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Sounding out the System: Multidisciplinary Web Science Platforms for Creative Sonification

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In this paper, we present our initial findings in using digital methods to consider the way that different devices can connect to the same object. We take a more experimental view of the ways in which network data might be used in compositions to help us to move beyond traditional sonification techniques into more musical territories which enables us to start to understand the ways in which archival data and tools might be used as a creative response to the data and provide a more human way of engaging with the data archive. Such approaches can inform the ways in which future research platforms for Web Science can be developed in a truly multidisciplinary way which matches the needs of the wider research community and supports public engagement.

CCS CONCEPTS • Human-centred computing • Applied Computing • Arts and Humanities Computing

Additional Keywords and Phrases: Sonification, Networks, Mobile Devices, Tool Criticism, Web Science

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1 Introduction

Sonification, the transformation of data relationships into non-speech sound [9], has long been associated with understanding the machines and networks. Listening to the static on transistor radios and placing hoot commands into the programs to aid comprehension preceded domain specific languages that were used to understand running machines [1,2], to aid in network security tasks [10] or to raise awareness of trackers [11]. Analogue phone networks were explored by phone phreaks through both designed and re-purposed tools [3], such as a whistle. Digital methods [4] can be used to explore the network connections from the perspective of studying both technical and social questions raised by a reliance on understanding and engaging with digital technologies.

In this early research we draw on these traditions as well as incorporating an Experimental Digital Humanities [5,6] perspective which enables us to engage with the digital world in a more novel way (*see* Figure 1, *Pen Dinas in Voice*, an Experimental Digital Humanities inspired composition). This approach encourages different more experimental ways of the understanding and responding to the data created, the system and the languages being used. We build on our previous work in reflecting the way that the

sonification of the network backbone [7] as noise could be used to represent the growth of Internet use.

As part of the research, we have been working with the artist-researcher Alan Chamberlain [1]to take a more experimental view of the ways in which network data might be used in compositions to help us to move beyond traditional sonification techniques into more musical territories which enables us to start to understand the ways in which archival data and tools might be used as a creative response to the data and provide a more human way of engaging with the data archive, either in terms of a musical piece or embodied physically in IoT- based applications. In this project we have started to explore those responses and although we can only discuss this work in short, we would like to raise it, as such approaches can inform the ways in which future research platforms for Web Science can be developed in a truly multidisciplinary way which matches the needs of the wider research community and supports public engagement.

These techniques are in many senses 'experimental', but at their foundation is the notion that these works can offer a way for researcher's to translate their findings and practices into different domains, for example composition and the outputs of these creative experiments act as a way to engage the public in scientific debate and enable the researcher to understand the implications for their work and in doing so develop a deeper understanding of the problem which engenders new research. In many respects it requires the researchers involved in this form of research to be open and radically engaged with a mix of methods which go beyond research in a traditional sense, requiring the researcher and artist to engage in each other's disciplines and ways of working.

In this paper, we present our initial findings in using digital methods to understand the different ways that devices can reach the same website. Sonification is used as a method of comparative reading and to consider the method as a representation. First, we present our experiment to listen to network connections before discussing the existing work and related discussions.

Figure 1. An image from "*Pen Dinas in Voice*", composed by Chamberlain 2019. Performed at Bangor Music Festival and shown at "Living with the Internet of Things" Tate Modern. Using Numbers into Notes software developed by Dave De Roure.

2 Listening to Connections

In this section, we outline the process used to get the data and prepare it for sonification and composition. We used three different devices, two phones and a laptop, to connect to a particular website to understand how the network is constituted by device and connection type. This raises questions about how the connections are related and the entities involved in providing the connection. One phone used its 4G connection and the other, WiFi. Each device had a packet capture programme running on it and all used the Firefox browser to make the connection for about four minutes. The two phones used the tPacketCapture application to monitor their connections and the data was written to the used device before being connected to a laptop to remove the data. The laptop had tshark running when the connection was made to the website to record the traffic. The text files, created from using tshark to convert the data and extract the Internet Protocol (IP) addresses and times, are processed using Python to apply different parameters to the data [12].

[1] Alan Chamberlain – For an overview of Alan's work see https://alan-chamberlain.tumblr.com/Music

These files create midi files which, can be used by Alan in his compositional practice.

3 Discussion

Sonification is challenging when we use the technical approaches that we have outlined in the earlier part of the methodology. In using mobile devices with different types of connection, we can think about comparative readings to listen to understand the differences and similarities in the datasets. This moves towards rethinking the relationship between human and machines, not only in studying networks but also being social machines [13]. In expanding upon this relationship, we need to consider the interactions between human, machine, and the music – the creative process and the ways in which people might engage with the data, their workflows, and the tools that they need to create to create music. In this respect the Web Science tools, and platform become the interface between technologist, archivist, curator, scientist, and artist.

The sonification allows us to consider the notion of time within a research method. The times derived from the data stream reflect the machine-based time stamps that we can use to understand but also to manipulate to support comparative readings. As the devices were run at different times, it is possible to align the timestamps to support them being played in tandem with similar sonifications. In calculating the offset between the current time and start time, we create the possibility to compare two or more time series, such as comparing how two phones using different networks. Design challenges are raised to understand how to represent the time in music or sonification and to reflect on it in the original data. It might be sped up to create a macro view to focus on a pattern that has less detail about events or slowed down to allow a micro examination of a section or event rather than showing the trend. The context may also derive a constraint on time, for instance the timing of connections in either engineering or security contexts. As audio is temporal, sonification supports a consideration of how time matters are considered and the relationship between human and machines.

When the connections – such as the browser and website or servers that manage the data – are made between the machines, they create streams rather than being a singular stream. Using different channels, these connections can be represented in time and to explore these relationships. The data suggests a form using the source and target IP addresses along with the connection streams. As it is presented, we look at the IP addresses, but it may be fruitful to place this within the companies associated with the host addresses and to tag these to understand their role, such as hosting or service provider, within the web. This sound design becomes a watershed where experts can engage to create a shared language that draws from Web Science and sound. This can be used to sonify the trends using a domain language or to sonically explore the data. This develops a further set of options to create representations such as phrases or particular frequencies that could be extended for work on IoT devices.

This gestures towards considerations expressed in critical visualization. In identifying the differences between the representation and the underlying network object as presented through the tool, Daniela van Geenen and Maranke Wieringa [8] explore the role of algorithms in creating visual layouts of networks. This can be reframed to raises a fundamental question about is being heard and how it is understood as an epistemic object. Algorithms and designs can be used to create the heard audio, but it is a representation of the network object taken from the data. When the music is heard, the various times and notes are a product of a social machine that is an invitation to engage with the data to understand an event. We contend that these considerations become part of the design process that is undertaken to represent a digital object to enable a critical view.

This critical view places the platform into the space of a boundary object, allowing multiple researchers to appreciate the ways in which content, data and tools are used by a range of researchers. Issues such as temporality, timing and trust are not only fundamental to security research but are factors that are core to a range of musical contexts, as they are to historians, archaeologists, sociologists and designers. In appreciating the foundational interconnected nature of research platforms and their role in numerous disciplines we can start to appreciate the way that we might look towards both developing software and approaches to working with these tools and develop theoretical frameworks that let us start to conceptualise how we might archive systems and the full gamut of

responses to these socio-technical systems in the future.

4 Conclusion

We present our work in progress on the comparative sonification of network connections from different devices in different conditions. Using tools to enable a reading of the data allows us to think about the types of language used in the representation and the objects being studied. Our future work has two distinct research approaches; firstly, we will continue to explore the languages required to create the representation as well as using sonification as a way of re-presenting the network as a series of temporal snapshots to understand how the network and its edges change over time. Secondly, we aim to expand upon our current 'experimental' creative use of the midi files which can be created by the system to create pieces of music, examine the creative opportunities afforded by the technology (in real-time and archival) and start to look at the ways in which 'network noise' can be used in compositions to explore musical notions of improvisation, create Sound Art pieces which represent the 'invisible' state of the network (e.g. a cyber-attack or IoT-based technologies interacting with one another) and be used in an aleatoric way to develop music which goes beyond mere sonification, allowing people understand, what this might sound like from a human perspective, something that might give the listener an emotional response. We would hope that this might inform people's response to archives and data. A future step may be to embed such approaches into IoT technologies and develop automated audio responses which are constantly generating streams of audio, or useable midi streams.

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