INTERPRETING DATA THROUGH CREATIVE AUDIOVISUALISATION (IDCA)

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ABSTRACT

This paper will present recent work on a year-long research fellowship entitled Interpreting Data through Creative Audiovisualisation (IDCA) undertaken by the Professor Louise Harris (University of Glasgow) in collaboration with colleagues at Oxford Brookes, The University of Luxembourg and The University of Dundee. Three specific strands of the research will be discussed, each exploring a distinct dataset. The relative success of each of these phases, with respect to both the scientific processes in which they were embedded, and the development of Professor Harris's personal creative practice will be discussed, with particular reference to the development of the key compositional strategy, *Composed Audiovisualisation*.

1. INTRODUCTION

The Interpreting Data through Creative Audiovisualisation (IDCA) project built on a small, Scottish Crucible-funded pilot project that developed an audiovisual approach to data exploration in the field of epigenetics. This involved audiovisualising mutations in the genome sequence of breast cancer patients and utilised a well-understood dataset to identify whether audiovisualisation yielded additional insights. Professor Harris and her collaborators discovered that certain pairs and trios of chromosomes developed mutations at the same point in the sequence; something only noticeable when the sequences were presented temporally through the creation of audiovisual compositions that utilised the data.

Extending from this initial study, in this Fellowship Professor Harris worked with researchers based both within Scotland and further afield, including Dr Louise Marryat (Health Sciences, Dundee), Dr Olga Barrera (Mechnical Engineering, Oxford Brookes) and Dr Jun Pang (Machine Learning, University of Luxembourg). Harris developed systems to audiovisualise the data provided by each of these labs, with the intention of revealing trends, patterns or other information that it is not possible to demonstrate through either visual or sonic representation in isolation. Further, as each of the datasets utilised were of a distinct type, this allowed for an assessment of the applicability of audiovisualisation techniques to diverse research processes. The primary focus of the fellowship was on the development of the author's individual creative practice through processes of data audiovisualisation, but the collaborative component has laid the groundwork for larger-scale future projects.

The fellowship had three main objectives:

1: To produce and exhibit engaging audiovisual artworks that communicate and analyse large-scale data sets;

2: To establish audiovisualisation as a method for data exploration across diverse scientific disciplines, and as a compositional strategy in the field of audiovisual arts;

3: To engage the public in cutting-edge arts-science collaborative research, through exhibitions, festivals and installations of these works.

This paper will consider the success of each of these objectives through a consideration of two specific elements of the fellowship.

2. A TRANSPERCEPTUAL APPROACH TO THE KNEE MENISCUS

The first strand of the project emerged out of a European crucible collaboration with Dr Olga Barrera, a reader in mechanical engineering at Oxford Brookes, Dr Jun Pang, an assistant professor in Computer science at the University of Luxembourg and Dr William Peveler, a lecturer in the school of chemistry, also based at the University of Glasgow.

This pilot project was relatively small scale, looking at the possibilities of taking an audiovisual approach to representing data associated with the knee meniscus.

Complex soft tissues, such as the knee meniscus, play a crucial role in mobility and joint health but are incredibly difficult to repair and replace when damage due to the highly hierarchical and porous nature of the tissues. To design tissue substitutes, the internal architecture of the native tissue needs to be understood and replicated and this phase of the project aimed to try to enhance some of this understanding through taking an audiovisual approach to the data.

The methods used both imagery and sound generated from each image of the knee meniscus to rapidly compare

and contrast the porosity and pore size within the samples. It then tested a generative adversarial network (GAN) on 2D image stacks of a knee meniscus. To understand how the resolution of the set of training images impacts the similarity of the artificial dataset to the original, the GAN was trained with two datasets. The first consisted of 478 pairs of audio and image files for which the images were downsampled to 64 × 64 pixels. The second dataset contained 7,640 pairs of audio and image files for which the full resolution of 256 × 256 pixels was retained, but each image was divided into 16 square sections to maintain the limit of 64 × 64 pixels required by the GAN.

The intention of this stage of the project was to assess whether it was possible to train the GAN to reproduce image analysis results when being trained by the sonified data and if, by extension, it might then be possible to use artificially sonified data (i.e. algorithmically generated rather than working from a direct meniscus sample) to build a huge catalogue of possible outcomes for porosity, pore size and tortuosity and, by extension, a more complete picture of the functioning of the knee meniscus. The results showed close adherence between the original audiovisualisations and those produced by the GAN, with a mean variance in each of the parameters of between 4 and 8 percent.

Although this is still very early-stage work, these results suggest that an audiovisual approach has the potential to be extended to larger datasets to explore how similarities and differences can be audibly recognized across multiple samples. The results of the study were recently published in Frontiers in Materials [1], and there are plans in place to take this work onto its next logical step.

3. GROWING UP IN SCOTLAND

Phase 3 involved utilising data from the Growing Up in Scotland project [2]. GUS is an ongoing longitudinal study, following up 5,217 children born in the 2004/5. The study is led by NatCen Social Research and funded by the Scottish Government. Every 1-2 years children and their families are asked a range of questions including on health, education, relationships.

Mental health data from GUS for the mother and child, respectively, were used to create both the sonic and visual components of the work. Mental health data for the mother was self-reported and comprises two different scales: the Depression, Anxiety and Stress scale (when child is aged 2 and 4 years), and the SF12 mental health component (when child is aged 10 months, 3, 5, and 10 years). Mental health data for the child uses Goodman's Strengths and Difficulties Questionnaire (SDQ) Total Difficulties score, completed by the parent at ages 4, 5, 6, 8, 10, 12, and 14 years.

In the audiovisualisations, each reported score has a particular pitch and rhythmic pattern associated with it and the mother and child scores, in pairs, are clustered together in groups by colour, with maternal mental health represented by circular shapes and child mental health represented by conical shapes. Increasing amounts of distortion, dissonance or interference in the audio component, alongside increasing size and motion in the visuals, indicates higher scores on the relevant utilised scale. The system built for this work allows representation ranging from individual mother-child pairings up to a complete, simultaneous representation of all the mother-child pairings in the study for whom there is sufficient data. The most extended creative realisation of the work involves a 6 screen, 36.6 (scalable to 6.1) speaker audiovisualisation intended for expanded audiovisual format installation, in which each screen is representative of a particular urban or rural population area in Scotland, from inaccessible rural to accessible developed urban. Exploration of the data in this way allowed for a clearer representation of the mother-child pairings and their relative MH scores and, as one of the GUIS researchers put it "you can really see and hear the distinct clusters around each person's mental health". This preliminary work suggests significant potential for development, as both the audiovisualisation methodologies and the creative outputs for this phase are still in development.

3.1. Composed Audiovisualisation

It became clear as the fellowship progressed that the compositional results achieved through direct mapping of the datasets to elements of the compositional model - such as pitch, rhythm, timbre, etc – were yielding results of limited compositional satisfaction (for the composer at least). Whilst there was a clarity and legibility to this approach for the benefit of the science researchers, that legibility often came at the expense of realizing genuinely interesting and engaging audiovisual compositions. Consequently, alternative methods were sought and the example presented at this conference is an embodiment of one of these methods; specifically *Composed Audiovisualisation*.

*Composed Audiovisualisatio*n (CA) can be seen as an extension of an existing compositional strategy developed by Professor Harris called *Algorithmic Aleatoricism* (AA), and it would be useful here to first define this approach before discussing how CA can be seen as an extension of it.

AA is a compositional method in which the overarching plan of the composition is defined algorithmically – in this case, through a max patch - but the fine details (rhythm, pitch, timbre, velocity etc.) rely to some extent on chance. In AA, Meyer-Eppler's presentation of aleatory processes is most instructive – "a process is said to be aleatoric . . . if its course is determined in general but depends on chance in detail" [3]. In previous works (see [4], [5]) AA has been used as a way of both controlling, and not controlling, the audiovisual outcome; a compositional design is mapped out, usually involving an algorithmic process for many of the formal elements, but much of the fine, internal detail is defined by chance-based procedures.

Within CA, in this particular example the algorithmic element is provided through the mapping out of a composition of a fixed duration in Max; this includes number of voices (defined by number of streams in the data) and the basics of rhythmic, pitch and timbral change, whilst the patch cycles through a series of rules concerning when/how it is able to make changes or move through the compositional

structure. The aleatory element is provided by the dataset utilized – in this case mental health data from the Growing Up in Scotland project – to intervene, shape or alter the algorithmic basis of the composition. This might include when a voice begins, how it evolves over time, it's rhythmic/pitch/timbre, levels of dissonance etc; the dataset can control one, or many, of these things to a greater or lesser extent and this is, in itself, chance-based.

The implementation of CA in this phase of the work precipitated compositions which, for the composer, were both more satisfying to compose and more convincing as finished works in their own right. There were impacts with regard to legibility; approaching the compositions in this way made it more difficult to discern obvious changes and trends in the data, and consequently, further etxneisons of this work would seek to combine both the legibility of earlier stage, direct mappings alongside the compositional subtlety and interest afforded by CA.

4. CONCLUSION

This fellowship attempted to develop genuinely meaningful arts-science collaboration, with potentially significant impact for all the disciplines involved. It aimed to offer a unique mechanism for marrying creative processes in data exploration and audiovisual composition in ways that contribute to the research processes of both the author the scientists she worked with; specifically, it intended to assess the potential to embed these processes of data audiovisualisation into scientific enquiry at a more exploratory stage, and lay the groundwork for developing an entirely new method of data exploration that is significant to both the arts and science disciplines involved.

To revisit the aims of the project:

1: To produce and exhibit engaging audiovisual artworks that communicate and analyse large-scale data sets;

The project afforded the opportunity for fully integrated arts-science collaboration, through detailed consideration of what an audiovisualisation of data might look and sound like, not only from a practical and perceptual perspective, but also from an aesthetic perspective. The need to create an audiovisualisation that was useful to the research underlying the data was considered as being of equal importance to producing creative works that were engaging, aesthetically rich and in keeping with the research trajectory of the author's creative practice, particularly her development of engaging, coherent and decipherable audiovisual works for a general audience.

This was successful, at least to an extent. Certainly, methods were established for working in this way, and pathways were opened for extending each of the phases of this project further. However, with only a year and a single researcher engaged in the work, the results were necessarily limited and require significant further development for their potential to be fully understood.

2: To establish audiovisualisation as a method for data exploration across diverse scientific disciplines, and as a compositional strategy in the field of audiovisual arts;

One aim of the fellowship was to determine whether processes of audiovisualisation can be used to meaningfully represent and interpret a range of scientific datasets. As has been discussed, there is significant potential to further extend each of the elements of this work, but as yet there is not enough evidence of significance to establish this methodology as fully viable and transferable for data exploration. During the coming years, the work of the fellowship will be disseminated as a series of open-source software tools through github, to allow artists and researchers not directly involved in the project to date to engage with the processes and apply them to other areas of research.

3: To engage the public in cutting-edge arts-science collaborative research, through exhibitions, festivals and installations of these works.

Events such as ICAD2024 are key to this project aim, and there are a number of conferences, talks and residencies planned in the coming two years that will disseminate the work further. One principal realisation from this project is that there are simply too many competing elements involved in facilitating work of this kind to successfully be accommodated by a single creative researcher – as a consequence, follow-on funding is being sought to support small research teams, consisting of a combination of artists and science researchers, who will consider a specific data problem and attempt to develop audiovisual solutions to solve it. This should provide a more systematic approach to assessing the value of interpreting data audiovisually, and lay the groundwork for more extensive studies in future years.

5. REFERENCES

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