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BACHELOR THESIS

Data Sonification: Approaches, applications, and limitations (with implementation in Python)

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Declaration of Authorship

I, Vladyslav VELYCHKO, declare that this thesis titled, "Data Sonification: Approaches, applications, and limitations (with implementation in Python)" and the work presented in it are my own. I confirm that:

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"All poets write bad poetry. Bad poets publish them, good poets burn them."

Umberto Eco

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Abstract

One of the main tools for solving complex problems is changing the perspective. Finding ways in which you can explore data from a diferent standpoint. Visualisation is core of data exploration, it's efficient way to communicate a huge amount of information with relatively simple representation, in a way it's compressing text/tables/numbers into more efficient pictures. But the main question of this thesis is what you do when you can't use visuals, are there problems for which other perception organs will do a better job, and why we are so centered around our vision. In particular, this work is about Sonification and aimed to find what people are missing not using audio to the full extent, but also describe the creation of a simple extendable tool for sonification and some background of its development.

The developed Python library can be found on GitHub: link

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List of Abbreviations

LAH   List Abbreviations Here
WSF   What (it) Stands For

Physical Constants

Speed of Light $\quad c_0 = 2.997\,924\,58 \times 10^8\,\mathrm{m\,s^{-1}}$ (exact)

List of Symbols

a	distance	m
P	power	$W\ (J\,s^{-1})$
ω	angular frequency	rad

Chapter 1

Introduction

Sharing knowledge is an important ability, that humans and not only humans, developed via evolution. It is such a powerful skill mainly because you don't need to fight a tiger if you know when it will come and leave before that happens. In a way, our whole world is just a compilation of physical senses which is also information. Once it's obvious the whole species working on the same thing – information. At first simple signals, screams, signs, drawings. Later language, clothing, symbolic systems. Then post offices, telegraph, phone, Internet. The whole purpose of humankind started to grow around the idea of knowing to do "what?" and "when?". Huge evolution algorithm that collects data about how to live longer and happier. But when you collect data, you need somehow to store it and to share it. Because it may be easy with a small amount of information like a presence of a tiger, but it becomes harder and harder. Now we have huge complex systems that answer our questions. Sadly computers now can answer our questions much faster than we can ask or understand the answer. Of course, at some point, we will develop a neural interface that will make our IO magically fast. Or maybe a computer that will ask other computer questions, so we will need to only hear the answers to our abstract questions like: "Why am I such an awesome human and dolphins are stupid?". Until then we need to work on our data transfer and get the most from our eyes, noses, ears, etc. Eyes already have most of our attention [Hut19], so my choice lands on ears and hearing. So how to pass information by hearing, of course, there's language and speech, but it's a more appropriate topic for a linguist and not something new. Our task is to find some semiotic apparatus of sound similar to one for visualization. Data visualization is a set of disciplines that studies ways to communicate data graphically. Same for a sound there is Sonification.

Chapter 2

Sonification

To give a definition we should decide the terminology. There are three words that describe communicating data via sound without verbal signals. Audification, sonification, and auditory display. But for simplicity, we will work with the term Data Sonification. Data sonification has a lot of different definitions, mostly because it's hard to draw a line where sound representation is not a sonification anymore. Obviously, most people when to hear sonification and probably visualization will think about some direct mapping of data to some sound parameter, for example, the amount of precipitation is the frequency of the sound wave (pitch). But this mapping might be indirect and guided with some complex algorithms. Or some previous experience can be associated with data representation. Complex models may appear if you decide not to map data, but create a soundscape to give the user a feeling of the data. David Worrall in Sonification Design developed his own definition of Data sonification.

> "Data sonification is the acoustic representation of informational data for relational non-linguistic interpretation by listeners, in order that they might increase their knowledge of the source from which the data was acquired." [Wor19]

It should be noticed that its definition of data sonification and not sonification in general. Worrall combined definitions from multiple previous works to create a boundary for this topic. It is different form the sonification or the auditory display as those terms may have much wider or complex semantic connections. Also, this definition includes "non-linguistic" to separate sonification from linguistics, it may be compared to a less abstract level of programing if language is a programing language then sounds are simple primitive instructions or even electricity itself. The second important part of the definition is "might increase the knowledge of the source from which the data was acquired" it is important to state that the aim of data sonification is to communicate information gathered from raw data. Of course, this description doesn't explain the ways data can be communicated through sound. Mainly this is because sonification has its own separate types and sound has many parameters to tweak. I will describe sonification types based on two sonification books [Wor19] and [HN11]

Bibliography

[HN11]   Thomas Hermann Andy Hunt and John G. Neuhoff. *The sonification hand-book*. Berlin Logos Verlag, 2011.

[Hut19]   Fabian Hutmacher. "Why Is There So Much More Research on Vision Than on Any Other Sensory Modality?" In: *Front Psychol* (2019). DOI: https://doi.org/10.3389/fpsyg.2019.02246.

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