SuperLattice

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Summary

SuperLattice documents the creation of a hybrid structure that combines human perception with computational methods of processing information. Through *SuperLattice* I showcase the malleability of data and highlight the creative and narrative choices that are implicit in the recording and presentation of information.

The artistic work accompanying *SuperLattice* is designed to manipulate data and detail how narrative structure and didactic text have the power to transform the meaning of data. To an extent *SuperLattice* is inspired by Angela Carter's novel *The Infernal Desire Machines of Doctor Hoffman*, with the exhibition taking the form of a futuristic Wunderkammer or cabinet of curiosities. Through projected light, mechanical devices, ephemeral and historic objects I intend to reveal the simultaneous reality and unreality of data, asking questions about how this data constructs our perception of the world around us and how this perception is affected by the errors, biases and glitches that alter information.

Acknowledgements

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As a non Canadian I am lucky to have found an amazing support network of friends who have enabled me to feel happy, welcome, creatively inspired and well fed. Thank you!: Amahl Arulanandam, Angus Tarnawsky, Bekah Simms, Evan Bowen, Katika Marczell, Robb Oates and Myles Braithwaite.

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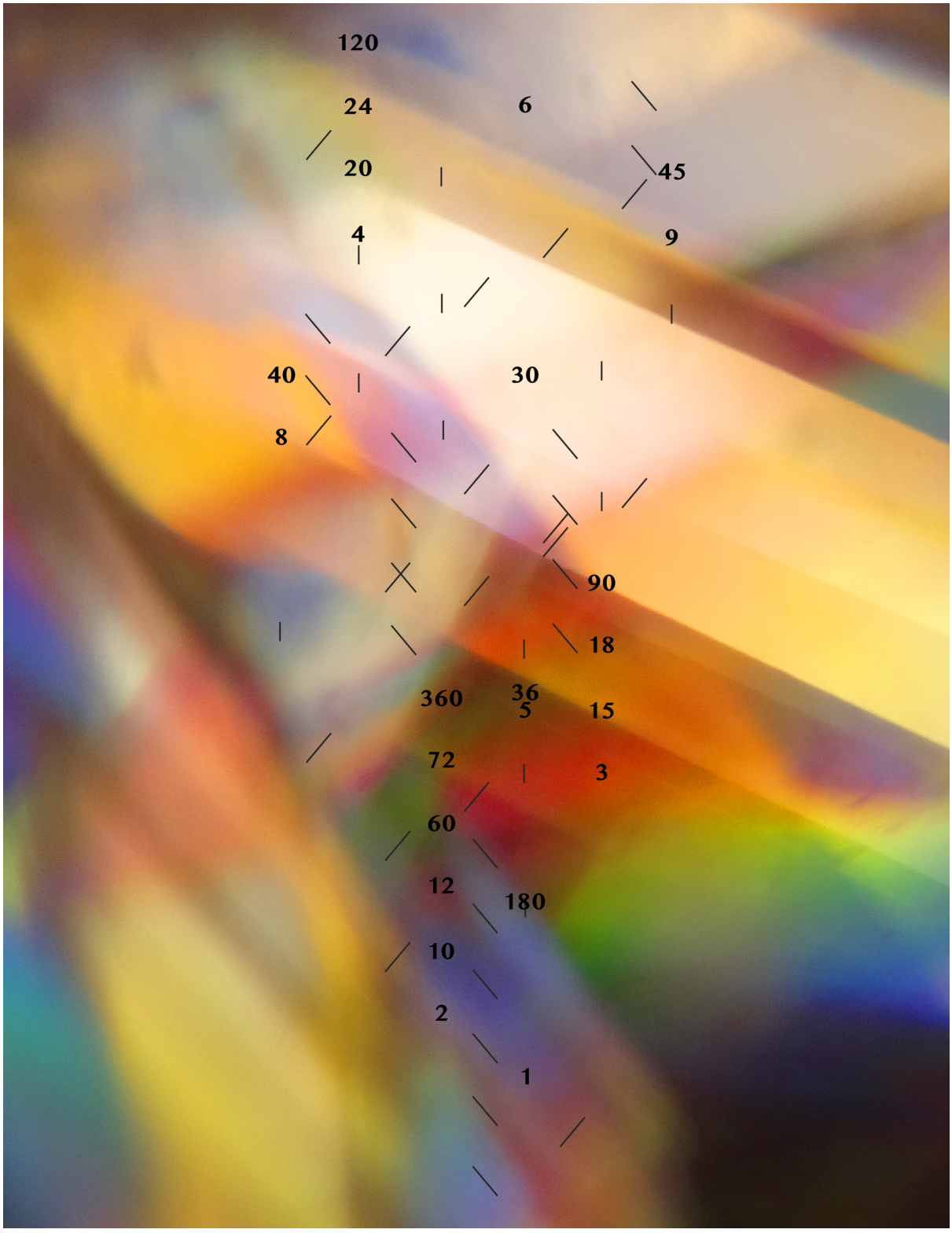
Table of contents

List of figures

Figure 0. A Score for Navigating Crystals

The interior of a calcite crystal and the first image recorded in my journey towards *SuperLattice*



1: Humans as Sensors

Humans are sensors.
We collect information through our eyes, ears, skin, nose and mouth.
Our brain is a processor, taking this information and compiling it into our experienced realities, storing this information for future recall in the form of memories.

As sensors humans have limitations.
We only have access to tiny parts of the vibrational spectrum of light and sound.
Our methods of compiling information are based around past experiences and a wide array of diversity in our cognitive apparatus results in subtle to large differences of interpretation by different individuals.

We imagine that our senses are fixed, un-malleable, rooted in the same perceptual spectrum as everyone else, but this is wrong. Around 4% of the world's population experience synesthesia — experiencing the stimulation of one sense through a second sense removed from the stimulus. For example, associating colour in the visible spectrum with smells, tastes or sounds. Even without synesthesia, we can be confused by our senses, and experience visual and auditory illusions.

Technology enables us to expand and remould our senses. Vibrations applied to the tongue through electrodes allow the blind to see and a growing number of people identifying as cyborgs augment their bodies with custom sensors and machines.

Through a structure called SuperLattice we can expand our senses beyond simple forms of sensory translation, creating perceptual synesthesia where multiple forms of information can be experienced as one.

2: Introduction

I am interested in how sensory information is translated and mediated through technology. We have the potential to access this data in any way we choose but we stick to familiar forms. For example viewing visual information in the form of pixels and hearing the vibrations captured by microphones played back at standard audio rates. I find the idea of manipulating and translating information into forms far from their origin extremely compelling as this presents the possibility of engaging with the same data set in many different ways.

My current work focuses on data and the stories that we extract from information, particularly data from astronomy, physics and the environment. Often these stories are sculpted and mediated by other parties, often invisibly. These decisions can be as simple as removing an unhelpful variable to reduce noise and increase legibility or as dramatic as choosing to filter or not to display information that doesn't harmonise with a particular viewpoint or with an organisation's overall message.

Some of these stories are constructed by applying scientific theories and analysis, some through history, tradition or politics, or through literature and other ways of combining information into a narrative.

However stories are constructed, each method incorporates various assumptions and biases — some of which are evident, but many of which are hidden. As someone who is fascinated by sound, science and space exploration, I was extremely excited to listen to data sonifications (information translated into sound) taken from space probes and radio telescopes. However after listening to these recordings I found myself with more questions than before.

- How was this sound collected?
- What processes were used to record and present this sound?
- How do presentation methods and media dissemination strategies affect the way listeners hear and interpret this sound?

Media representation of data sonification is not very transparent, often invoking the idea that the sounds are acoustic, real time representations of the phenomena they represent, when in fact this is an impossibility as sound is unable to travel in the vacuum of space.

Through research I was able to find scientific papers and large quantities of open source data from organisations such as NASA. This provided a window onto my first question of how these sounds were collected — sensor readings parsed into spreadsheets. However there were very few details around how this information was transformed into sound.

This lack of accessible information led to me attempting to develop sonification systems that could mimic and improve on the sounds I had heard. I found a number of methods of converting information to sound, many of which were quite simple and involved directly scaling numbers into audio signal or midi range.

Since this point much of my work has focused on using data as raw material and asks questions about how this information is perceived after it is manipulated and altered. An area of special interest for me is how overlaying a narrative can change viewers' relationships to the information they are experiencing. Through my work I seek to showcase the malleability of data and highlight the choices that are implicit in the recording and display of information as well as amplifying errors in technology and translation that are manifest within data sonification and visualisation.

By probing the way sensory information is translated and mediated through technology, I ask questions about data and the way it's used to present stories:

- What happens when we let the form of our information become more malleable, presenting it in different mediums such as art?
- What happens when we access images through sound?
- What happens when new layers of meaning are added through combining and convoluting data sets?

I have developed a structure called the *SuperLattice* to think about these malleable forms of data. A *SuperLattice* is a multidimensional object created from computer code and datasets to build a hybrid structure consisting of a series of layers. Each layer contains a grid of information stored in a similar manner to a two dimensional array — a computational structure used to store data.

These layers of information can be combined and recombined in different orders, and layers can be removed or added, making it easy to transform the constituent parts of information into something new.

The idea behind *SuperLattice* is that objects and systems are made up of multiple simplistic behaviours that when combined form complex and emergent behaviours that we perceive as form. The *SuperLattice* allows the potential to create new ways of relating to seemingly overwhelming quantities of information, and to explore new possibilities that emerge from interactions between the layers of information.

My conceptual inspirations and influences in developing *SuperLattice* are described in section 6, while section 7 describes the evolution of *SuperLattice* through iterative cycles of experimentation. The example below details a *SuperLattice* created through combining satellite imagery with the genome of a virus. In this example I create a height map from the nucleic acid sequences (represented by the letters GACT) of an Adenovirus and apply this to a series of open source satellite images. The resulting image is distributed across four levels, each representing a specific nucleotide.

Figure 1. Creation of a *SuperLattice*

Adenovirus DNA sequence (cropped)

```
   1 cctatctaat aatatacctt atactggact agtgccaata ttaaaatgaa gtgggcgtag
  61 tgtgtaattt gattgggtgg aggtgtggct ttggcgtgct tgtaagtttg ggcggatgag
 121 gaagtggggc gcggcgtggg agccgggcgc gccggatgtg acgttttaga cgccatttta
 181 cacggaaatg atgtttttg ggcgttgttt gtgcaaattt tgtgttttag gcgcgaaaac
 241 tgaaatgcgg aagtgaaaat tgatgacggc aattttatta taggcgcgga atatttaccg
 301 agggcagagt gaactctgag cctctacgtg tgggtttcga tacgtgagcg acggggaaac
 361 tccacgttgg cgctcaaagg gcgcgtttat tgttctgtca gctgatcgtt tgggtattta
 421 atgccgccgt gttcgtcaag aggccactct tgagtgccag cgagaagagt tttctctgcc
 481 agctcatttt cacggcgcca ttatgagaac tgaaatgact cccttggtcc tgtcgtatca
 541 ggaagctgac gacatattgg agcatttggt ggacaacttt tttaacgagg tacccagtga
 601 tgatgatctt tatgttccgt ctctttacga actgtatgat cttgatgtgg agtctgccgg
 661 tgaagataat aatgaacagg cggtgaatga gttttttccc gaatcgctta ttttagctgc
 721 cagtgagggg ttgtttttac cggagcctcc tgtactttct cctgtctgtg agcctattgg
 781 gggcgaatgt atgccacaac tgcaccctga agatatggat ttattgtgct acgagatggg
 841 ctttccctgt agcgattcgg aagacgagca agacgagaac ggaatggcgc atgtttctgc
 901 atccgcagct gctgctgccg ctgataggga acgtgaggag tttcagttag accatccaga
 961 gttgcccgga cacaattgta agtcctgtga gcaccaccgg aatagtactg gaaatactga
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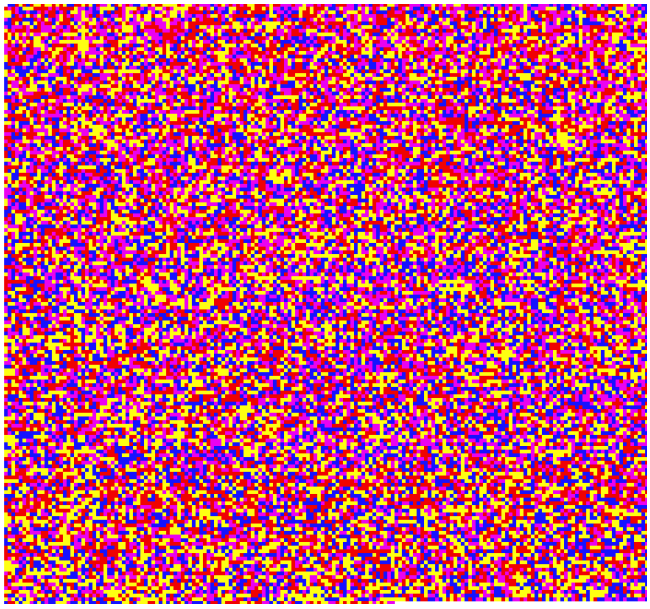
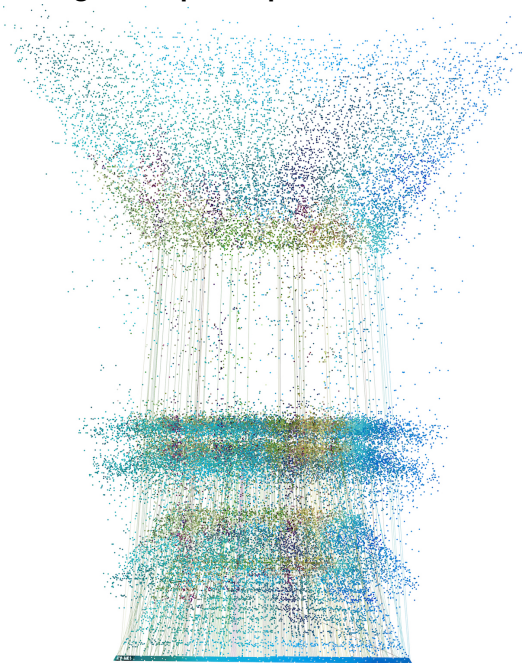
Adenovirus DNA sequence visualisation (cropped)



Adenovirus applied to satellite image as depth map



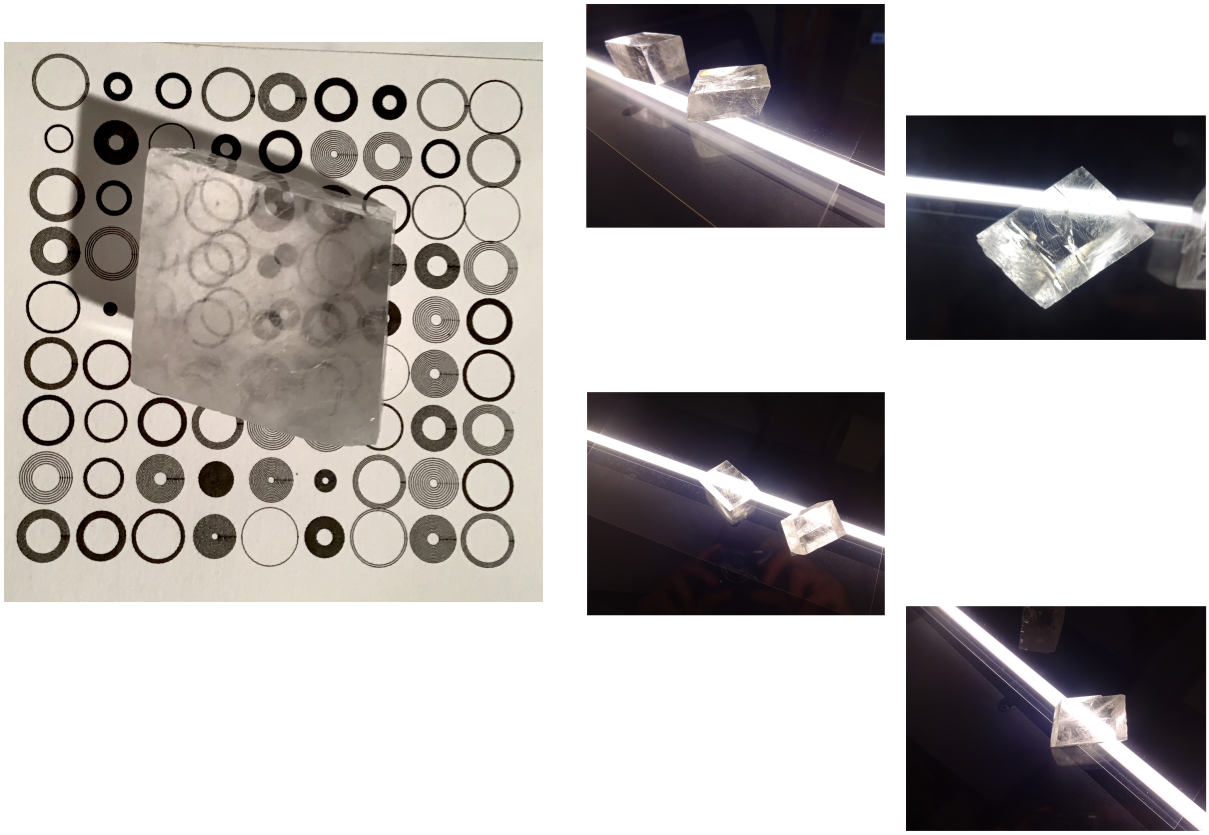
3: Description of the Installation

As an exhibition *SuperLattice* is envisioned as an immersive space combining sound and moving image. The exhibition utilises numerous methods of displaying sound, image and data which are played in randomly sequenced patterns. The exhibition takes the form of a new media Wunderkammer, or cabinet of curiosities, making accessible a large amount of information presented as digital and physical objects. These objects are presented in a non-linear, fragmented arrangement which acts as a sort of abstract puzzle that challenges the viewer to find patterns within varied and sometimes disparate elements.

Four forms of work are presented in *SuperLattice*, engaging and interacting with each other. These forms are:

- Projections. Digital and analogue projections of films, animations, still images, light and shadows.
- Ephemeral Objects. Transparent and refractive devices that manipulate light. These take the form of crystals and transparencies.
- Mechanical Devices. Sensors and machines that gather information from their surroundings and respond through sonic or kinetic action.
- Miscellaneous. Objects that do not fit into the above categories. These consist of found objects such as historical slides and 3d models generated from data derived from SuperLattices. These objects manipulate light and information in their creation but are now static forms.

Figure 2. Early studio experiments with materials and light



As a physical form *SuperLattice* places these objects, forms and devices inside a glass display cabinet which is then projected upon via four projectors (one projector for each side of the cabinet). Projection mapping is used to animate the light and distribute projected material to different sections of the cabinet.

Projecting light onto the surface of a transparent object is challenging. There will be significant interference between the light projected onto each face as it is reflected by the inner and outer glass. This interference with light, the cabinet and the objects within will create new patterns of light that will be distributed throughout the gallery. Throughout the exhibition sensors will be gathering information from the space, converting these readings into drawings through mechanical movements and relaying information as sound. This presents a dichotomy between the presented works that have been distorted, treated and displayed to document *SuperLattices* and the quantitative, analytical processes that underpin the creation of these *SuperLattices* — single layer, two-dimensional data sets.

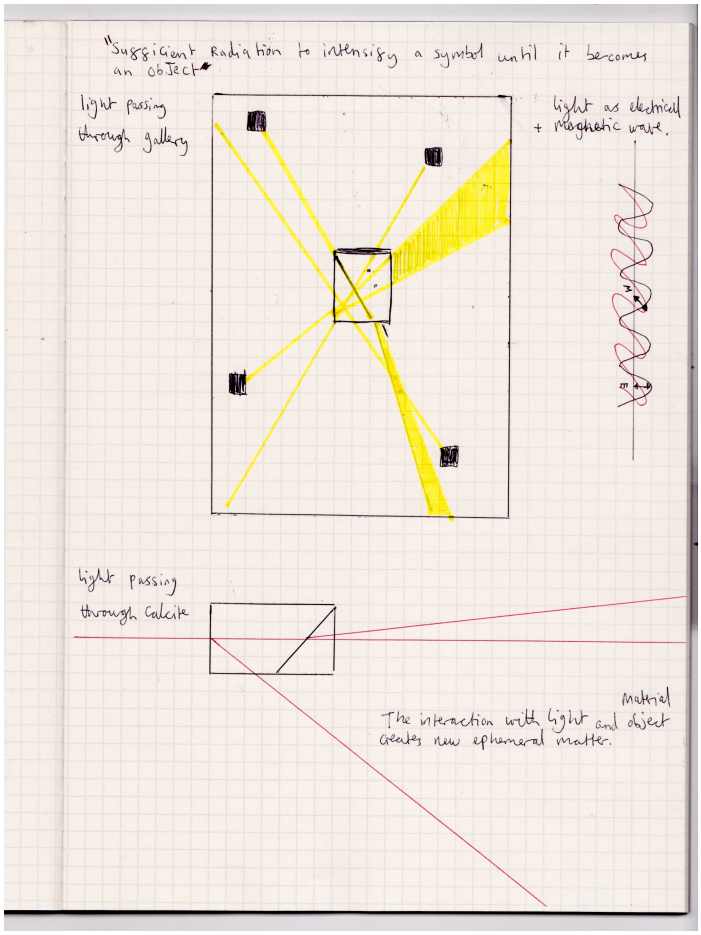


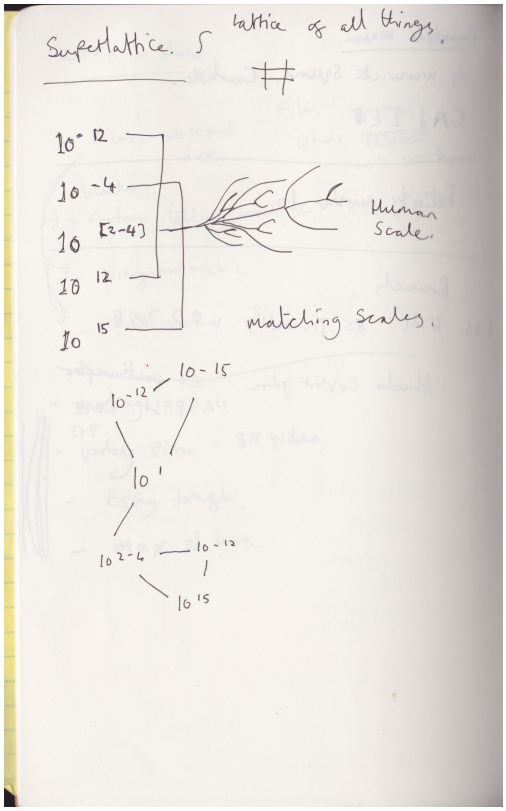
Figure 3. Diagram of exhibition.

Projected light passes through a cabinet, reflecting the contents of the light and expanding the interior of the cabinet across the room as shadows and reflections.

3.1: Cabinet Taxonomy

The cabinet presented in the exhibition acts as a *SuperLattice* consisting of four layers of information displayed via projection and through physical objects and machines. This information is arranged by scale with data from the smallest sources (atoms and DNA sequences) placed at the bottom of the cabinet and data from the largest sources (groupings of planets and constellations) placed at the top. The central shelves represent information from a more human scale — satellite imagery of earth and data collected in realtime from sensors placed in the gallery space. The layers of the cabinet interact with each other, with each level being manipulated by information from above and below. An example of this can be seen in *Figure 1. Creation of a SuperLattice* where data from the genome of a virus is used to manipulate satellite imagery.

Figure 4. Early sketches of cabinet and connections over scale



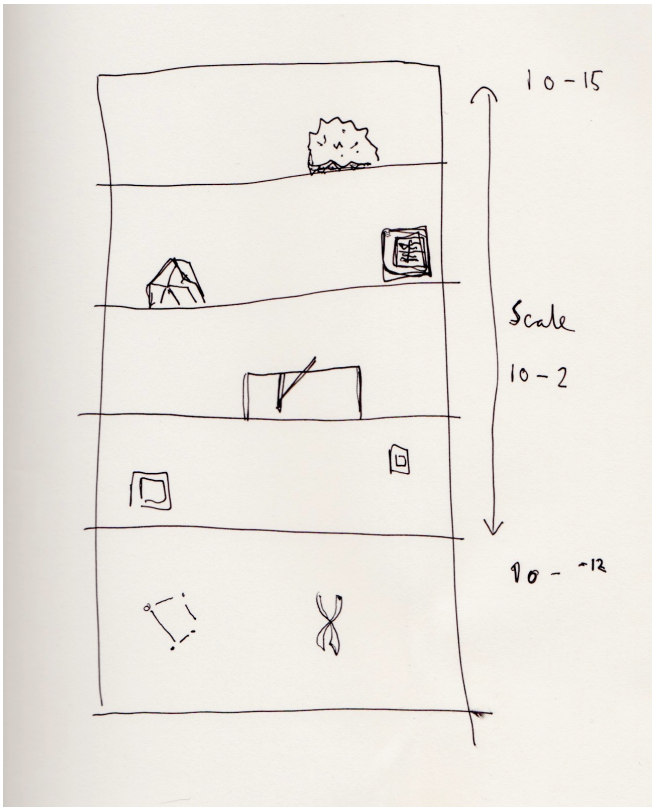
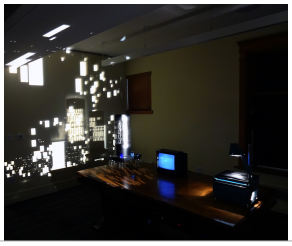
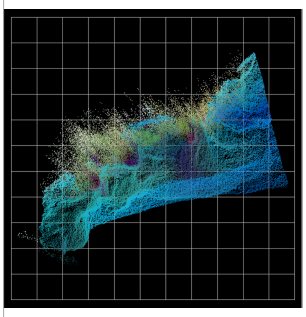
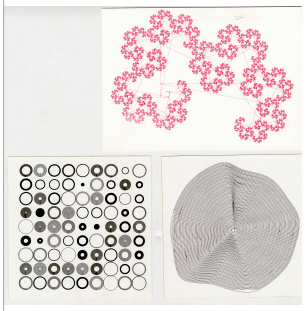
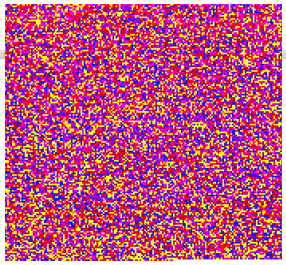


Figure 5. Layout of projections and objects within display cabinet

Cabinet layer	Scale	Data/objects	Images detailing the aesthetic
Top layer	10^{11}	Data documenting star and planetary orbits and movements, including constellations and alignments such as syzygy's. This is displayed in the exhibition through transparencies and projections manipulated through glass and crystals. Image: *Syzygy - a conjunction of things, unexpected and surprising.* (see page 35) An installation where I worked with poetry, planetary data and combined these with projected light. Image: *Nova*, an installation presented within my project *Turbulent Forms* (see pages 26, 31-32) where I worked with supernova data to control the distribution of light.	 
Middle layer (top)	10^{4}	Satellite imagery of damaged and polluted areas of earth. These source images are distorted by data sets extracted from these polluted environments as well as information from layers above and below, e.g the genome of a virus (bottom layer). In the exhibition these feature as animations, prints and 3d objects. Image: *Wounded Terrain* (see page 38)	
Middle layer (bottom)	10^{0}	Data gathered directly from the surrounding environment of the exhibition. this includes light, heat and movement. This data is transferred to other layers of the cabinet and also controls machines in real time, creating pen plotter drawings and sonified sound. Image: assortment of pen plots from environmental data. (see pages 22 - 24)	
Bottom layer	10^{-7}	Data converted from DNA from genomes of bacteria and viruses. Image: *Visualisation of Adenovirus genome* (see page 5)	

4: Chaos and Logic, the influence of Angela Carter in creating SuperLattice

The approach I have taken in creating *SuperLattice* combines logical elements from computer science and data analysis with chaotic systems from surrealism and Pataphysics — the science of imaginary solutions. A particular inspiration for this method comes from Angela Carter's novel *The Infernal Desire Machines of Doctor Hoffman* where Doctor Hoffman is attempting to "demolish the structures of reason and liberate man from the chains of the reality principle". (Carter, *The Infernal Desire Machines of Doctor Hoffman*, pg 236). The protagonist Desiderio navigates a shifting reality in the middle of a combat between Doctor Hoffman, an agent of chaos and an unnamed minister, an agent of logic. The minister is constructing a vast computer and information centre that will store information about every object or phenomenon that exists or could logically exist, while Doctor Hoffman is creating reality modifying machines formulated on a model of objective chance. The structure of the *SuperLattice* is formed by fusing the rigid uncompromising logic of the minister with the malleable reality of Doctor Hoffman.

The Minister — an agent of Logic

> "He was in the process of constructing an immense computer centre which would formulate a systematic procedure for calculating the verifiable self consistency of any given object. He believed the criterion of reality was that a thing was determinate and the identity of a thing lay only in the extent to which it resembled itself. […] He believed that the city – which he took as a microcosm of the universe – contained a finite set of objects and a finite set of their combinations and therefore a list could be made of all possible distinct forms which were logically viable. These could be counted, organized into a conceptual framework and so form a kind of check list for the verification of all phenomena, instantly available by means of an information retrieval system. So he was engaged in the almost superhuman task of programming computers with factual data concerning every single thing which, as far as it was humanly possible to judge, had ever – even if only once and that momentarily – existed. Thus the existence of any object at all, however bizarre it might at first appear, could first be checked against the entire history of the world and then be given a possibility rating" (Carter, *The Infernal Desire Machines of Doctor Hoffman*, pg 28)

Doctor Hoffman — an Agent of Chaos

> "'Allow me to introduce,' said Hoffman with a pale smile, 'my reality modifying machines.' […] These machines were formulated on the model of objective chance, taking "objective chance" as the definition of the sum total of all the coincidences which control an individual destiny.
>
> 'For the last five years those transmitters, powered by simple, radiant energy, have been beaming upon the city the crude infrastructure of
>
> (a) synthetically authentic phenomena;
>
> (b) mutable combinations of synthetically authentic phenomena; and have also been transmitting
>
> (c) sufficient radiation to intensify a symbol until it becomes an object according to the law of effective evolving, or, if you prefer a rather more explicit term, complex becoming.' " (Carter, *The Infernal Desire Machines of Doctor Hoffman*, pg 217)

In a *SuperLattice* the structure is logical, similar to the machines of the minister, containing finite sets of data. However the methods of accessing and working with this information are more chaotic, allowing layers to be translated, morphed and combined into a multitude of new possibilities.

SuperLattice has also allowed me to explore the role of narrative and text in how we experience and interpret data. By presenting data alongside text based explanations or applying narrative structure I am able to transform the perception of information, manipulating its form just as dramatically as manipulating data points. This ability to manipulate information through an accompanying text is important to me as it allows me to showcase the power of description and narrative in guiding our perception.

5: Hauntologies and the *SuperLattice* "layering of the past and present”

A possibility that arises within a *SuperLattice* is playing with interactions between layers of information from the past, and from the present, to create a type of hauntology.

Hauntology was first introduced as a philosophical concept by Jacques Derrida, and is derived from his deconstructive methodology and approach to studying history and identity; it is now applied in many other fields, including visual arts and music. A hauntology may represent a deliberate inclusion of past elements in a modern setting, as in post-modern art and design; but it may also arise accidentally, for example through glitches and errors introduced by technologies, a ghost in the machine. Or a hauntology may be an influence of the past on present thought, behaviour, organisations or designs, as they evolve and change.

Hauntological elements are present in my work through the use of old data; for example, in my 2016 work *Heliosphere* (detailed in section 7.2), where I use old data on solar activity to create new visual and sonic works and through the glitches introduced through the technologies and processes I use. One of these processes for *Heliosphere* involved converting images to radio waves and bouncing them off the moon.

> “To haunt does not mean to be present, and it is necessary to introduce haunting into the very construction of a concept. Of every concept, beginning with the concepts of being and time. That is what we would be calling here a hauntology. Ontology opposes it only in a movement of exorcism. Ontology is a conjuration.” (Derrida, *Spectres of Marx*, pg 202)

I have a strong interest in data from space and astronomical observations and analysis are a fascinating field for considering hauntologies. Ancient light and radio waves from the very edges of our observable universe are captured and translated into data sets, allowing us to extract information about planets, stars and clouds of gas. The most distant light detected may have been travelling for over 13 billion years — almost the entire age of the universe. The time travelling information it

contains is extracted into usable forms through multiple algorithms cleaning the data, amplifying and extracting specific areas of information for use.

Similar operations are performed to extract information in signals stemming from the tiniest of objects in the shortest imaginable timescales, to investigate the physics of sub-atomic particles. Particle collisions collected at the Large Hadron Collider (LHC), CERN produce gigantic amounts of computational information. In the LHC particles collide approximately a billion times per second. The data collected from this process is about 1 petabyte (a million gigabytes) every second. This amount of data is impossible for current computer systems to store so algorithms filter this information looking for specific areas of interest and dump the rest of the data.

These processes to extract meaning from past and present data effectively form *SuperLattices*. Each algorithm performs a specific task that it has been built for by human engineers, disregarding information it is programmed to not find relevant. The process of extracting and disregarding information inherently places a layer of bias and narrative over the information that is saved. Errors in the algorithm's programming and performance also add in layers of new meaning with these errors becoming concrete artefacts incorporated into the data set. These algorithms — including machine-learning and artificial intelligence algorithms — imprint hauntologies onto the outputs they generate.

If these processes were to be visualised in the form of a *SuperLattice* the viewer would explicitly see the transformation of the information and the implicit biases and decisions that went into defining the data's end result. Works such as *ImageNet Roulette* created by Kate Crawford and Trevor Paglen go some of the way to revealing these underlying structures. In this work an AI trained on ImageNet — a database of 14 million images used for deep learning — responded to publicly uploaded images of faces, analysing them and outputting the resulting descriptions. The outputs evidenced systemic biases input into the AI by human authors who wrote the initial metadata to describe the images that were used to train the system. Training sets for machine learning systems are large and pre-compiled sets can be purchased or acquired open source. Due to this the initial biases in these training

sets can be transferred and propagated sometimes unknowingly, with negative knock-on effects to marginalised communities. The simple act of showing the AI's response enabled people to become more aware of these implicit biases and take action.

The awareness the project generated resulted in over 600,000 images being removed from the ImageNet database.

6: *SuperLattice*, Conceptual and aesthetic framework

In my research to develop *SuperLattice* I have drawn on influences both conceptually and aesthetically. Conceptually I have taken inspiration from the work of Florian Hecker and from Pataphysics, the science of imaginary solutions. The aesthetics of *SuperLattice* have taken inspiration from digital artists such as Ryoji Ikeda and Ryoichi Kurokawa as well as light and conceptual artists Liliane Lijn and Anthony McCall.

6.1: Conceptual framework

6.1.1: Florian Hecker

Florian Hecker is a German artist and electronic musician with a background in computational linguistics. His work investigates the mechanics of information and perception. Hecker's work is often minimal, focusing on information found within short auditory events, these works take the form of installations, performances, recordings and writing. In a project named *Chimerisations*, Hecker investigates the concept of chimeras — organisms containing a mixture of different genetic tissues formed through natural fusing, human intervention or mutation — and applying chimeric processes to sound.

> "Hecker's chimeric compositions are attempts to decompose common sense about sound, hearing, and listening. Simply explained, auditory chimeras are sound events realized through a technical practice of sieving one sound through another—pressing the "fine structure" (the second-to-second pitch and texture) of one sound (say, a drum) through the "envelope" (overall attack, sustain, and decay profile) of another (say, a piano). What results is a sonic chimera (in my parenthetical example, of a drum sound that has something of the feel of a piano). This chimera delivers a kind of structured nonsense meant to force listeners to confront their assumptions about how and what they are hearing when they hear. One might make an analogy to the writing trick known as the ambigram, in which words are forced into a conformation that permits the reading of two things at once, as with this rendition of "light is a particle"/"light is a wave"" (Helmreich, *Florian Hecker: Chimerisations*, pg 9)

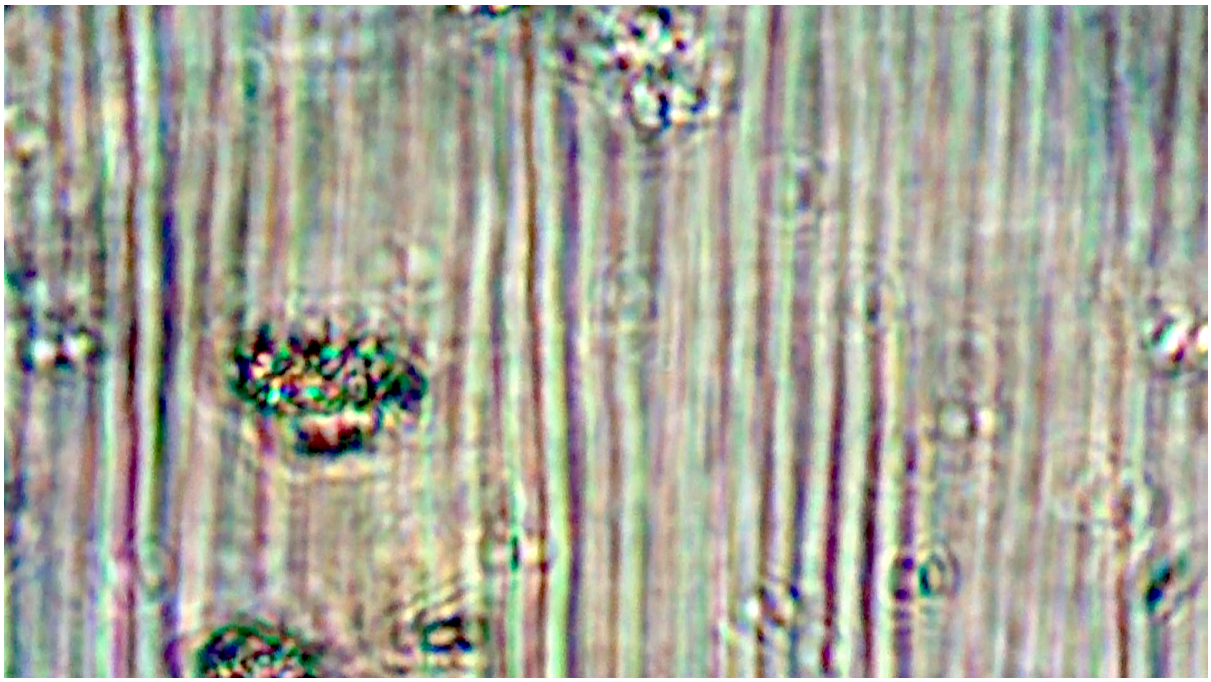
Figure 6. “light is a particle”/“light is a wave”

Image from *Chimerisations*, uncredited

Hecker’s work conjures artificial auditory illusions from applying the characteristics of one sound to another. This method acts as a *SuperLattice* and allows for the dispersion of multiple streams of information through a single output. Hecker’s work also utilises cognitive error and psychoacoustic phenomena involved in hearing and perceiving sound, forcefully applying the perceptual apparatus of the listener to become part of the sound processing chain.

This type of cognitive dissonance was made apparent to me early in my research for *SuperLattice* through experiments with optical calcite. This transparent mineral has the ability to polarise light, doubly refracting it into two beams which each take subtly different paths. Placing calcite over an image or piece of text results in a strong blurring and doubling of the source giving the impression of movement and the generation of new forms. This effect feels perceptually similar to animations achieved through Moiré patterns — interference patterns created from closely ruled transparencies layered and offset over each other.

Figure 7. Blurred lines in calcite under microscope



6.1.2: Pataphysics and the Oulipo

My approach to creating the artistic works in *SuperLattice* is similarly influenced by the chaotic and disorienting field of Pataphysics, whose spiral emblem acts as a sort of metaphysical Moiré pattern.

Pataphysics is defined by its creator, French playwright Alfred Jarry:

“Pataphysics is the science of imaginary solutions, which symbolically attributes the properties of objects, described by their virtuality, to their lineaments.” (Jarry, *‘Pataphysics a Useless Guide,* Hugill, pg 3)

A great deal of my work has been influenced by Pataphysics, which I discovered in 2015, and has enabled me to find an artistic vocabulary and conceptual framework to combine previously separate strands of my work investigating space exploration, sound art and data visualisation.

Pataphysics delights in absurdist bureaucracy in the form of nonsensical rules and structures in the vein of Rube Goldberg machines. The ideas between language and processing language found in *SuperLattice* are inspired by French pataphysical literary practitioners the Ouvroir de Littérature Potentielle (Oulipo). This title roughly translates as *Workshop for Potential Literature* and a characteristic of the group is utilising strict, self imposed systems, alongside chance and mathematical methods of working with text.

A famous example of one of these systems is *La Disparition* by Georges Perec which is written entirely without the letter “e”.

Other constraints include:

Univocalism, a technique where only one vowel is used. This technique is used by Christian Bök in his book *Eunoia*, which consists of five chapters named "A", "E", "I", "O" and “U”. Each chapter is constrained to only use the vowel titling the chapter.

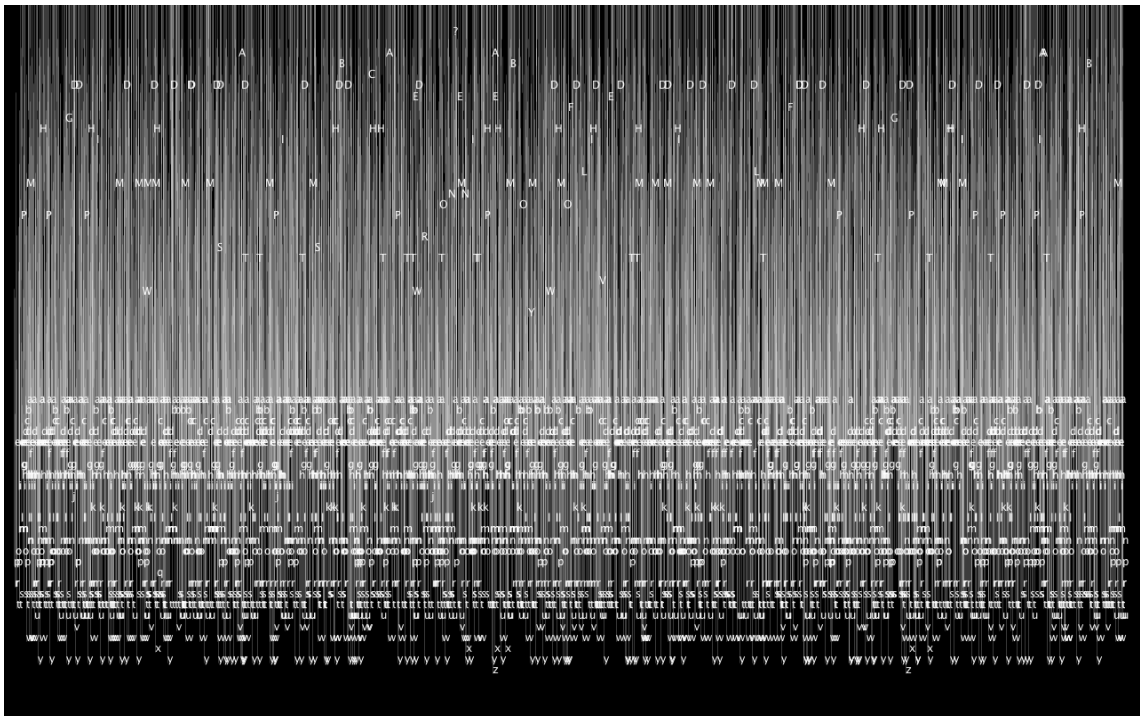
The N+7 method, Where every noun in a piece of text is replaced with the noun seven entries after it in the dictionary. In the example below I apply the N+7 method to the opening of Dante’s *the Divine Comedy*.

N + 0	**N + 7**
Inferno: Canto I	Inflammation: Capability I
Midway upon the journey of our life	Midway upon the jubilee of our lifetime
I found myself within a forest dark,	I found myself within a forgery dartboard,
For the straightforward pathway had been lost.	For the straightforward patrician had been lost.

I think of the rules utilised by the Oulipo in the context of simple algorithms and machines that when applied iteratively to a piece of information such as text have the potential to drastically alter the perceived meaning. One Oulipo inspired technique I developed for *SuperLattice* involves arranging the letters in a piece of text vertically based on their position in the alphabet with A at the top of this arrangement and Z at

the bottom. Vertical lines connect the repositioned letters to their original locations and the horizontal positions of the letters are not moved. The result is a structured grid that acts as a sort of text based heat-map of letter and punctuation usage.

Figure 8. Vertical rearrangement of my first thesis draft.



6.2: Aesthetic framework

The aesthetics I use in my work are informed by an ongoing interaction with art and design. I engage with artistic material as both a viewer and a collector, extracting small elements of reference material in a magpie-like fashion. These fragments of material include text layouts, colour palettes and artefacts left over from the creation process — for example the smudged edges of a charcoal drawing. These references can inform early sketches, visual styles and arrangements and are sometimes developed into more fully formed works. An example of how I utilise this material in my work is evidenced in my 2013 - 2018 project *Code Poetry,* an online diary cataloging my work in the field of generative art. When the website is viewed as an archive specific influences, trends and interests in my work become extremely clear. The influences in my work are wide, eclectic, tangential and often not particularly relevant to the completed work. In describing my aesthetic framework I have chosen to focus on four specific artists who have had a significant impact on the visual

development of *SuperLattice* — particularly in relation to creating immersive experiences through light and data based work.

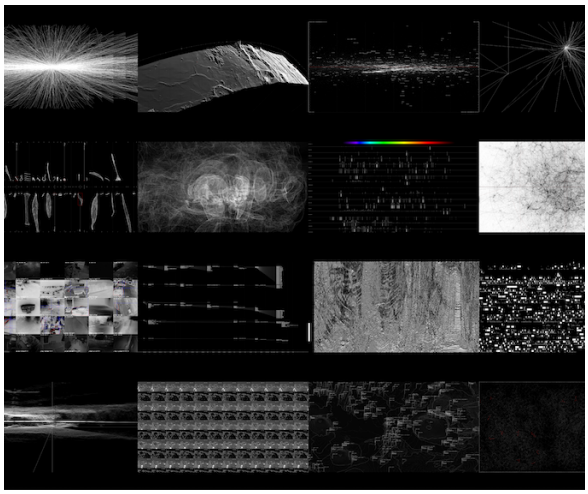
6.2.1: Ryoji Ikeda/Ryoichi Kurokawa

The digital content that is projected, printed and replicated in *SuperLattice* is influenced by Japanese audio-visual media artists Ryoji Ikeda and Ryoichi Kurokawa. Both artists utilise large data sets from science and the natural world, playing back full sections of raw data alongside segmented and manipulated images and data visualisations at very high speeds. Both Ikeda and Kurokawa create a complex and overwhelming audio-visual output from a limited palette which often consists of point clouds, computational wireframes, sine tones and white noise. Their work is often largely monochrome with small highlights of colour standing out starkly.

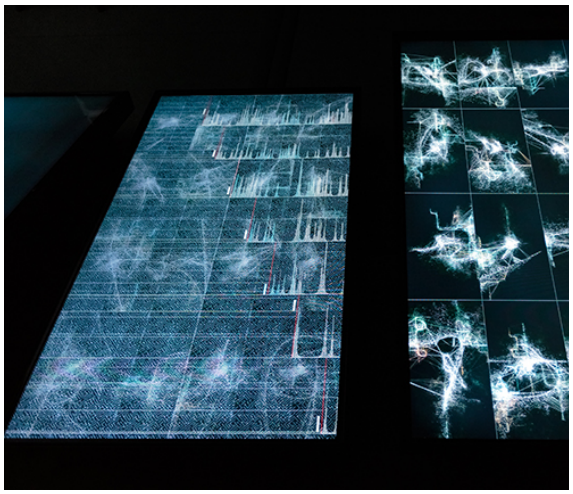
The material I present in *SuperLattice* is much slower and meditative than the fast digital flicker frames seen in the work of Ikeda and Kurokawa. However, there are some conceptual crossovers in terms of our cumulative interests in data sets that are simultaneously overwhelming to understand, yet fundamental to our existence. Both artists also share my interest in creating works based around data from astronomy and physics. My work *Wounded Terrain* (page 38) is an example of the aesthetic crossovers between Ikeda and Kurokawa's work with my own.

Figure 9. Ikeda, Kurokawa

Ryoji Ikeda, *Xverse*, 2018



Ryoichi Kurokawa, *ad/ab Atom*, 2017



Like Ikeda and Kurokawa I am drawn to the simple monochrome diagrams used by scientists and created through computational models. The simple graphical and colour content in these images not only references scientific diagrams but celebrates the fundamentals of early computer graphics that many computer artists are highly aware and reverential of.

In *SuperLattice* I take this shared interest in early computer graphics beyond screen based imagery and utilise pen plotter style drawing machines. Plotters were used in early computing to translate computational outputs into drawings on paper or transparent film. This was beneficial as computer screen technology was still in its infancy and the drawing quality from a plotter was more detailed than early dot-matrix printers. Pen plotters could also create large drawings that were useful for engineers and architects.

Due to the aesthetic and tactile quality of these machines the early pioneers of computational art made heavy use of them. These include artists such as Manfred Mohr, Vera Molnar and A. Michael Noll. Many of these early computer arts practitioners had careers in the sciences which enabled them access to these large and expensive machines.

I have been utilising pen plotters in my work over the last two years and they manifest themselves in the *SuperLattice* exhibition as mechanical devices creating drawings generated from datasets collected in the gallery space. These datasets are recorded using environmental sensors placed in the exhibition detecting noise levels and fluctuations in light. I find the aesthetics of pen plotters highly appealing as they translate digital information into something that appears to be hand drawn but still contains a slightly uncanny machine like quality. The implication of hand drawing in these machines often results in viewers relating more to works created using pen plotters than work created through more explicitly digital means. The pen plot process takes time and introduces a series of errors and fluctuations based on environmental factors. These factors include:

- Pens running out of ink or being unable to release ink in certain orientations and areas of the page.

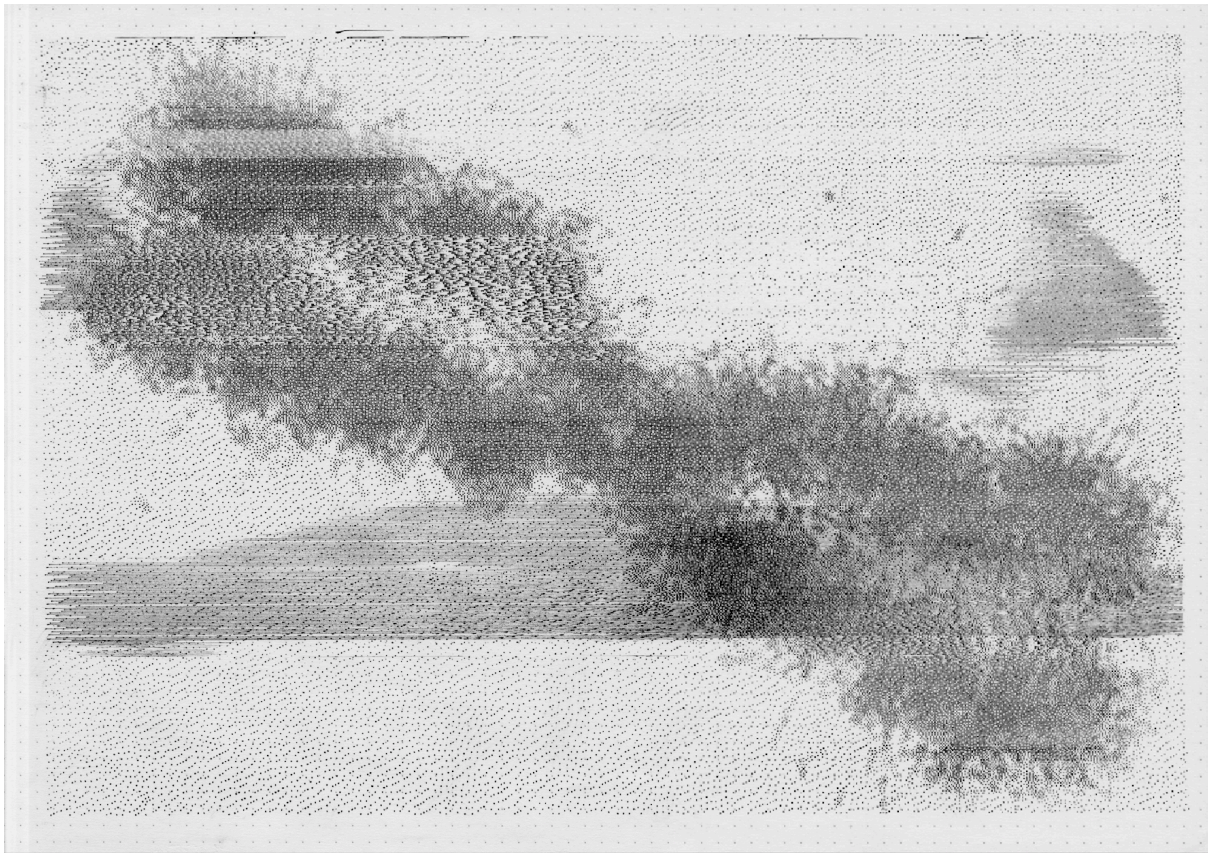
- The elevation of the page being slightly too high or low resulting in extended lines or lines dropping out.

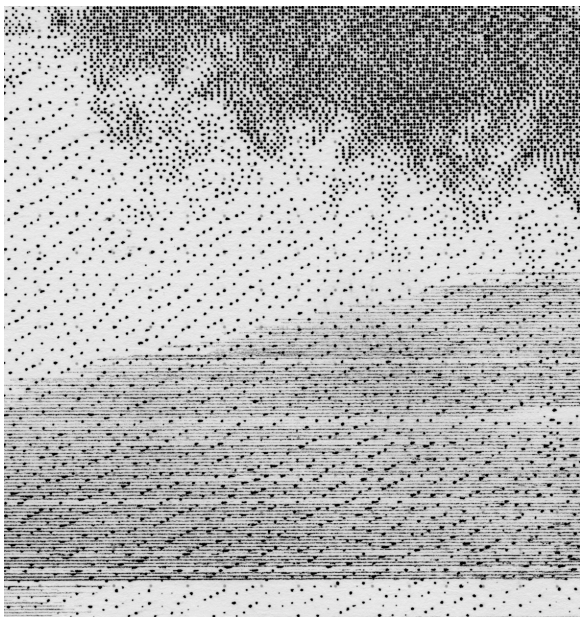
- Vibrations in the surrounding environment creating jumps and scribbles in the drawing.

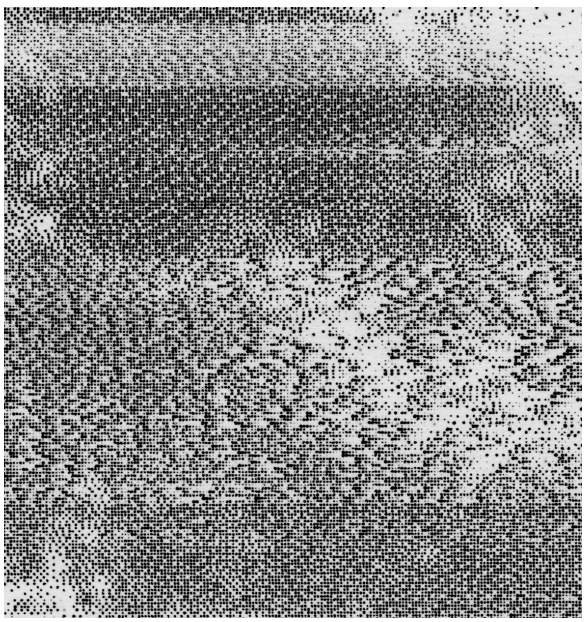
- Errors in translation between computer software and the pen plotter manifesting as oversimplified areas, missed sections of the drawing or areas being repeatedly drawn over.

The images in figure 10. detail pen plotter errors in the depiction of a chromosome. The source image is broken down using a custom dither algorithm that instructs the pen plotter to create an image from thousands of tiny dots. The plot was left unattended and areas where the page was slightly elevated can be seen in the form of continuous lines. Errors in the plotter's X,Y positioning and increases and decreases in ink flow result in different misalignments and clusterings of points.

Figure 10. Chromosome plot and details of chromosome plot







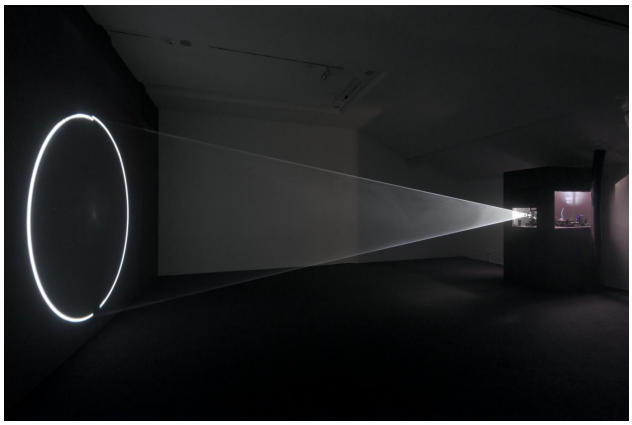
6.2.2: Anthony McCall/Liliane Ljin

My methods of working with light, space and objects in *SuperLattice* are inspired by the aesthetics of light artists Anthony McCall and Liliane Lijn. I am particularly drawn to these artists works as they create immersion through a limited set of materials. McCall's work *Line Describing a Cone* is created solely from projector/s and smoke machines placed in a dark room or space. The work takes place over a thirty minute period where the light traces the circumference of a circle while the central beam of light expands in size forming a cone of light that is given form by the smoke around it. While McCall creates the appearance of physical forms from intangible matter Lijn has created numerous works using a solid but ephemeral substance called aerogel, an extremely lightweight synthetic material made from polymers and solvents. Aerogel is highly absorbent with a large surface area due to nanoscale pores, and it has been utilised by NASA to trap small particles of dust from the tails of comets. Lijn's work *Heavenly Fragments* displays aerogel containing space dust illuminated with light to "imagine interstellar dust as space-time ruins with the surprising capacity to transform our perceived reality." (Lijn, artist website)

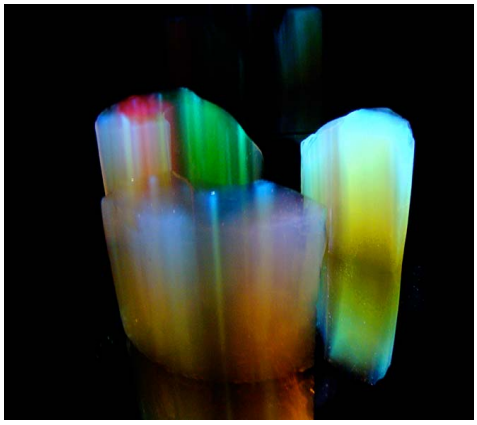
In the aesthetic context of *SuperLattice* I have focused on how these works utilise light to create form from almost nothing in the case of McCall and to emphasise the transparent and mysterious nature of a solid but ephemeral object in the work of Lijn. I intend to enlist similar techniques to alter the matter and form of objects both solid and ephemeral to give shape to light in the SuperLattice exhibition.

Figure 11. McCall, Lijn

Anthony McCall, *Line Describing a Cone*, 1973



Liliane Lijn, *Heavenly Fragments*, 2008



7: Evolution of SuperLattice from prior work/experiments: Experimentation, Development and Reflection Cycles

SuperLattice has evolved through an ongoing iterative cycle of experimentation based around creative practice and applied theory. Through this ongoing period of research and development (2013 - present) and by mapping the trajectories of exhibited works and process pieces I am able to linearly draw a path from my early work converting the electromagnetic spectrum into sound, to the development of *SuperLattice*. This path highlights specific pivot points in my journey and major developments in my practice that have come from periods of reflection and consolidation. An important example of this is my 2016 work *Heliosphere* which was my first work to combine sound and digital imagery sourced and created from data. The developments made through *Heliosphere* enabled me to create a methodology for working artistically with datasets from space and physics. This methodology has allowed me to formulate systems for creating work which have informed much of the work in my ongoing exhibition series *Turbulent Forms.* This includes the audio-visual installation *Nova* which incorporates these methods of presenting information through diffused light and sound which I build on in *SuperLattice*. This methodology has also been the source material for several masterclasses presented to artists and musicians wishing to learn how to create artistic work from data.

Figure 12. Nova, 2017, Canadian Music Centre

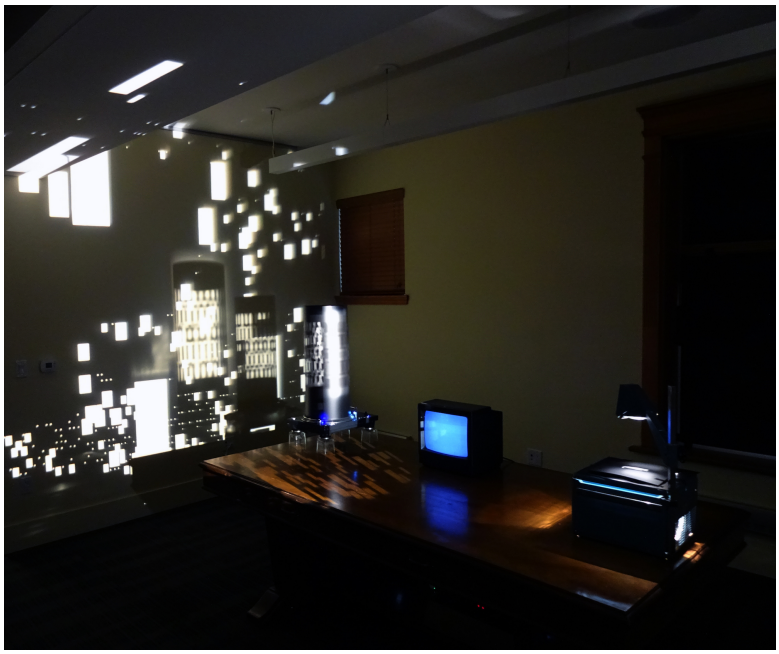
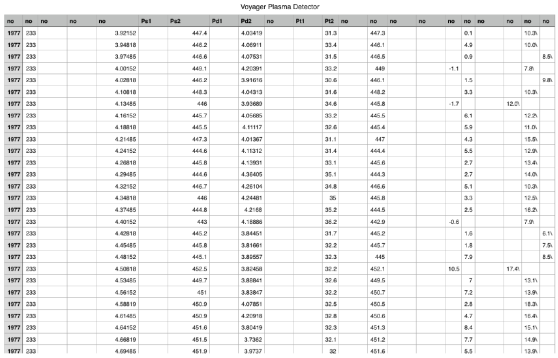


Figure 13. Evolution of *SuperLattice*: Experimentation, Development and Reflection Cycles

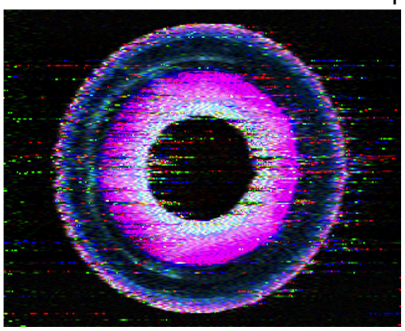
2013 - 2015: Work with VLF and datasets from space organisations



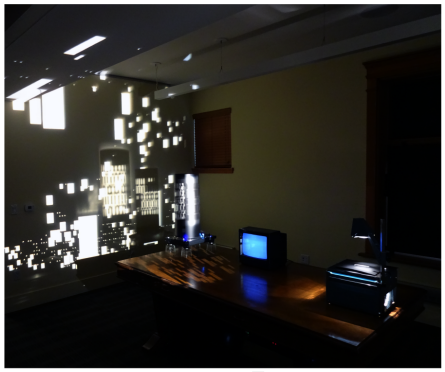
Voyager Plasma Detector

no	no	no	no	no		Ps1	Ps2	Pd1	Pd2	no	Pi1	Pt2	no	no	no	no	no	no	no	no	no	no	no	no	
1977	233				3.92152		447.4		4.03419			31.3		447.3				0.1				10.3h			
1977	233				3.94818		446.2		4.06911			33.4		446.1				4.9				10.6h			
1977	233				3.97485		446.6		4.07631			31.5		446.5				0.9							8.6h
1977	233				4.00152		446.1		4.20391			33.2		449				-1.1				7.8h			
1977	233				4.02818		446.2		3.91616			30.6		446.1				1.5							9.8h
1977	233				4.10818		448.3		4.04313			31.6		448.2				3.3				10.3h			
1977	233				4.13485		446		3.93680			34.6		445.8				-1.7				12.0h			
1977	233				4.16152		445.7		4.05485			33.2		445.5				6.1				12.2h			
1977	233				4.18818		445.5		4.11117			32.6		445.4				5.9				11.0h			
1977	233				4.21485		447.3		4.01367			31.1		447				4.3				15.6h			
1977	233				4.24152		444.6		4.11312			31.4		444.4				5.5				12.9h			
1977	233				4.26818		445.8		4.13931			35.1		445.6				2.7				13.4h			
1977	233				4.29485		444.6		4.36405			35.1		444.3				2.7				14.0h			
1977	233				4.32152		446.7		4.26104			34.8		446.6				5.1				10.3h			
1977	233				4.34818		446		4.24481			35		445.8				3.3				12.5h			
1977	233				4.37485		444.8		4.2168			35.2		444.5				2.5				16.2h			
1977	233				4.40152		443		4.18886			36.2		442.9				-0.6				7.9h			
1977	233				4.42818		445.2		3.84451			31.7		445.2				1.6							8.1h
1977	233				4.45485		445.8		3.81661			32.2		445.7				1.8							7.5h
1977	233				4.48152		445.1		3.80557			32.3		445				7.9							8.5h
1977	233				4.50818		452.5		3.82458			32.2		452.1				10.5				17.4h			
1977	233				4.53485		445.7		3.85841			32.6		445.5				7				13.1h			
1977	233				4.56152		451		3.83847			32.2		450.7				7.2				13.9h			
1977	233				4.58818		450.9		4.07851			32.5		450.5				2.8				18.3h			
1977	233				4.61485		450.9		4.21918			32.8		450.6				4.7				16.4h			
1977	233				4.64152		451.6		3.80419			32.3		451.3				8.4				15.1h			
1977	233				4.66819		451.6		3.7362			32.1		451.2				7.7				14.9h			
1977	233				4.69486		451.9		3.9737			32		451.6				6.5				13.0h			

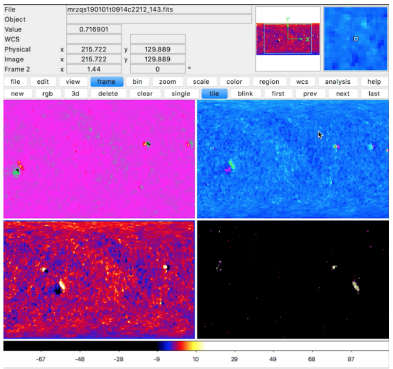
2015 - 2017: Combining sound, visual and data into more cohesive works such as Heliosphere



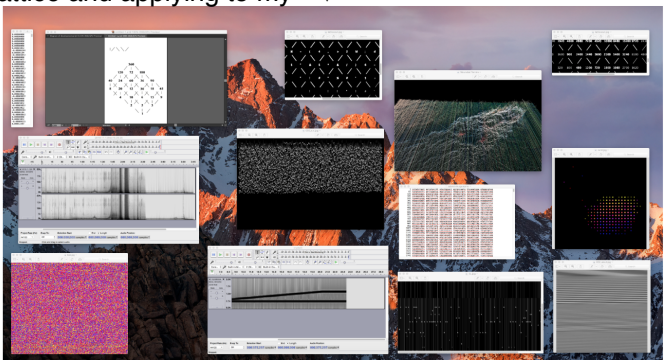
2017 - 2019: Creating methods for working with data



The outcome is the ongoing R&D project Turbulent Forms



2019 - 2020: Developing SuperLattice and applying to my work



SuperLattice is a framework allowing me to contextualise previous work and create cohesive and exciting new works

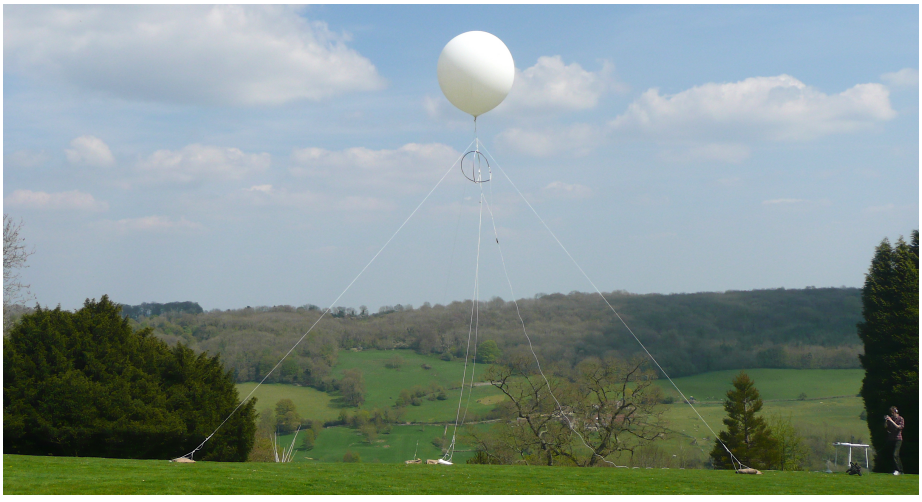
7.1: A Machine to Listen to the Sky

An early example of my interest in translating information can be found in my work with Very Low Frequency (VLF) natural radio, an area of the radio spectrum that contains signals naturally occurring in Earth's ionosphere such as lightning and the Northern Lights. I first came across VLF through a brief comment in Nicolas Collins' book *Handmade Electronic Music: The Art of Hardware Hacking.*

> "Fans of what is know as VLF (Very Low Frequency) radio make big coils by wrapping yards of wire around big wooden crosses and then camp out on remote hilltops like hermits. Get far enough from civilization's ubiquitous 60/50 hz hum and you may be lucky enough to pick up the Aurora Borealis, "whistlers" induced by meteorites self-immolating as they enter the earth's atmosphere, the pipping of GPS satellites, or top-secret submarine radio communication." (Collins*, Handmade Electronic Music,* pg 18*)*

My early experiments with VLF revealed an exciting hidden world that was accessible through simple DIY radio devices. VLF receivers are essentially low-powered radio telescopes and this work acted as an initial introduction into how information can be gathered and transferred through sources such as radio from thousands of miles away. This early interest in converting natural radio into sound and experiencing VLF phenomena in a quite analytical way — logging sounds and their possible sources in VLF diaries — led to a greater interest in information, data and how this is communicated both scientifically and artistically.

Figure 14. A Machine to Listen to the Sky, VLF installation, 2013 American Museum in Britain



7.2: Heliosphere

In addition to translating data into sound and image *Heliosphere* is also an early example of my application of a loose narrative structure to data, creating an audio-visual journey from the sun to the outer edges of its influence.

Heliosphere is a creative exploration of the solar system through sound and image. The piece involves a variety of techniques to creatively interpret information gathered from space — sonifications and visualizations of planetary orbits, controlling a synthesizer using the electromagnetic emissions of a pulsar, and low-frequency radio signals from the earth's ionosphere. I also built a makeshift model heliosphere from a balloon and string of lights which I used used to resonate sound and perform audio reactive light painting.

By combining audio synthesis, image creation and composition with data sonification techniques, *Heliosphere* explores the creative elements that are present in the choices made in the representation of sound and visual data from space –- much of which has been edited, sonified, visualised or approximated by researchers and organisations.

While I used some scientific methods for visualising and sonifying data — these methods included mapping planetary orbits and rotations to pitch and volume and converting pulsar data into sounds used in the composition — my main goals of *Heliosphere* were to ask:

- How far can I stretch this information before the source becomes irrelevant?
- How will people respond to something that calls itself a representation of data but is tentatively connected?
- At what point does the source become simply a tool of the artist's intention?

Through placing the material in *Heliosphere* into the context of a journey I was able to use narrative to imply a layer of connection that was not continuously there. *Heliosphere* contains a loose framework of images and sounds that clearly relate to

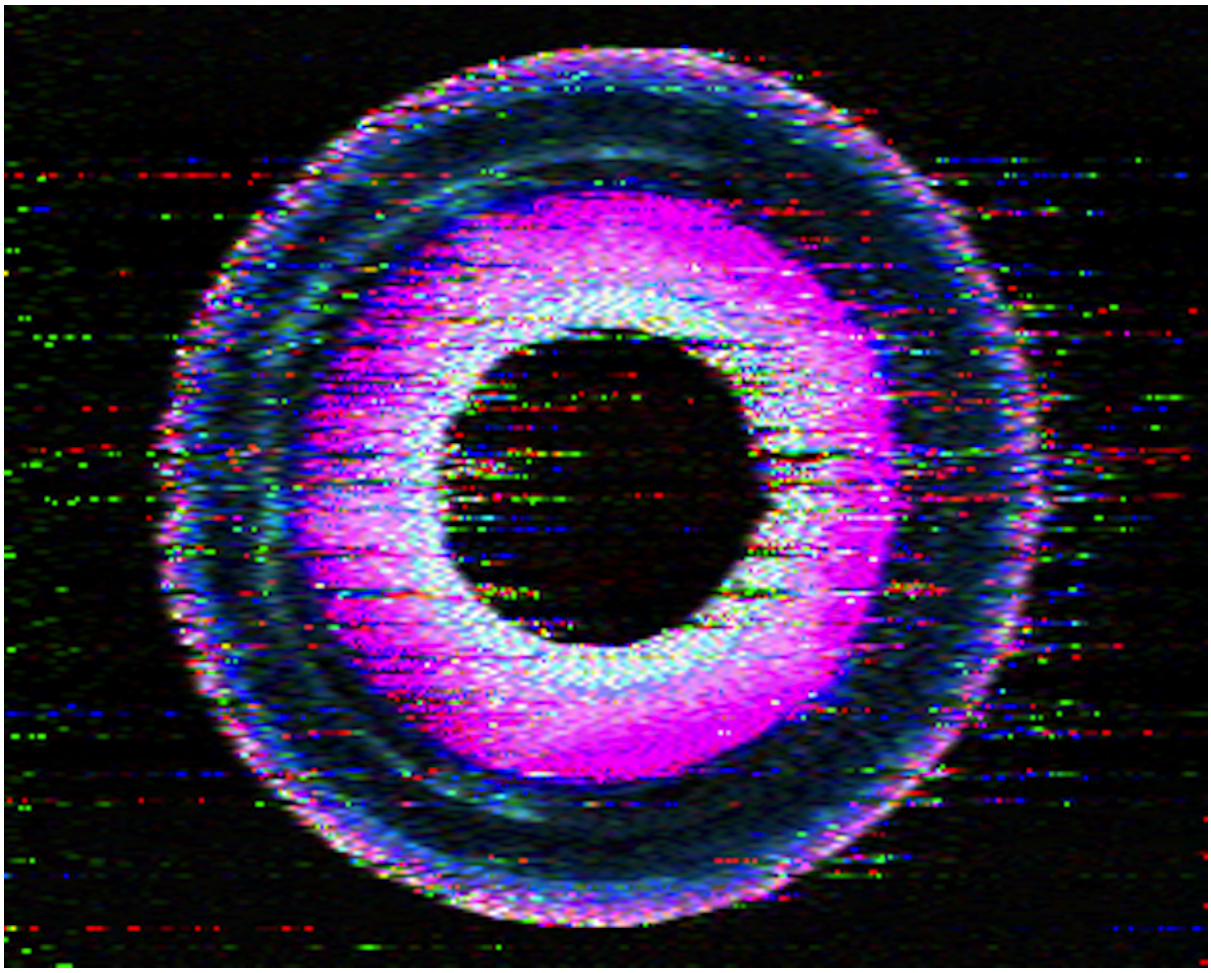
space, the sun and the heliosphere. These were placed at intervals throughout the work to create a tie-in to the source material. The material in between these sections is much looser and ranges from completely improvised to creative and far out interpretations of the data — such as creating a model heliosphere from a balloon. The combination of strongly relevant images with more experimental material creates an illusion of tone and a blurring of what is directly connected versus purely created.

Later in 2016 I was able to extend the journey of *Heliosphere* in a collaboration with artist Daniela De Paulis at the Seeing Sound Conference, Bath Spa, UK. This involved converting images from *Heliosphere* into radio signals that were bounced off the moon in a process called earth-moon-earth communication, using a radio telescope to transmit signals and receive their reflections from the moon. The radio signals that returned were recombined into images that contain alterations and distortions as a result of their transit.

It is a poetic notion to think of information sourced from within our solar system, converted into images and then fed back into the space that birthed it. Portions of this radio signal that missed the moon during transmission are still travelling outwards in space to this day.

The positive response *Heliosphere* received from audiences, and the satisfaction I had in creating it, led me to continue to develop the data-driven sound and visual works that encompass a large part of my current practice.

Figure 15. Visualisation of planetary orbits and rotations bounced off the moon



7.3: Developing methods for working with data/Turbulent Forms

The creation of *Heliosphere* enabled me to put in place some methods for collecting, translating and presenting data. I was able to develop these methods into a more robust creative methodology through funding from Arts Council England and The British Council. The resulting work involved teaching workshops where I instructed on how to creatively collect and use data. These workshops fed into an exhibition named *Turbulent Forms* where my work was presented alongside the work of artists who had attended these workshops.

All the exhibited works were inspired and derived from physical data gathered by space organisations and physicists as well as using thought experiments, illustrative techniques and imagination to create parallels and appreciation of complex, abstract

and theorised concepts. The data sets used in the exhibition included: gravitational waves, the cosmic microwave background, sunspot activity and the electromagnetic emissions of pulsars.

In developing the teaching materials for the workshops I identified the three main ways that I work with data, these ranged from quantitative to chaotic. The definitions below are taken from my workshop notes:

Ways of Working with Data

Quantitative: *Taking data and making direct, obvious mappings. Examples of these methods are graphs and clear infographics. Data mapped to sounds controls simple parameters such as pitch and amplitude.*

Abstract/Metaphorical: *Taking data or using an aspect of data as inspiration to convey a narrative linked to the source material. An example of this can be found in my work A History of the Universe in Noise where an analogy is created between information that is lost through the repeat copies of image files and the slow reduction of radiation that makes up the cosmic microwave background — left over from electromagnetic radiation emitted in the early stages of the universe.*

Collisional: *Taking spreadsheets of data and using this information in its full form with no shaping etc. This results in an output that is seemingly random or removed from its source. An example would be taking every value in a spreadsheet and converting these values into a single complex sinusoidal wave. The output is likely to be random and chaotic sounding but there may be potential to gain new and unexpected understandings of data sets through these surprise collisions.*

8: Early SuperLattices (2018 - 2020)

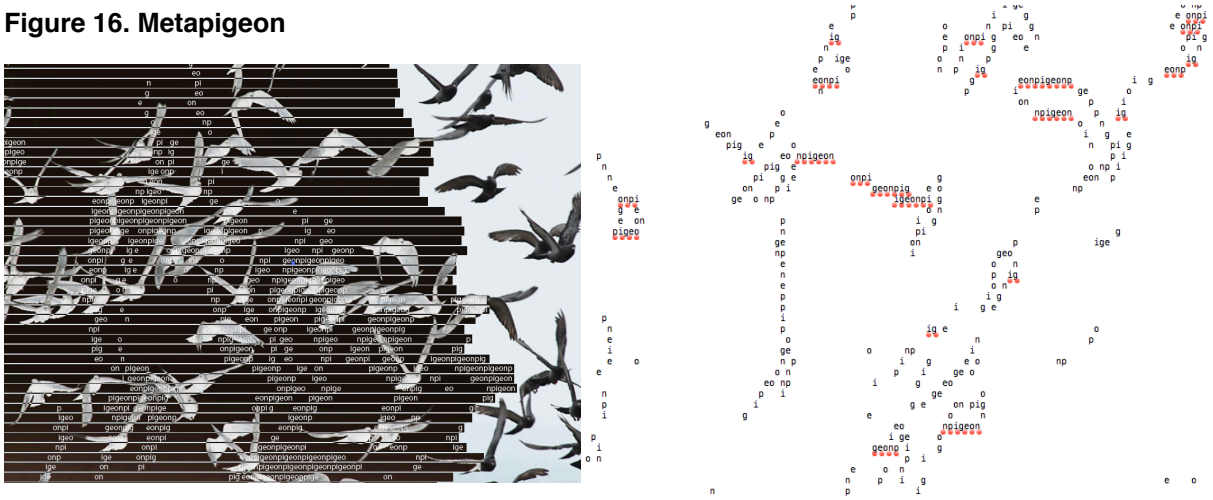
8.1: Text based data works

The formative works detailed in section 7 outline my approach to working digitally and with data that led to the creation of *SuperLattice*. Section 8 details the more recent works that define the visual aesthetic and form of the *SuperLattice* exhibition.

Before entering the MFA Visual Arts program at York University my work mainly focused on the creation of digital sound and image. It was my goal to utilise my time at York to develop a strand of my practice that engaged with creating physical objects that could be physically seen, touched and stored outside of a computer. The conception and formation of these works still relied heavily on digital technology but they were made real through print and CNC fabrication methods.

The earliest works I created in this style were experimental poems written during night time walks. In these walks I would track my GPS position and log points where I was writing text. I then digitally reconfigured this information into maps, cataloguing my movements and redistributing the text to the location it was created. Several of these maps were transcribed onto paper via a pen plotter, with the intention of creating a book. While making these works I found that I was far more interested in the visual structure of this computationally distributed text than the text's actual written content. I began to develop simple software that could extract and format the metadata used to store information on images into shapes and motifs found in the images themselves. These text works were printed onto transparencies and placed over the original image.

Figure 16. Metapigeon



These works involved breaking apart the seen and unseen information associated with digital images and configuring this into new forms built from individual layers printed on transparencies. I expanded these works by introducing overhead projectors to add more control over elements such as light, shadow, scale and image overlap. These early works that explore deconstructing and creating new assemblies of information using a series of layers underpin much of the creative inquiry I have based *SuperLattice* on. The expansion of these images through light and projections informs the presentation of the *SuperLattice* exhibition and the techniques used to make work during this period of research and creation.

8.2: Syzygy

An example of the development of this work can be seen in my 2019 installation *Syzygy — a conjunction of things, unexpected and surprising*

In *Syzygy* transparencies containing images and text are distributed to create a network of chance accumulations. As the parts move and spiral in space there are moments of alignment where a nearly tangible entity is formed. The information on the transparencies documents a syzygy — the alignment of three celestial objects — through diagrams and a interpretive poetic text that is split between five transparencies. Occasionally at the correct rotation and viewing angle the transparencies align allowing the images and text to be fully visible in their original form.

Syzygy presents a form of visual puzzle where the viewer is challenged to make associations based on something that may seem completely random. Based on the synopsis and information visually available, the viewer applies a new layer of experience as they attempt to seek patterns that align the imagery to their imagined interpretation of a syzygy.

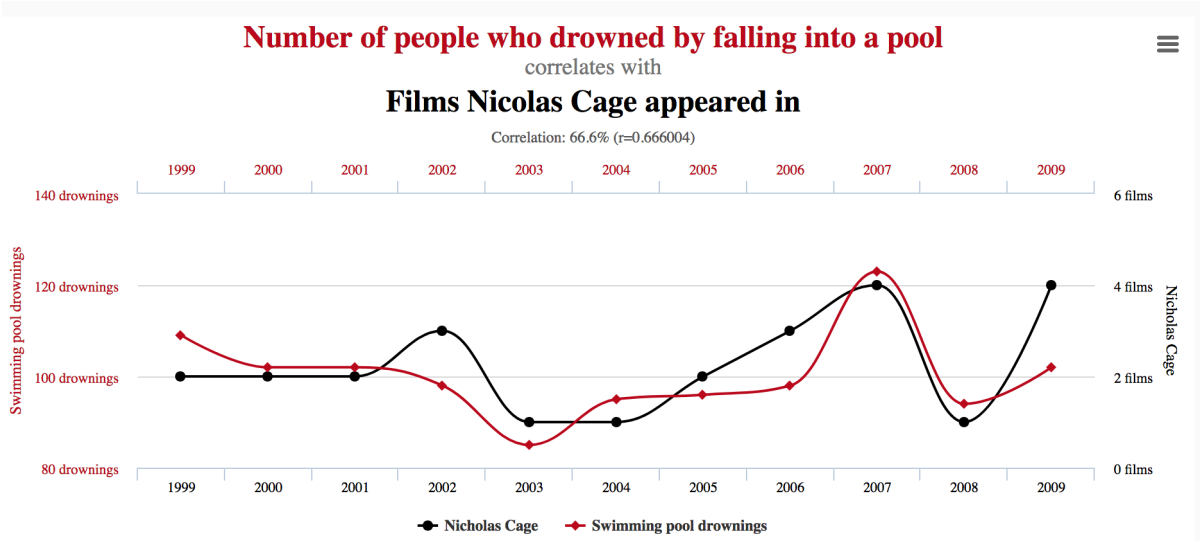
Figure 17. ***Syzygy - a conjunction of things, unexpected and surprising***

8.3: Wounded Terrain

The obfuscation of information is something I regularly utilise in my work. Through splitting information across transparencies and manipulating information into sounds and images I hope to highlight that data is malleable. I wish to emphasise that the presentation of data, alongside the textual information given to decode it is highly impactful on the meanings we extract. An example of this can be found on the website *Spurious Correlations* by Tyler Vigen, where humorous graphs are made from uncorrelated data sets that share similar trajectories. In these works the viewer is guided by the named variables attached to the graph.

Figure 18. Spurious Correlations

Tyler Vigen, *Spurious Correlations*, 2009



In my 2020 work *Wounded Terrain* I attempt to emphasise this text guided method of displaying data in a more serious context, presenting abstract visual information alongside clear didactic text to see if this can create critical thought around environmental impact caused by humans.

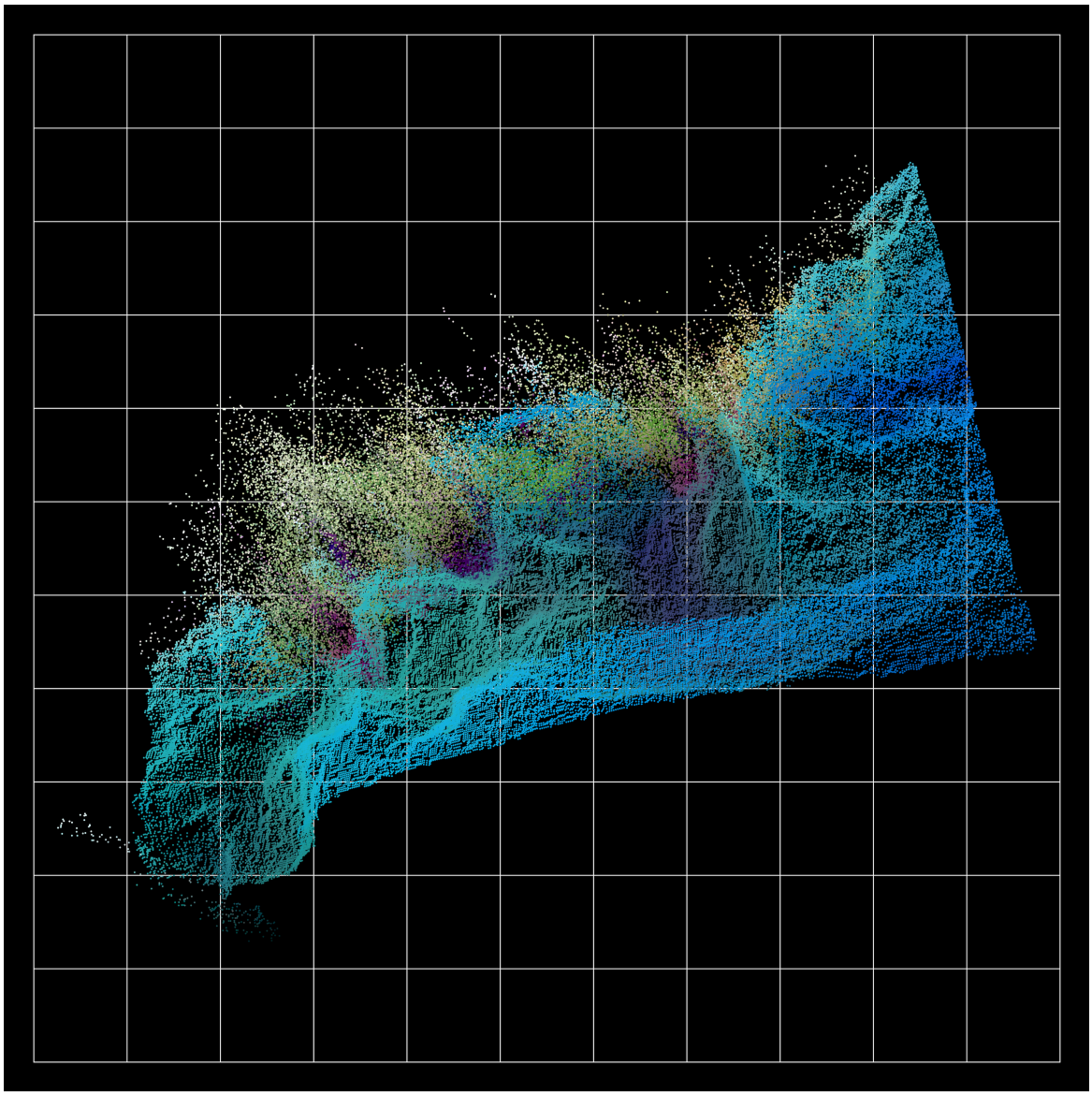
The work consists of three-dimensional animations which are created through manipulating satellite images. These initial images focus on highly polluted or

damaged areas of nature and distort them by applying topographical, chemical and biological data sets. The results are diagrammatic and abstract with the intention of breaking the image into something seemingly quantifiable but foreign from its source.

Like in *Syzygy* the information required to understand and decode the material is presented but not immediately accessible. Simple didactic panels provide information on the locations used and how they are damaged and polluted. However, they do not explicitly state how data is applied to these images, leaving the audience to attempt to identify the data and its relationship to the images for themselves. I think of these works as abstract documentaries where part of the information is provided via text but for the audience to understand the full story they must engage with the work spending time to identify how these landscapes are distorted by data and what that data means.

This process of engagement allows audience members to use the work as a way of creating space to think and meditate upon climate change as they work to understand the information displayed. The goal of the work is not to be dictatorial or prescriptive but to present simple statements of fact alongside a new way of viewing and engaging with information related to the environment. Despite presenting the works in this manner there is of course a personal bias embedded in the work. This stems from my feelings of horror and helplessness in the face of climate change; I attempt to mitigate the impact of this bias by making these pieces as aesthetically engaging as possible. I hope that if a viewer is not particularly interested in learning about climate change or disagrees with my stance, that they will at least enjoy engaging with the visual component of the work and maybe this engagement will encourage them to think on the subject more deeply.

Figure 19. Wounded Terrain



Polluted Rivers, North Carolina, USA.

Increased flooding results in rivers carrying excess pollutants and sediment that is deposited into the sea off the North Carolina coast. This sediment consists of phosphorus used to grow crops and large quantities of manure from pig farming. This sediment is rich in nutrients that allow for huge algal blooms to grow, draining oxygen from the surrounding environment and destroying habitats.

9: Exhibition Experience, Machine Sight

Much of *SuperLattice* has been built around systems and rules, sometimes simple and logical, sometimes convoluted, repetitive and absurd. These processes are performed numerous times and applied to a wide variety of source material. In a way the application is similar to the early stages of a scientific experiment with a hypothesis (the expected output) being checked against the reality of the system until it works as expected or until a satisfactory alternative/glitch is found.

The central structure of the *SuperLattice* exhibition is a large glass display cabinet and this cabinet contains the work and experiments made whilst creating *SuperLattice*. This work takes the form of objects, machines, projections and miscellaneous artefacts. Like many of the works referenced in the paper there is an interplay between these objects, devices and the information projected. Together these accumulations of images and matter create a shifting body of information that can be combined into a cohesive whole but is disparate in appearance. The magnitude, speed and ephemerality of the information making up this whole is too great to fully perceive, leaving the viewer to mentally compile accumulations and correlations between small groupings of objects and light.

SuperLattice gives the audience a high degree of agency to create their own experience of the exhibition. However, a risk of my method for working with data can be that information is taken too literally, resulting in people interpreting the artistic outcome as fact or feeling as if the work is somehow intended to trick and misinform. Due to this I will place a disclaimer in the exhibition materials detailing that the exhibition is intended as a conceptual space for thinking about and engaging with the idea of information, and not as a directly factual or educational tool. I will also highlight the computational elements that *SuperLattice* imposes upon the viewer, engaging them in a similar method to a machine learning algorithm. This is a system of viewing that I have utilised in several of the works presented in SuperLattice.

One specific machine learning technique involves the conversion of audio files into images each containing one second of information (44100 pixels) and using these images to train a Generative Adversarial Network (GAN) — a class of machine learning systems that can be used to detect similarities and transfer styles between images. Once the system is trained using this initial image set I reapply the exact same set to the GAN, allowing the process to detect similarities between images and use these similarities to create new images where the computer applies the learned areas of one set of images to another.

Once the process is complete I convert the outputted images back into sound. These sounds carry the artefacts of the machine learning process and amplify the dissonance within as the algorithm attempts to convert information from the same source into something it perceives to be even more similar to itself. This process of conversion between two sets of the same material is similar to the intended outcome of how *SuperLattice* is experienced as a viewer:

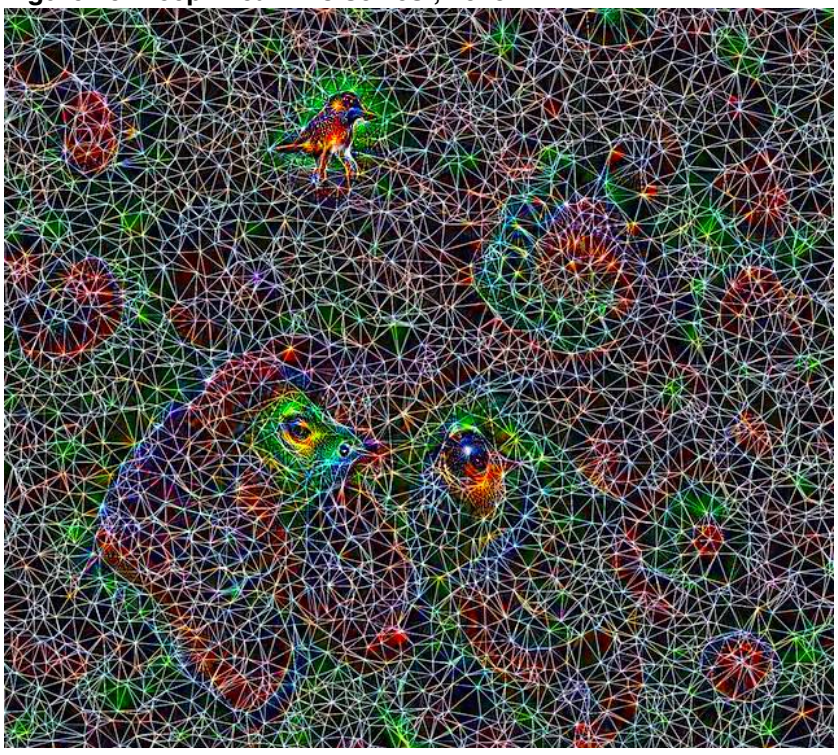
- In *SuperLattice* the viewer experiences a set of items and objects and identifies points of specific interest. This is similar to the initial collection of images or data to be fed into a machine learning system.

- To understand and engage with the exhibition the viewer has to focus on these points of interest, extracting certain features and commonalities that they identify throughout the visual work. This is similar to training a machine learning system where the information that is input to the system to an extent defines how information is output. An example of this is evidenced in Google's 2015 neural network *Deep Dream* where user images were processed through a neural network. The resulting outputs were psychedelic and contained large amounts of dog related imagery. This was because a large proportion of the images used to train the system were photographs of dogs.

- The understanding generated by the viewer is applied to new areas of the exhibition and environment. The assumptions and identifications made can be used to identify features of the work and make predictions of data sources and how the work is interconnected. This is the last stage of the machine learning system, where a trained system is used to identify and transform features in images.

The connections and assumptions made in the early stages of viewing the exhibition are continuously applied and reapplied by the viewer as they seek to extract meaning from a large amount of information and harmonise their experience with their initial predictions. A computational analogy for this experience comes from a 2015 experiment where I input an image of featureless white noise into Google's Deep Dream neural network. The resulting image is generated from the initial patterns that the system identified within this noise. As the process continues the image becomes more concrete. The final image strangely results in much more coherent shapes than many Deep Dream outputs which are applied to more complex photographic images.

Figure 20. Deep Dream Noise Test, 2015



10: Conclusion and next steps

Through the creation of *SuperLattice* I have been able to explore multiple ways of manipulating and processing data through a conceptual structure. This structure has allowed me to see and define ways in which data is shaped by digital processing techniques, analytical text and applied narratives.

The artistic works in *SuperLattice* have developed from simple experiments into complex, interconnected structures and forms that highlight data and the visible and invisible realities of this data in our lives and experiences.

Through my research I have found answers to my initial questions. Data is malleable and easily converted and augmented through digital processes. I have however found that the most important tool for shaping information is how it is positioned in the mind of the viewer using stories and text. These stories have the power to transcend written instructions, keys and statements and invisibly inform the images and data used to train machine learning systems, leaving a mark that can have major impacts on individuals and society.

I intend to continue developing and building upon *SuperLattice* as a body of creative work and research. I am particularly interested in two areas of growth for the project.

- Exploring machine learning and artificial intelligence more deeply. In *SuperLattice* I have only touched the surface of this subject due to its complexity and my own personal learning curve. In the future I wish to create machine learning tools that will enable me to use elements of the *SuperLattice* concept to process and create new sensory media. I wish to use this artistic creation to increase public knowledge on machine learning and showcase the human errors and biases that can be unknowingly propagated with these tools.
- Developing the *SuperLattice* framework into an educational tool to teach students about how information is collected, presented and manipulated. I want to create a simple way of explaining the importance of information and how it can shape and control our everyday lives as well as providing real world methods of reducing

and mitigating these effects. This program would not contain complex coding and would act as an exercise in data literacy and protection.

In the *SuperLattice* exhibition I envisage beams of projected light trained on the central cabinet as the consolidation of all the work and research that has gone into the creation of *SuperLattice*. As these streams of light transmit images created through *SuperLattices* they reflect and refract off glass and objects creating new forms. To a viewer it is unclear if the trajectory of the light is intentional or in error and this disorientation in perception feeds back into the *SuperLattice*. As the viewer attempts to understand this information they begin to create their own narratives that alter their experiences and perception, creating a *SuperLattice* that is so much deeper and more complex than I could create alone.

As the light continues to illuminate and shift I imagine the unreality machines of Doctor Hoffman and how the prolonged observation of this ephemeral light manifests *SuperLattice* into reality:

“sufficient radiation to intensify a symbol until it becomes an object according to the law of effective evolving, or, if you prefer a rather more explicit term, complex becoming.” (Carter, *The Infernal Desire Machines of Doctor Hoffman*, pg 217)

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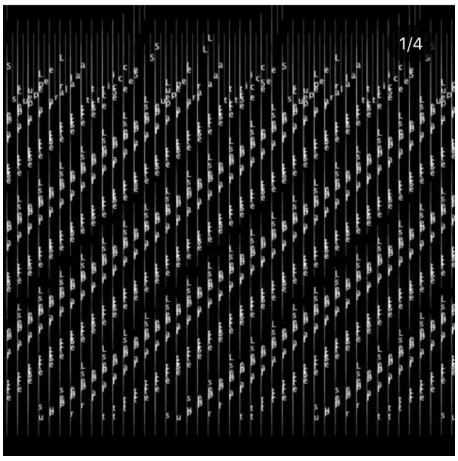
Appendix A: Instagram version of *SuperLattice* exhibition

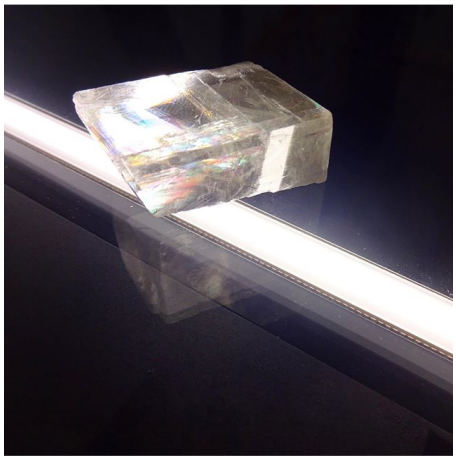
Due to the *SuperLattice* exhibition being unable to go ahead due to Covid-19 I initiated an Instagram takeover of the @yorkumfa Instagram account to share some of the work and research I would have been presenting in the exhibition. This takeover took place April 6th - 11th, 2020.

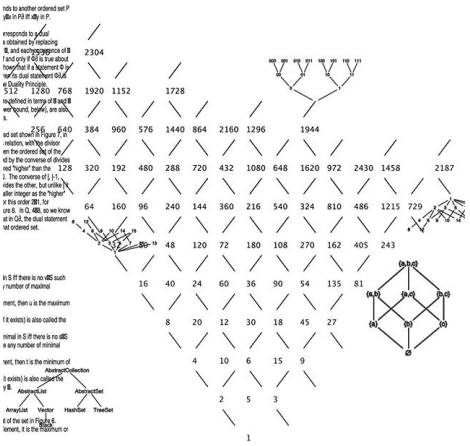
Figure 21. Day 1

yorkumfa SuperLattice - an Instagram takeover by @visualcodepoetry April 6th - 11th. SuperLattice is based around the development of a hybrid structure for investigating human and computational perception. Over the next week I will post process images and documentation for what was intended to be my MFA thesis exhibition. The intended form of the exhibition was a Wunderkammer (cabinet of curiosities) animated through light and projections, showcasing the malleability of digital information and sense.

Edited · 1w







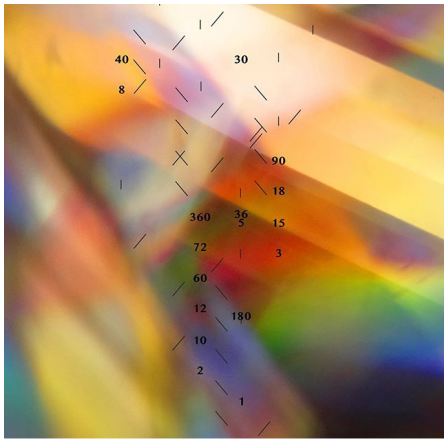
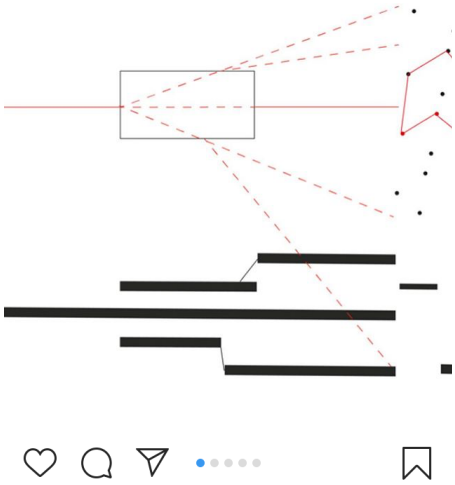
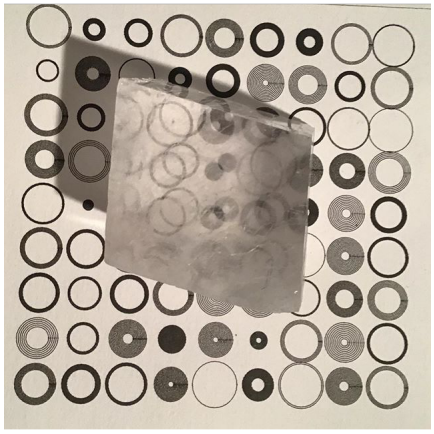


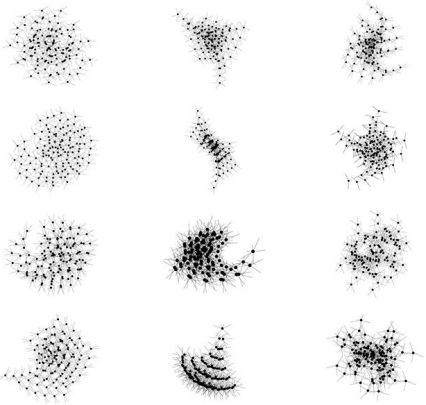
Figure 22. Day 2

yorkumfa Instagram takeover by @visualcodepoetry day 2: SuperLattice began with an interest in using optical calcite — a mineral that has the ability to split and polarize light — to act as an optical method of processing and manipulating data. This early stage research led to an interest in the aesthetics of scientific diagrams alongside exploring fractals as scores to navigate a path through the myriad of faces and walls within the crystal.

6 days ago







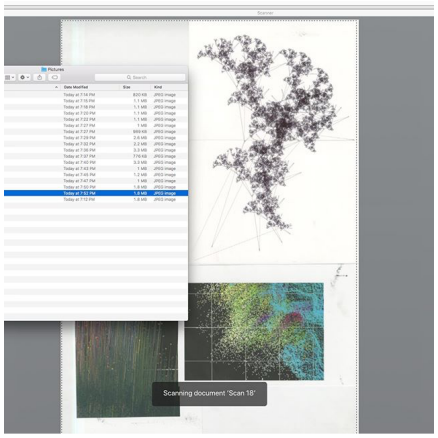
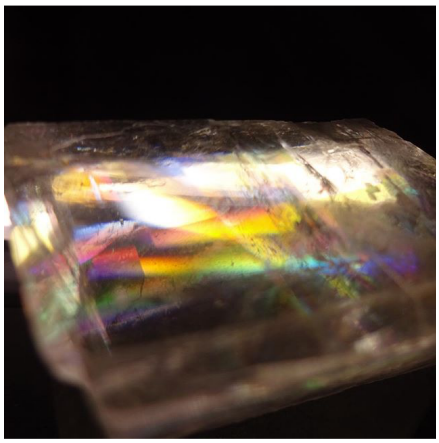


Figure 23. Day 3

yorkumfa @visualcodepoetry Instagram takeover. superLattice: calcite crystals break light into multiple paths, distorting and shimmering through the crystal. Images from calcite scanned and under microscope.

6 days ago



yorkumfa Instagram takeover by @visualcodepoetry day 3: My experiments with optical calcite progressed into an interest in translation of images and information — asking questions about how the data we interact with has been shaped and distorted by companies and 3rd parties and what these distortions mean. I began to develop a concept called the SuperLattice which acts as a sort of multi-dimensional array of information. In the SuperLattice data sets cross pollinate with each other in a kind of machine synesthesia. Images, sounds and datasets can morph between each other creating new sensory relationships alongside highlighting the malleability of data. In the images in this post information from the genome of a virus is applied to satellite imagery of damaged and polluted terrains, infecting these images and making them as unrecognizable as the human processes destroying the landscape.

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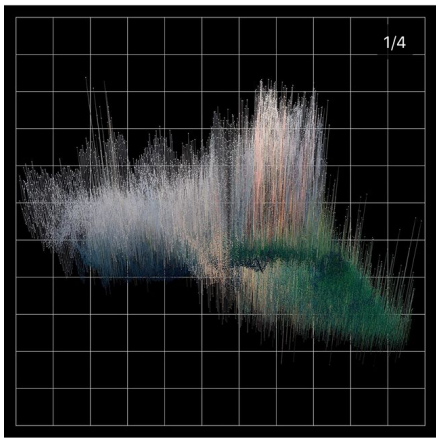


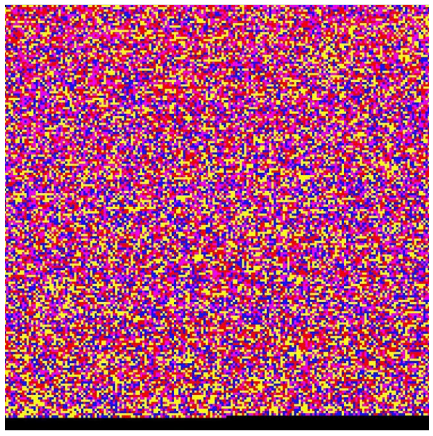
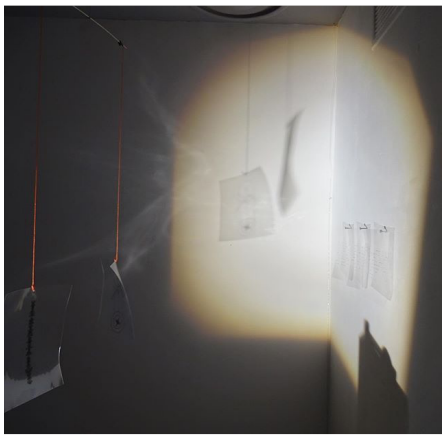
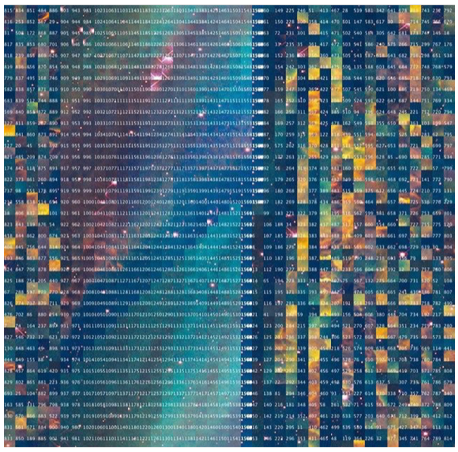


Figure 24. Day 4

yorkumfa Instagram takeover by @visualcodepoetry day 4: What happens when information is broken and redistributed to be rearranged in the mind of the viewer? Datasets broken across physical and digital forms like fragmented puzzles. Images 1,2,3,4 reference - planetary data, sorting algorithms, conversion of information into machine drawings, translation of information into playable grooves

5 days ago





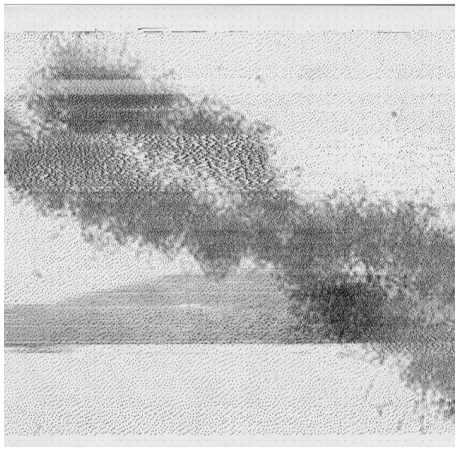
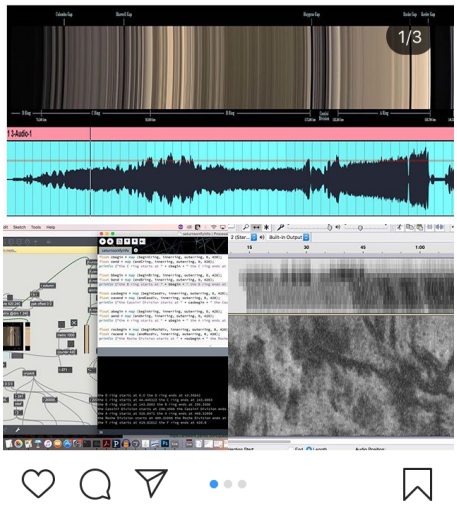
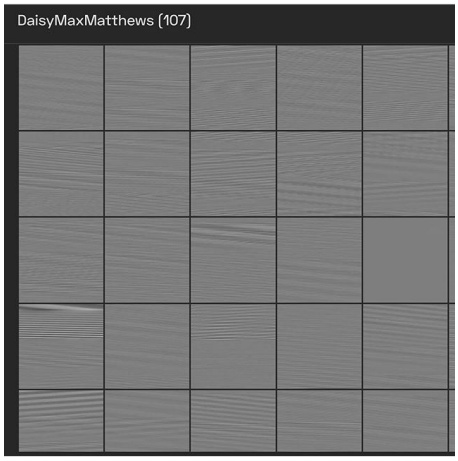


Figure 25. Day 5

yorkumfa Instagram takeover by @visualcodepoetry day 5: superLattices combine multiple layers of translation, conversion and learning. Errors in these systems are amplified and made into concrete artefacts where processes become forms. Images:1, Translating Saturn's rings to be encoded into vinyl discs. 2, applying machine learning algorithms to Daisy Bell — Max Matthews. 3, sonogram output of ML output

3 days ago





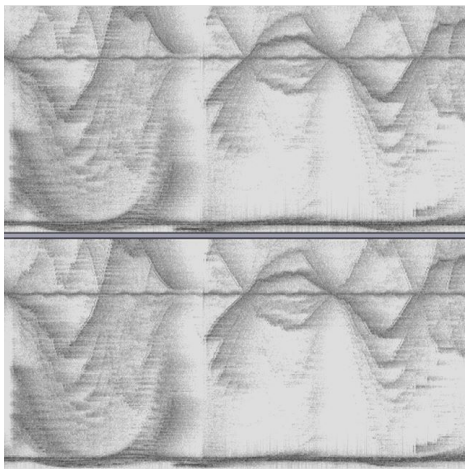


Figure 26. Day 6

yorkumfa Instagram takeover by @visualcodepoetry day 6: In the absence of being able to stage a physical exhibition I have compiled a series of images documenting previous exhibits that were key in developing SuperLattice. A big interest for me is distributing information in non tangible ways to create immersive installations and experiences where the viewer is placed at the centre of the data. To achieve this I use bright diffused light and multichannel sound to create an environment that can be explored sonically and visually from many different angles. Images are: NOVA installation first presented at @cmcnational, Helios presented at @factorymediacentre , gallery experiments at York University (images 3,4,6,7), Wounded Terrain presented @varleyartgallery and time lapse of Helios exhibition @factorymediacentre video captured by Alex Volkov

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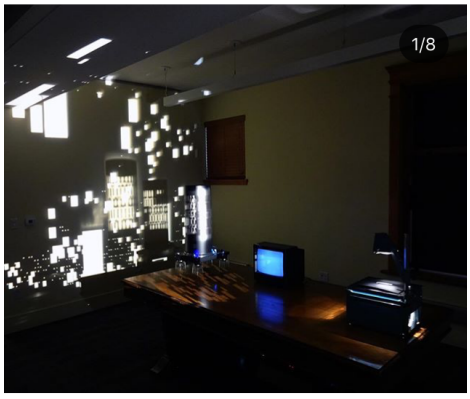
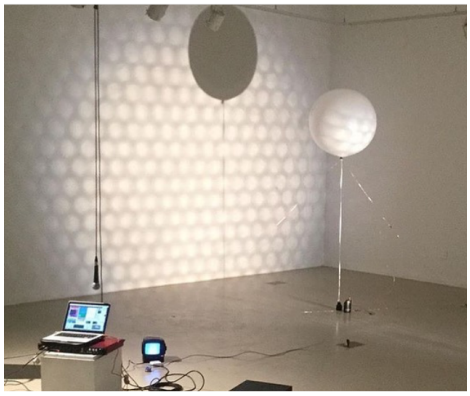
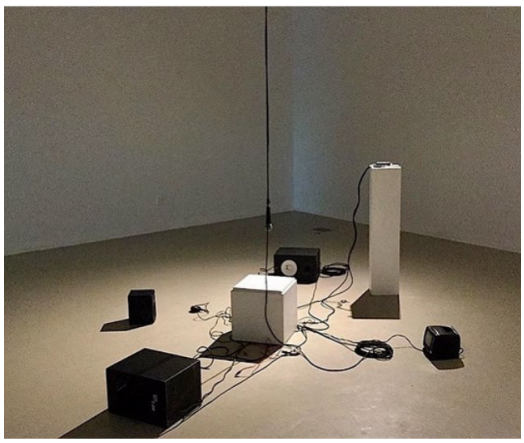






Appendix B: Excerpt from Creative Applications interview

An interview conducted in 2017 by Greg J. Smith for Creative Applications Network. The interview touches on my recent exhibition *Turbulent Forms* and focused on my methods of working with data.

Figure 27. Excerpt from Creative Applications interview

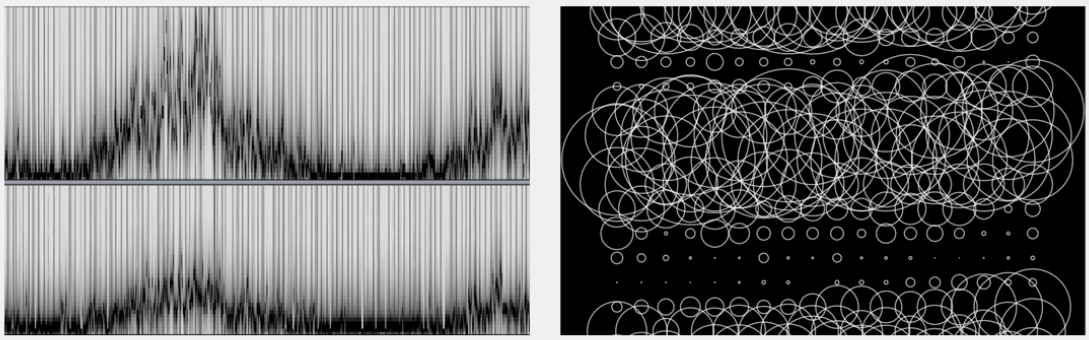
Across the *Turbulent Forms* project you have produced visualizations and sonifications of the cosmic microwave background, gravity waves, and sunspots. Can you talk a little bit about how each of these phenomena serve as muse and as data?

I started *Turbulent Forms* with a large list of possible data sources, this included data sets such as: near earth comets, planetary orbits and chaos theory. From my visits to the Canadian Music Centre where the exhibition would take place I had decided that the most powerful layout for the space would be three large scale print works and a full room audio-visual installation. This meant that I needed to shorten and refine my list to find the four data sets that I was most excited about working with in terms of the subject matter, format of data and creative possibilities for sound and visual work. The four data sets I chose for Turbulent Forms are each very different but connected with me on a deep level, inspiring a number of different ideas in how to develop work that poetically represented the underlying data.

The data sets I chose were:

- Sunspots occurring between 1991–2017
- Gravity waves, sonifications and data from the Laser Interferometer Gravitational-Wave Observatory (LIGO)
- Cosmic Microwave Background data from the Wilkinson Microwave Anisotropy Probe (WMAP)
- Supernovae recorded between 1885–2017 (and four earlier galactic supernovae years: 1006, 1054, 1572, 1604)

I chose different methods of working with and processing the data for each piece, to highlight the source data and underlying scientific concepts. For example *A History of the Universe in Noise* creates an analogy between the loss of information from the Big Bang into the low level cosmic microwave background by using a process called generation loss where source information is lost and degraded through repeat copying. Other pieces such as *Solar Maximum* work more closely with data sets, creating a visualisation of the number of sunspots and sunspot magnitudes logged by month – this quantitative visualisation is then used to control a particle system that pushes and pulls particles to create pathways focused around points of high magnitude sunspots and solar maximums.

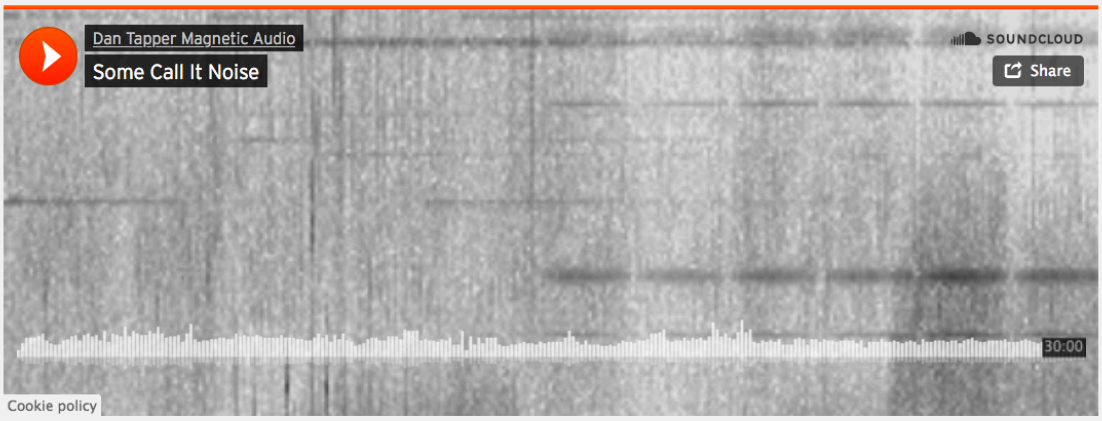


↑ Sonogram of sunspot sonification (left) and *Sunspots of my Life*, a sunspot data visualisation before particle system, 1991 – 2017

My goal for each piece was to create an experience that linked the viewer to the source information of each work and allowed them to view the piece as a work of immersive visual art or dive deeper into the underlying source. It was important for me to have a learning process and be inspired by each data set I was using so I could effectively communicate this information and creative vision to an audience.

Could you talk through the conception and execution of one of the visualisations and data analyses in more detail?

Solar Maximum is the most directly personal of the pieces in Turbulent Forms, it mixes quantitative and abstract visualisation methods to map all the sunspots recorded in my lifetime (January, 1991–August, 2017) I used information recorded by Sunspot Index and Long-Term Solar Observations (SILSO) these observations record the number of sunspots that occur over months, days and years. The visualisation comprises of a grid of circles representing regular monthly time intervals of sunspot data, the circles magnitudes are controlled by the number of sunspots recorded over each month. This simple quantitative visualisation is used to control a particle system modelled on magnetic repulsion and attraction, each circle has a push/pull force based on its magnitude – areas with high magnitude sunspots or a number of high magnitude sunspots attract more particles creating an abstract map reminiscent of magnetic fields and topographical charts over the sunspot data. Something that struck me when working with this sunspot data is how clear the 11 year cycles of solar maximum (highest concentrations of sunspots) appear in even a simple data visualisation or graph.



The full interview can be accessed at: https://www.creativeapplications.net/processing/music-of-the-spheres-a-conversation-with-dan-tapper/

Appendix C: *SuperLattice* website

I developed an accompanying website for *SuperLattice.* This website contains documentation on the artistic work and my creation process. The materials presented on the website include: a publication, video documenting experiments performed in the creation of *SuperLattice,* video of an artist talk I presented in association with InterAccess, Toronto*,* an image gallery and an interactive code work. The intention of the website is to act as a digital portal into *SuperLattice* that can be accessed during the current Covid-19 pandemic. I intend to keep the website online as an archive of *SuperLattice* and plan to incorporate it into future *SuperLattice* exhibitions.

The website can be accessed at www.superlattice.ca

Figure 28. SuperLattice website, title page

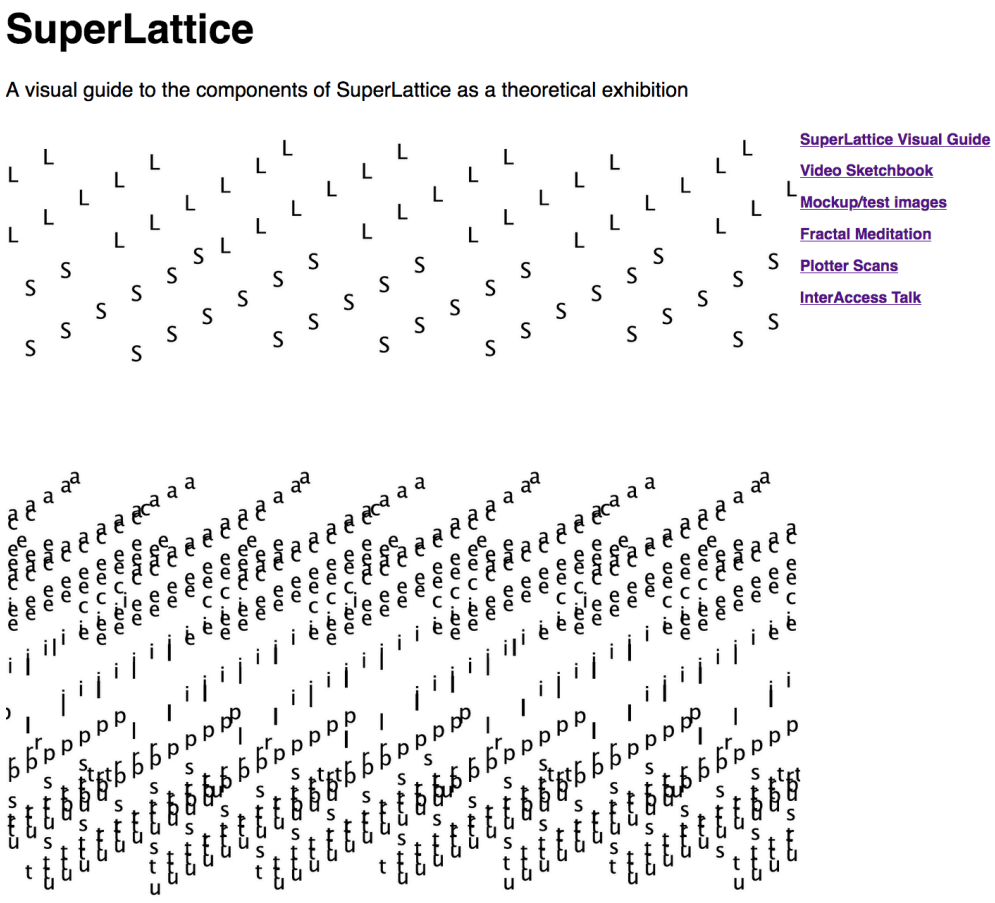
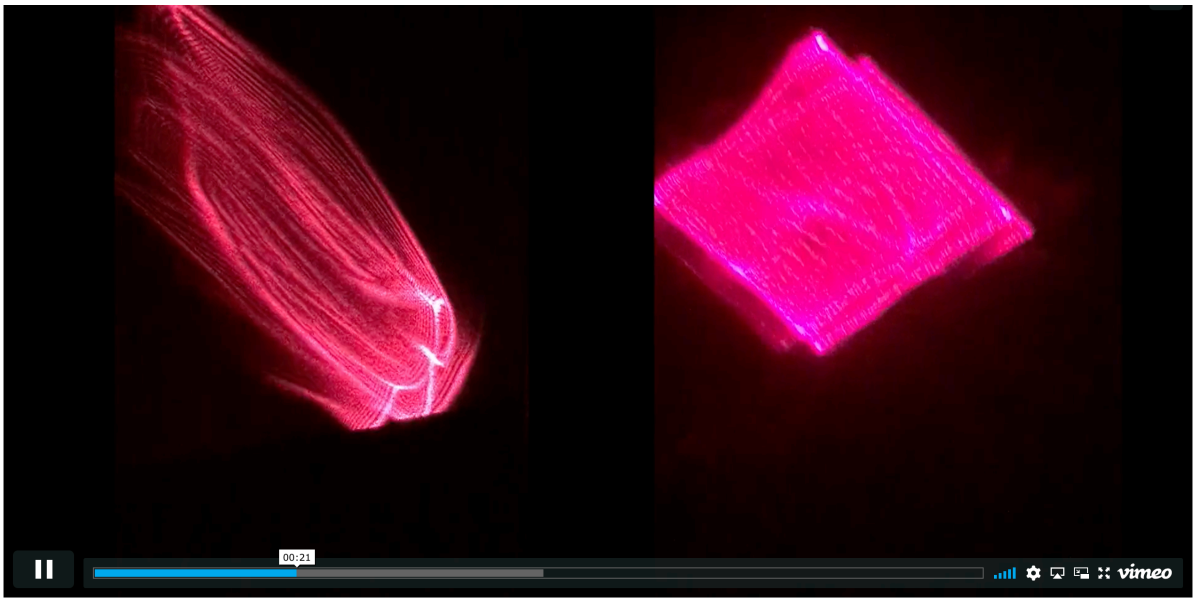


Figure 29. SuperLattice website, video sketchbook



Recordings from my phone detailing some of my visual and audio experiments in developing SuperLattice.

Light + reflective materials + sensors --> crystals + lasers --> fluctuations in laser converted to sound --> crystals imaged through scanners and microscopes --> crystal lattice simulation slowly breaking apart --> testing algorithms (such as sorting) and sound making studies --> Simple electronic synths and using these in conjunction with video --> DIY radio transmitters to test information transfer (arduino's and raspberry PI's used in my further experiments as more reliable) --> sound to image/image to sound --> 3d models shift and break, morphing between states --> projections onto glass and mirrors manipulate image

Figure 30. SuperLattice website, interactive generative fractal

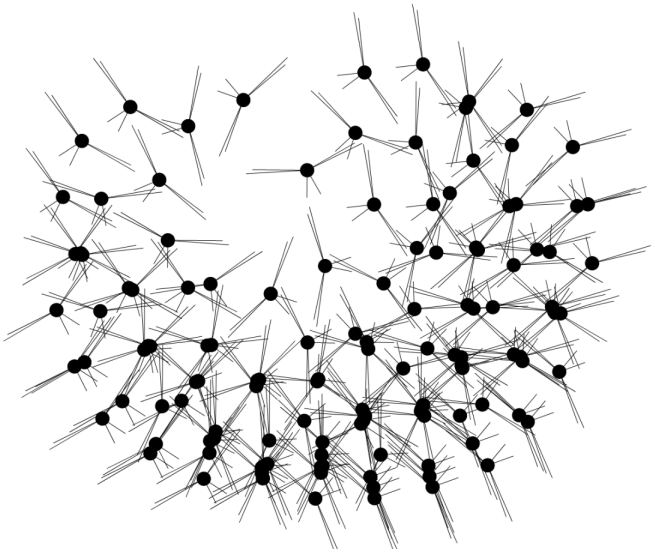


Figure 31. SuperLattice website, image scans