

Heritage Data Sonification — A Resource for Non-coders

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What is sonification?

Sonification is the process of interpreting and presenting data as audio. Established definitions often highlight the role of sonification as a means to “convey information,” and to “[facilitate] communication or interpretation” of data (Hermann, 2008, p. 1). Sonification is thus an intentional process. It can be entertaining but is not typically for entertainment alone in the way music can be. Hermann (2008) further highlights definitive features of sonification: it is a process which reflects objective properties in data in a precise and systematic manner (p. 2).

Sonification is typically done using a range of coding/sonification specific programs. It can be done using a diverse range of data:

- Images: i.e., photos from the Dura Europos archaeological site c. 1928-1937 (Graham and Simons, 2021),
- Data sets: i.e., a study on climate change and Alaskan yellow cedar trees (Sawe et al., 2020),
- And even live videos: i.e., AI video sonification to teach glassblowing techniques and heritage (Thanou, 2021).

Sonification can be done in pre-made sonification studios or using general coding languages such as

Python. The former option is generally the simplest but most restrictive option. The latter has much more freedom but often requires some knowledge of coding. I used two different programs for the sonifications produced during my placement. The sonification found in this repository was made using Python within Jupyter Notebook and the code found in the first codebook. For my other sonifications, I used a Python-based music-making environment called [JythonMusic](#), created by Bill Manaris. I used Python to sonify a data set, and JythonMusic to sonify two images.

Why is it important?

Sonification is a valuable resource for data representation for many reasons. To begin, it can make complex data more intellectually accessible to non-scientists. It is a multisensory process wherein information is conveyed quicker than visual feedback (Thanou, 2020) while simultaneously requiring the consumer to take the time to listen (Graham and Simons, 2021). Audiences of all intellectual levels, including those who are less scientifically literate, tend to be more sensitive to auditory changes and features than to trends in visual data (Sawe *et al.*,

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2020). This means that sonification can be a more efficient and accessible way to reduce “literacy and numeracy barriers” (Sawe *et al.*, 2020, p. 1) and to present complex data and ideas (Hermann, 2004; Sawe *et al.*, 2020; Supper, 2014). Not only is it important for intellectual accessibility, but it also helps to make data and information accessible to those with visual impairments (Quinn, 2012; Sawe *et al.*, 2020). Data and information can then be equally presented to people of varying visual capabilities.

Going further, sonification can make data more fun, entertaining, and affective. Rather than strictly trying to feed information to people, sonification helps to create a multi-sensory experience in which listeners engage with data in a unique way and draw meaning from their experience. This establishes “the learning process as an enjoyable user experience” (Thanou, 2020, n.p.). Creating an affective experience leads to improved information retention and data-based learning, particularly “when presented through an auditory modality rather than vision or touch” (Sawe *et al.*, p. 3). When listeners *feel* rather than just read or see, they operate in a more cognitively active and retentive way.

How can it be used in heritage?

Sonification brings all the key features addressed above into the heritage sector specifically. It works as a distinctive way to interpret, analyse, and present heritage data, and has potential for use in museum experiences and communication

(Baratè *et al.*, 2022; Graham and Simons, 2021; Supper, 2014; Thanou, 2020). For example, Thanou (2020) describes the potential for sonification-based heritage experiences to be natural, non-intrusive, positive, and enjoyable experiences, and Graham and Simon’s (2021) study fundamentally tackles the relationship between heritage sonification and affect and emotion by assigning emotion profiles to archaeological image sonifications.

Because they are more accessible and active forms of consuming information, sonification-based installations and activities in museums have incredible potential for getting visitors interested in the subject matter, as well as “allowing visitors access to more active, personal and memorable experiences than traditional museum displays” (Supper, 2014). Sonification takes data and uses it to tell an affective story in a way simply reading the data could not. This coincides with museological research that supports storytelling as an effective museum communication method which visitors are more receptive to, and as an important aspect of human cognition (Nielson, 2017).

Key considerations for sonification and for this project

There are several key things that one must consider when sonifying data. Before the sonification process begins, and while it is taking place, it is important to critically consider the data, the actual sounds you are

producing, the various relationships between the two, and the goals of your sonification. Sawe *et al.* (2020) efficiently breaks down such considerations, which they categorise as Data Fidelity, Complexity, and Aesthetics. When considering data fidelity, you must decide what data you use and what data, if any, you leave out. You must reflect on the goals of your data and sonification and decide how important it is to accurately represent that data. Depending, it is sometimes more beneficial to focus on the affective experience of the sonification, even if it is less faithful to the data.

Regarding complexity, Sawe *et al.* (2020) explain that you must consider how many dimensions of your data there are and the subsequent complexity of mapping these to different parameters. It is valuable to consider if and how the data can be simplified while still being accurate enough.

Finally, you must decide on the aesthetic parameters; what parameters will be mapped to what data? What in the data, if anything, decides auditory features such tempo, pitch, duration, dynamics, velocity, and silence? What actual sounds will you use; what instruments? What musical notes or scales? Sawe *et al.* (2020) explains that "because music evokes affective states, deciding how strongly to connect the data to emotional characteristics of the sonification, and in what ways, must be a conscious choice and responsibility" (p. 5). Each of these decisions will affect the end product and listeners' interpretations of it.

What is the point of this project?

When I first decided on sonification as the topic of my project, I was primarily concerned with how data could be used to create more engaging and entertaining experiences in informal educational settings, such as museums or science centres. I wanted to consider the benefits of the sonification of heritage data, as well as the sonification of scientific data for informal learning. One of my first steps was to come up with key questions to help guide my project:

1. What kind of information can be effectively communicated through sonification? Visual images? Physical objects? Data sets?
2. What information is entertaining and engaging for audiences?
3. How can I best represent data through sonification (i.e., what sounds/instruments can I use, what do I prioritise when assigning values, should I focus on colour, mass, size, amount, time, space, etc.)
4. Why is sound/audio a valuable thing to consider when focusing on knowledge communication and informal learning.
5. Why aren't more exhibits and experiences using sonification as a means of supplementing audience experiences? What are the barriers and difficulties associated with sonification?

I began my research to be able to select heritage data I wanted to sonify, to select a program for the actual

sonification process, and to tackle the above questions. I decided that I wanted to tackle the topic of space heritage as it is a novel and under-addressed topic. I wanted to focus on building an affective experience with my sonification as opposed to data representation alone. I quickly learned, however, that many sonification methods and guides are extremely inaccessible to heritage professionals without any experience with coding. Not only that, finding legible and usable data is often an overwhelming and difficult process.

Because of this lack of sonification resources targeted at non-coders, many heritage professionals who want to utilise sonification will be disproportionately disadvantaged. For those without experience in handling potentially complex and convoluted data sets, making the data workable is also a challenge. If they are unable to solve these issues and decide to turn to someone with a background in coding, they risk becoming removed from the interpretation, design, and presentation process.

The above issues led to this codebook. I eventually discovered a sonification guide video which I found accessible enough for non-coders (Matt Russo's [Sonification with Python](#)) but there were still many things within the code I found confusing or wished I knew more about. I ran into some common errors which I then had to solve. Making my chosen data set was also a laborious process. Because of these factors, this codebook includes the code I adapted from Russo's sonification guide, including extra

comments, information, and steps. I also include code I used to make my data set usable within the sonification.

It is my intention, then, that this codebook serves as an accessible resource for those without experience in coding and who want to sonify data. It aims to supplement Russo's guide, following and customising his code while further breaking it down. It further explains terms and code that I found confusing, adds and changes code in places to make it less confusing or to fix errors, and breaks down the process I had to go through to make my data workable. This is all so those in the future starting in my position have the sort of resource I wish I had when I began.

What did I hope to achieve with my sonification?

While the codebook is a fundamental part of my project, equally as integral were my actual sonifications which I created in conjunction with working on the codebook. Using the code and data found in this repository, I was able to successfully sonify satellite data showing the cumulative number of space debris objects in orbit from 1958 to 2023.

My aim was to address the topic of space heritage, which space debris is an important part of, and to consider the potential impacts of increasing numbers of debris objects in orbit. This is a unique and relatively novel area of archaeology and heritage, arguably pioneered by archaeologists such as Alice Gorman (Gorman, 2005; 2009).

Gorman has critically considered the dichotomy of space debris as a “serious threat for the continued provision of satellite-based services, such as navigation, telecommunications, meteorology, and earth observation” and space debris as objects of “social, historical, aesthetic, and scientific significance for nations, communities, groups, and individuals who will have an interest in decisions made about their long-term survival” (Gorman, 2009, p. 382). Space debris brings challenges commonly faced by other forms of heritage, such as the potential for salvage or tourism. It also brings the challenge of finding a balance between preservation and mitigation, between heritage and pollution.

One aim of my sonification was to audibly convey this tension, the build-up of human presence and heritage in space, as well as the build-up of “noise.” I chose to map both volume and pitch to the cumulative number of objects. As the amount of space debris went up, the volume increased and the pitch fell lower and lower. Once I had my .midi file, I used the Digital Audio Workstation (DAW) [FL Studio](#) to further customise the sonification. I copied the sonification across three tracks and chose synth-like instruments for two (to add to the atmosphere of the space-themed data), as well as a music box for one track (to add a “twinkling” feeling symbolic of stars). As the volume increased and the pitch decreased, an intensity grew which drowned out the twinkling. The choice to add twinkling to the sonification, knowing it would become less noticeable as debris

increased, served to symbolise the potential for pollution around our planet to impact visibility.

Through this sonification, I hoped to take a topic that people might not think about, space debris and space heritage, and to make it an engaging experience. It is one thing to try and read the complex numbers and another thing entirely to listen to the data and consume it in an accessible and thematic way. While staying true to the trends shown in the sonification, I built a layered and affective listening experience which told a short story about the progression of one aspect of space heritage.

Supplementary Sonifications

Finally, it is worth mentioning that while this codebook and this particular sonification were the parts of my project that I was most concerned with and which took the most time and effort, I also created two other sonifications of images using the JythonMusic program. Similar to this codebook, I took code from the JythonMusic website that was specifically for image sonification, chose a theme and images that fit within that theme, and made them workable within the code. I was able to alter the code as well to create the desired effects for my sonifications.

I first messed around with the code using images of black and white stripes so that I could figure out how the images were being sonified (i.e., what pixels, what direction, etc.). I then made my own specifications using my chosen images. The images I chose

came from Reuters, comparing the City Hall of Sarajevo after it was bombed in the 1994 Bosnian Serb siege to its restoration in 2014. The resulting sonifications, in comparison to one another, provided valuable insight into the images and the effects of war on heritage sites.

Once my sonifications were complete, I had the opportunity to create an experience in which I used the University of Southampton Digital Humanities' immersive audio-visual Igloo to showcase the images and their sonifications. This can be found in the repository.

Key Resources

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