. The scale of the solar system was the most popular answer. Their work included a survey of 5 questions about how interesting, pleasant, helpful and relatable the sonification was. This shows that it is not just about how sonification can increase understanding of something, but that it also needs to be pleasant and relatable when listening to it.

3 Method

To enable sonifcation with OpenSpace, the data first has to be extracted from OpenSpace. When this is working, the sonification process can begin and user tests can be executed. The work is planned in three steps, categorized in three subjects shown below.

3.1 Extraction of data

OpenSpace currently does not have any permanent functionality to send data from the software. Only temporary solutions have been implemented to for example extract the time of the software to present a planetarium show. A permanent solution must therefor be implemented to extract and send data to a audio synthesizer to sonify the data. Data that could be interesting for sonification is the position of the camera, distance to the sun, the velocity of a planet and so on.

3.2 Sonification

The sonification process will begin by first experimenting with SuperCollider while the extraction process is being completed. Sound parameters like reverb and pitch will be manipulated to find a suitable sound for the sonification.

When the data from OpenSpace can be extracted the actual sonification of the data can begin. A number of examples will be created to demonstrate the use of sonification. These will then be used in a user test to attempt to answer the research questions.

3.3 Evaluation

The evaluation setup can happen in two ways. If possible, the Dome will be used to conduct user tests. This will be beneficial as the Dome is the suitable location for the sonification. A more flexible alternative is a quadrophonic speaker setup, which is a setup of four speakers positioned around the listener. This setup could essentially be placed anywhere. The evaluation process itself will draw inspiration of the survey done by Tomlinson et al. [6].

4 Timeplan

The implementation steps mentioned above is in this section structured into a timeplan. This timeplan is illustrated as a gant scheme in figure 2. The report of the thesis will be continuously written throughout the project, where one day each week will be dedicated to report-writing.

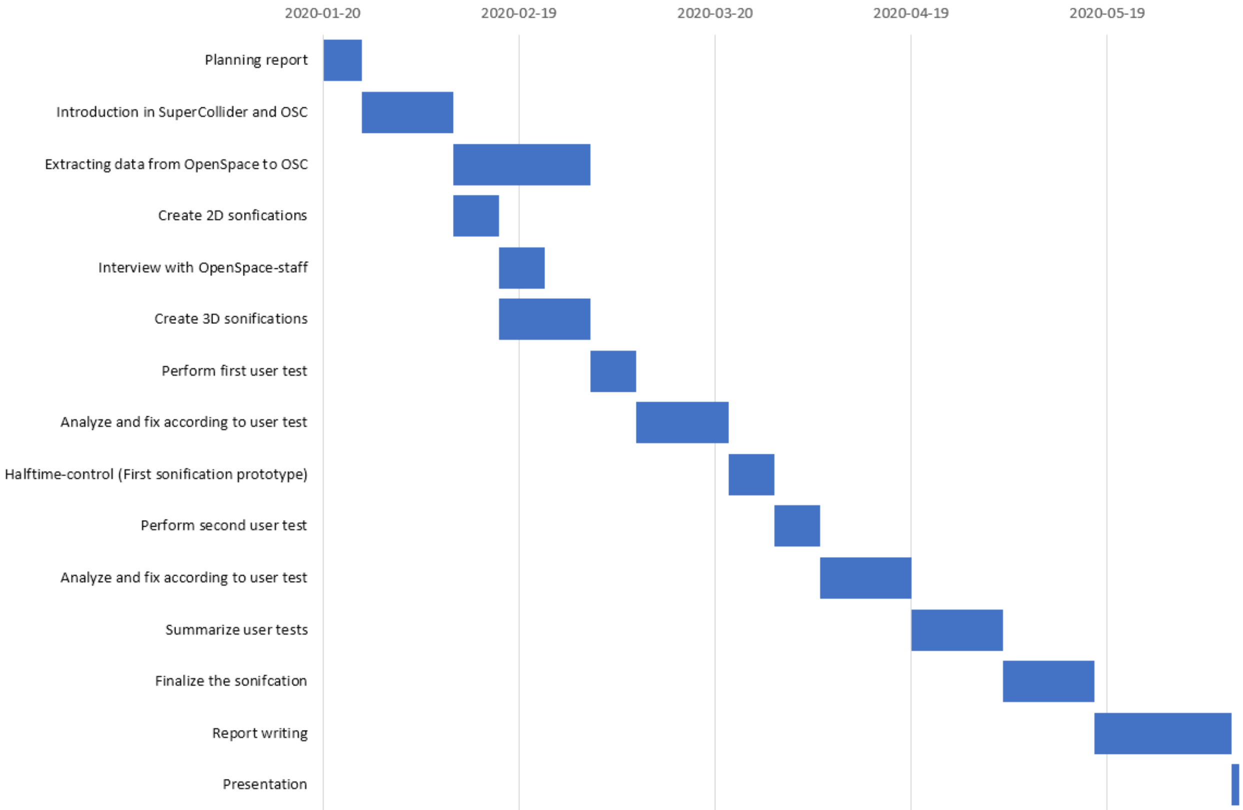

Figure 2: Gant scheme for the timeplan.

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