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Re- imaging visual information complexity: A creative approach to information entropy, perception, identification and understanding

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Abstract: The author considers the material nature and aesthetic role of information complexity in creative production. Outlining the context of computer based artworks within the visual/fine arts and the relationship of dematerialised media to digital code, computer science techniques are redefined as both artwork, and method of creative investigation. A discussion of several of the author's artworks illustrates these themes.

Introduction

The research outlined in this exegesis began by posing the question, is it possible to make an image that contained so much information[1] it was beyond the means of a human being to determine any meaning and what would such an image look like? The research also sought to determine the relationship between information complexity and how we appreciate images. Key to this was the idea that all possible images could be placed on a continuum ranging from an image with no information content, essentially a blank medium, to an image encoded with the maximum amount of information.

To understand this, imagine two blank pieces of paper, the same height and width, and capable of representing colours[2]. The height and width of the paper, along with the number of possible colours, and the number of image elements (small pieces of the image[3]) would describe the total amount of information that the image could carry.[4] On the first page, the image with the minimum information content is an image with nothing encoded, so this page is left blank, and it conveys to us nothing other than it exists as a medium.[5] The second page carries as much information as possible, the maximum that can be encoded and carried by the media.

Imagine that these two hypothetical images, the empty page, and the full page indicate the endpoints of a continuum, along which all possible images could exist. Starting with the image that represents the minimum information content, extending through images that would contain, at each step more information, finally reaching the maximum that can be encoded.

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[1] The term information is used here in terms of bits, and will be discussed in greater detail later in the section "A measure of information."
[2] A blank piece of paper can represent anything dependent entirely on the information encoded onto it.
[3] These small pieces can be any small size, but all pieces must be the same size. The size of these pieces determines the sample resolution.
[4] This describes the bandwidth of that particular image container. For example with a piece of A4 paper we can fill its surface with a certain amount of information determined by the size of the small pieces or samples; however with a piece of A1 paper we can fill its surface with four times the information that could fit on the A4 page, simply because of the larger surface area. The bandwidth of an A1 page is larger than the bandwidth of an A4 page.
[5] Surprisingly, by its existence this empty image implies a very large number of potential images, in that our medium is capable of representing any image of which the actual image shown is only one.

Investigating these concepts posed further questions, what is information, what is its material[6] nature, how is it stored, altered, and transmitted?

The following points arose during the course of the research.

- That information is poorly understood in terms of its relationship to structure.
- That information is a part of reality as asserted by Vlatko Vedral, and that information helps to constitute what can be considered real (*See Chapter 1: What is information?*).
- We utilise or map information onto media to make signs, the concept of signal and substrate.
- That information has no intrinsic meaning.
- Information is encoded at a point of change in a medium; it has a liminal nature, existing in boundaries between one state and another. This is discussed in detail in Chapter 3: Dematerialisation of media.
- Information that is captured is a part of its source, that is, although captured and separated from its source, it tends to remain a part of the source.
- Information can act as a physical property, similar to an electric charge accumulating around a dielectric material, information can accumulate around media.[7]
- The role of digital capture of information as images or imprints of the real world.
- Temporal sorting reveals the informatic exchange in a system in contrast to the energetic exchange of the time lapse image, and is a visualisation of the exchange of information states.

This exegesis is divided into four parts, chapter 1 looks at information, what it is, and perhaps what it is not. How information is measured and how it relates to encoding media. Chapter 2 looks at computer based art, and common criticisms as

[6] The word "material" is used in the sense that it is a defining characteristic of the substance or thing in question. For example, the force of gravity has the defining characteristic that objects with mass will be drawn together through space, although gravity itself is not a physical thing it still has properties that define it.

[7] A painter starts with a blank canvas, which is an empty medium or communication channel. By adding paint, slowly information is encoded onto the medium, collecting an information "charge" that will remain with that painting.

defined by Dominic McIver Lopes (McIver Lopes 2010). Chapter 3 investigates digital code and its role in the dematerialisation of media. This chapter also looks at issues of quantization, and subdividing data, drawing on the ideas of Henri Bergson, and discusses the technique of temporal sorting used in creating several of the thesis artworks. In chapter 4 the thesis artworks are discussed in relation to the issues raised in this exegesis.

Chapter 1: What is information?

Our ability to understand the role of information in the physical world is under developed. It is hard to imagine let alone quantify the amount of information contained in a rock, or the changing information content in water as it rushes down a stream. In the words of Professor Wojciech Szpankowski of Purdue University, "no theory exists to provide a metric for how much information is embedded in structure. There's not even a good way to quantify complexity"(Neil 2011, 17). Furthermore, wherever a process occurs information is being exchanged. "Anything that exists in this Universe, anything to which you can attribute any kind of reality, only exists by virtue of the mutual information it shares with other objects in the Universe"(Vedral 2010, 204). (*See footnote 13*)

If we accept that information is a property of the reality we inhabit, then recording in any form becomes an act of capturing a part of the subject. The information inherent in an ordinary fire hydrant can be captured and mapped onto a different media; however it is still part of the fire hydrant. William S Burroughs in describing his system of "playback" wrote of the power of recording. "So a recording made from the Moka Bar is a piece of the Moka Bar. The recording once made, this piece becomes autonomous and out of their control"(Burroughs 1989, 19). So a digital photograph of a fire hydrant will capture some of the hydrants redness, and shape and its relation to the footpath. While constructing an indexical sign that represents the hydrant, the information used in constructing the sign is derived from the state of that particular hydrant at that particular point in time,[8] and remains part of the hydrant.

[8] The role that time and information states play becomes more important later in this exegesis.(*See Chapter 4: The thesis art works*)

A measure of information.

Claude Elwood Shannon, building on the previous work of Harry Nyquist, and Ralph Vinton Lyon Hartley, defined information as a quantity he labelled 'entropy'. "How is an information source to be described mathematically, and how much information in bits per second is produced in a given source? The main point at issue is the effect of statistical knowledge about the source in reducing the required capacity of the channel, by the use of proper encoding of the information.." (Shannon 1948, 4-5) It is worth noting that while Shannon was closely focussed on the engineering requirements of a communication channel, he properly notes the importance of the role of encoding. While the medium in this case was telegraphy the role of encoding can be viewed as the embedding of information within an indexical sign. While information might form a part of a message, the amount of information (entropy) is measured regardless of its meaning. "In Shannon's theory, information, which consists of bits, is that which reduces a recipients statistical uncertainty about what a source transmitted over a communications channel"(Neil 2011, 16)

Randomness, data compression, and information redundancy.

All digital files are programs, and all programs are processes in written form. The size of an image file is therefore the length of its program. The size of the shortest program possible for a particular result is an indicator of the "algorithmic information content"(Chaitin 2005, 89)

At the upper most position on our complexity continuum of possible images, (*see the Introduction*) is the image that contains the most information, an image with randomly arranged pixels. Perfectly compressed data is indistinguishable from random data; this is also true for data that is perfectly encrypted. If the encryption algorithm is good the resultant cipher text will have all the attributes of random data. (Schnieier 1996, 226-7) This implies that randomness, what we see on our televisions when we tune off channel, or hear as radio static, could be meaningful information that we simply cannot understand, because we do not have the necessary algorithm or cognitive/cultural tools to decompress or decode it.

Because randomness implies an excess of information it can also be understood as the maximum degree of "internal qualitative relation" (Deleuze 1993,

46). In terms of images "the most informative picture is one in which each pixel is a complete surprise."(Chaitin 2005, 76). When we generate random values, either by electronic[9] or mechanical means, we are tapping into, and manifesting an underlying property of reality, randomness is there already, we just give it a voice. "random things are everywhere, they're the rule not the exception" (Chaitin 2005, 34).

Furthermore according to algorithmic information theory a specific arrangement[10] of random pixels cannot be made by any other program that is smaller than the image file. Every program you can write to create a specific set of random pixels must be the same file size as the image file, or larger[11].

More than we need to know.

Information redundancy is a term used to describe the relationship between the bits used to transmit a message minus the number of bits of information in the message. It is information that is not needed, duplicated or extra to the message. For example with the English language the information redundancy level is approximately 50% (Shannon 1948, 14)[12]. With digital code information is mapped onto data, it exists not in the ones and zeroes, but in the relationships or changes between them. Repetition of bits gives rise to patterns of binary, and in turn the repetition of those same patterns.(Deleuze 1993, 41). If we view reality as a large computational process[13], and accept that background randomness might be an expression of perfect compression or encryption, perhaps the coincidental,

[9] As part of the research experiments were conducted in generating random values from quantum events, firstly using radioactive decay in low sodium salt substitute, and secondly by using a type of electronic circuit known as a "shot noise" circuit.

[10] Any random arrangement of pixels can be generated quite easily with a program that is relatively tiny compared with the resulting file size. However any random arrangement is not any specific arrangement. A specific arrangement of pixels is one amongst a very large set of possible arrangements.

[11] This assumes that the method of writing the image has been optimised, to make it the most efficient method.

[12] For example, your mobile phone service might be quite bad, and only transmit or receive to your handset 50% of the time. If you are communicating in English, then you should still be able understand the meaning in the conversation, even though you are only hearing half of what is being transmitted to you. Another example is where certain letters can be removed from text, without destroying the meaning of the text. "rmvng ll th vwls cn mk mssgs shrtr whtt dstryng mnng" (removing all the vowels can make messages shorter without destroying meaning) or "rmvn eey scn lte de nt dsry te msae" (removing every second letter does not destroy the message

[13] Part of Alan Turing's contribution to the field of computing was the disembodiment of computation. Computation was no longer about the mechanism of the computer, but about process. (Cooper 2012, 76)

synchronicities of life[14] are the computational process of reality decompressing or decoding and revealing hidden information. Meaningful coincidence being the reintroduced redundant information experienced as a type of repetition.

Understanding: a process of compressing knowledge.

Understanding arises from a process of mapping our experiences into a relational, idiosyncratic model of our world. The stream of perceptual information is converted to manageable form, by utilising abstract concepts that stand in for the more complex reality[15].

"there is a dichotomy between our desire to compress information (distil our whole understanding of reality into a few encompassing principles) and the natural increase of information in the Universe (the total amount we need to understand)."(Vedral 2010, p.11-12)

The relationship of a map to the represented landscape provides a suitable analogy. What we read from a map is a condensed synthesis of critical elements from our already abstract understanding of the landscape. Details are dropped in favour of a compact description that contains important key aspects of the landscape. By distilling a topic into a few key principles, we are compressing information; the removal of redundant content allows us to form a better understanding. (Vedral 2010, 11) This compression in terms of a few key principles redefines the original source in terms of its description.(Bolter and Grusin 1999, 44-45). Our understanding of the landscape is reified in terms of the map, and our understanding filters what we perceive of the landscape. But this condensation down to a few key principles is also a removal of information redundancies.

Sorting as a method of reducing Information content.

The bubble sort algorithm was chosen to rearrange pixels by numeric value, and an implementation written that would order pixels from dark to light, in three different ways. Firstly in columns from left to right across an image preserving the X axis address of each pixel (*see Figure 14*), secondly in rows arranged from top to bottom down an image preserving the Y axis address, and thirdly across the entire

[14] For example thinking about someone from childhood, who you haven't seen or thought of in decades, and running into that same person later that day.
[15] Our thoughts, ideas and knowledge, like computer files can be thought of as indexical signs. The medium is our cerebral cortex, and the information comes from our senses.

image, preserving neither X nor Y addresses[16], by starting from the top left, finishing at the bottom right.[17] To reverse the direction of the sort from light to dark simply meant flipping the image after sorting.

While inefficient in terms of speed the bubble sort process, as an in situ sort, is easy to understand and reflective of sorting items in the real world. The creative insights gained from its use more than compensated for its lengthy execution time.

"It would be nice if only one or two of the sorting methods would dominate all of the others, regardless of the application or the computer being used. But in fact, each method has its own peculiar virtues."(Knuth 1998, 380)

While there are no thesis artworks that display bubble sorting in action, the steps of visualizing the sorting process, and watching the execution of the sort, led to consideration of sorting data across sets of images and in turn led to sorting over time.[18]

It was initially thought that sorting pixels would provide a type of metric based on complexity that would perform as an aesthetic measure, as described by G.D. Birkhoff. (Birkhoff 2000, 2185). This would allow a computer to autonomously select images that contained a certain amount of information complexity, and thus a certain level of aesthetic quality, from a region on the complexity continuum described earlier. However, experimentation led to a realization that aesthetic choice should reside with the artist. Reliance on a computer program would result in the choice of more images that were of the right level of complexity but of little aesthetic value, while rejecting images that were of aesthetic potential but containing an inappropriate level of complexity.

Sorting an image reorders each pixel in relation to all others and in doing so reduces the complexity of an image, thus reducing the amount of information the image contains. The relationship of the individual parts to all other parts, which collectively constitute an image carries and transmits encoded information to the

[16] The term "address" is used to denote the Cartesian coordinates of a pixel located within an image.
[17] The development of temporal sorting took place at a later time.
[18] It should be noted that the choice of the type of measure, in this case the bubble sort can in some sense predefine the results of the measuring. For example the unit of length used to measure an irregular line, can directly influence the measured length. The smaller the unit of linear measure, the longer the measured line.

viewer.[19] Sorting replaces the context between pixels with a new set of relationships based on externally supplied criteria.

Figure 1: An image comprised of random pixel values. File size 1,220KB.

Figure 2: The same image dataset as Figure1, after sorting each column. File size 701KB.

By simply rearranging the pixels from Figure 1 to Figure 2, sorting from light values to dark values, information redundancies have been introduced, the next pixel in the sequence is no longer such a surprise,(Chaitin 2005, 76) correspondingly the file size decreases because the second image can be described in fewer terms[20]. In this circumstance the pixels in Figure 1 and Figure 2 are the same pixels rearranged,

[19] The difference in brightness and colour between one pixel and its direct neighbours, (those pixels that share a common coordinate) encodes the information at the scale of those pixels. The difference in brightness and colour between a pixel near one edge of the image and pixel near the opposite edge of the image encodes information at the scale of the image. These differences in brightness and colour between pixels define their relationship to each other. That this occurs simultaneously at various scales of perception is something that will be revisited later in this exegesis.

[20] In a similar manner to forming and understanding, the presence of information redundancies introduced by sorting, allows the image to be compressed, or described in fewer more concise terms.(*See Understanding: a process of compressing knowledge.*)

and demonstrate that visual information is encoded neither in the number of pixels, nor the colour of each pixel but in their arrangement in relation to each other.

A short exercise in manipulating information.

Imagine a picture, perhaps a photograph, of a cat, printed on paper. Imagine that we take a knife and cut the image into small pieces each about a millimetre square, at this point each piece is still in the relative position it held before it was cut out, so when looking at the picture, it is still recognizable as representing a cat, (Ignoring for the moment the relationship of photographs and the referent or semiotic object (Barthes 2010, 5)). Looking at one piece in isolation doesn't tell you much more than it contains a colour, but by including pieces that surround it, a little more of the image becomes apparent. If we keep adding surrounding elements to the group, eventually we begin to perceive clues to the subject of the image, and we can see that we are looking at a representation of a cat.

This threshold of recognition is related to information redundancy. The percentage of picture elements[21] required to perceive the object (the Cat) represents the minimum level needed to successfully transmit the message, which is the information encoded in the image. (*See More than we need to know.*) Imagine that we take two pieces from the image and swap them, and keep repeating this process until eventually the image becomes unrecognisable. The point where the 'recognisable' vanishes also indicates the level of information redundancy for the image. If the percentage of the image that had been shuffled was approximately seventy per cent, the image has an information redundancy of about thirty per cent. So thirty per cent of the image could be missing and what it represented, its object would still be identifiable.[22]

Imagine that as we shuffled the picture elements around, we kept a record, writing a list of each swap containing the coordinates (X, Y) of the elements involved. With each swap, we would add a new item to the list specifying the locations of the swapped elements, and the order in which the swaps occurred. As

[21] This percentage is in relation to the total of all picture elements in the image.

[22] As mentioned previously, Information redundancy = (The number of bits to transmit the message) - (number of bits in the message) which is equivalent to (all the picture elements or 100%) – (the number of picture elements removed when the semiotic object disappears or 70%) = 30% picture elements surplus to conveying the object. Note that we are treating each piece of the picture as one bit. This is for the purpose of this exercise only.

before there would be a point when the ‘recognisable’ vanishes, raising the question, where did the usable information about the cat go?

It hasn’t vanished instead it has been transformed, and no longer resides encoded solely within the image. The information that identifies the object, (the cat) is now carried within the list of swaps which holds the identity of the elements along with the order in which they were swapped, and the current scrambled group of picture elements.[23] To demonstrate this we could restore the image by following the list of swaps in reverse, and as each reverse swap was completed, removing that swap from the list. If we are lucky no mistakes would have been made in undoing the steps that gave us the list and the scrambled picture elements would return to their starting position revealing an image of a cat. The list of swaps at this point would be empty; because the information has been successfully transferred back to the image.

The full list acts as a description of the picture of a cat; it isn’t the image itself, but a type of meta-data (an indexical sign) that relative to that specific group of picture elements constitutes the image. For example if during the restoration process, before all swaps were complete, a real cat jumped on the table and moved the picture elements around, leaving us to put them back as well as we could, the positions of the pieces would be different.[24] We could continue to follow the reverse list, and move little pieces of colour back and forth, but the picture of the cat would be changed. The information stored in the list would be intact, but the information stored in the arrangement of picture elements would have been lost when the real cat intervened and importantly information stored between the arrangement of picture elements, and the list would be altered.

Imagine there was a way to store all the information from the image, starting from the state where no pieces have been moved. Luckily we have cut the image into a neat arrangement of rows and columns so each picture element is in an easily described position, and the height of each column is 1080 picture elements, and there are 1920 columns. Starting from the top left we could write down the address of the picture element as 1-1, (column1, row1) and its colour. Moving down the column to

[23] The information describing the cat is no longer carried solely by the picture elements, or solely by the list of transactions. It is carried by a combination of the two, the list, and the current scrambled picture elements. To get back the image of the cat, you need both the list and the set of picture elements.

[24] Assuming that the person putting the pieces back does not have an eidetic memory, it is almost certain that the pieces will not be returned to their proper place.

1-2, (column1, row2) again writing the address and colour. We would continue this process until we reach the end of the first column. Then move to the second column writing 2-1, (column2, row2) and the colour, repeating this process as we did for the first column. We could keep repeating these steps until all 1920 columns have been transcribed. We would then have a long list that holds each address, and the colour found at each address[16]. It wouldn't matter if the real cat interfered with our image; we would have a description that would allow us to recreate its original condition whenever we wanted, as the information from the image is now encoded in the list.

We need not have the original picture elements to rebuild the image we only need the list. Using the description of the colour for each address, we could mix some paint to recreate the original colour and by putting the paint onto a small squares of paper recreate the original picture element. If we repeat this process for every item in our list we would have recreated our image. It's not the original, but depending on how good we are at replicating colour, and following the description (list) it would be a reasonable facsimile.

At this point it might be beneficial to reflect on what is actually happening in these processes. If the original image represented a cat, then the list holds a description of what is needed to reconstruct that image, the semiotic object of the list is the image (itself a sign); the object of that image is the cat. What has occurred is a process of abstraction, certain key properties from the photograph of the cat, including the information carried in the photograph have been encoded into the list[25], and central to this abstraction is the separation of the signal (the information) from its substrate (the cat, and the photograph of the cat) that was mentioned earlier. This means that the actual paper pieces that comprise the image are not important; any pieces of paper of suitable colour can be used, the useful information is the colour and the relative placement of each colour and this is what our list contains, the essence of the semiotic object (its information) stripped of its physical medium.

The length of the list, literally the number of characters, is indicative of the amount of information that the list and correspondingly the image carries. We can

[25] This is similar to our mapmaking example described earlier.

perform simple operations on the list to make it shorter, compressing the list[26] and the associated information.[27]

For example instead of having two coordinates for each address, we can have only one. In this model imagine each column joined end to end, the image is rearranged into one long row of coloured swatches. Finding the associated address of each picture element becomes a matter of locating the element along this line, this is a simple matter of counting until the end of the row.[28] We know that the original image had height and width, but we can reduce the length of the description by only stating the height and width once at the beginning, and then describing a new list of colour values, so if there are 2073600 picture elements we are swapping one description for the 2 x 2073600 descriptions for each address in the old list[29].

How do we reconstitute the image? Imagine that we make a space that is 1920 elements wide and 1080 elements high on a table top and starting at the top left address place the first colour from our shorter list. We proceed down the first column until the 1080th space is allocated its colour, and then move onto the next column, while simply moving onto the next item on the list. This process is repeated until we have allocated a colour from each position on the list to the next empty element address on the table. If we are careful and have made no mistakes (after all there are 2073600 opportunities to mix things up), we should have our image of the cat reconstructed out of tiny colour swatches.

Key to making a shorter description of the cat image was not describing the cat, nor describing the image of the cat, but creating a description of the description of the image of the cat. Put another way, the photograph of the cat is an indexical sign of the cat. The description of the photograph is an indexical sign of the photograph. Finally the condensed description is an indexical sign of the long description. This compression of descriptions is only possible because we can separate the signal, the information, from the substrate, removing any elements surplus to encoding the information. Each layer of abstraction takes us conceptually further away from the real life cat, sacrificing immediacy for brevity.

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[26] Note that the list is a medium (data), combined with the information it constitutes an indexical sign.
[27] In no way should this example be confused with data compression as it is actually implemented. These examples are intended to demonstrate in simple terms how data can be compressed.
[28] Counting from 1 to perhaps 2073600 which is the number of pixels in image 1920 pixels wide multiplied 1080 pixels high.
[29] (X,Y,) becomes X, by using one coordinate we can reduce the positional description by approximately 50%

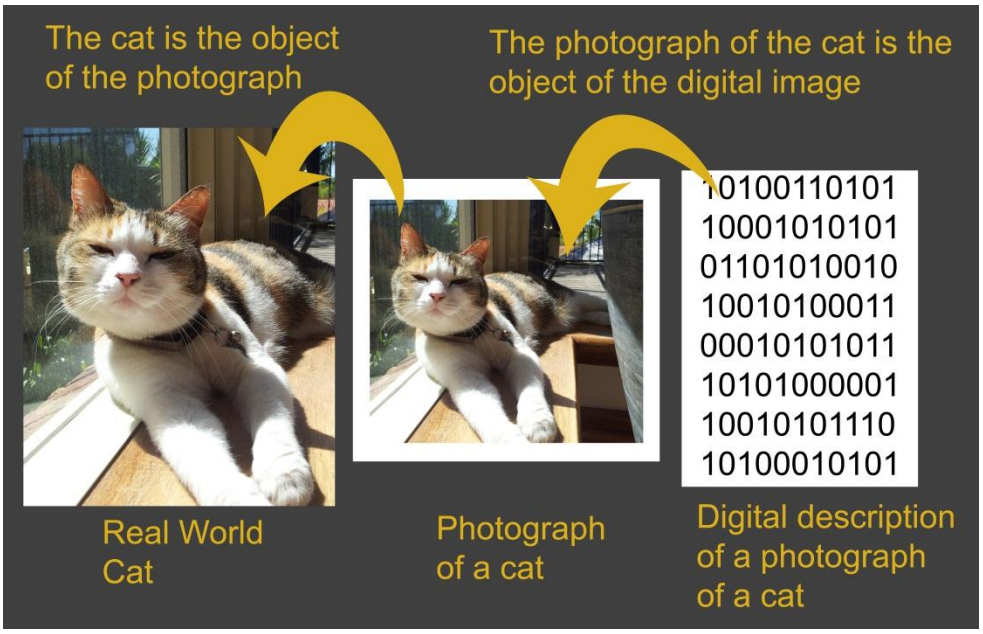

Figure 3 levels of abstraction from the real world to the digital representation. This pattern of abstracted representation is indexical in nature and not reliant on resemblance to the semiotic object of a real world cat.

We can further reduce the size of the description needed to reconstruct our cat image, by describing the list of colours. A simple method is to look for patterns in the sequence of colours. If there are a number of adjacent elements in our list of the same colour, we can shorten the description by making a new list containing instructions for making our last list. Insert the colour Cobalt Blue 74088 times, then Napthol Red 1764 times, Then Payne's Grey 42 times, and so on, with each new instruction making one line on the new list instead of 74088 or 1764, or 42 lines on the old list. [30]

Relating this to the earlier example of random pixels.

The earlier example using randomly generated pixels becomes more interesting once we consider it in terms of information content. The level of information in a randomly generated image is nearly at the maximum possible[31] confining any attempt to describe the image to a list of the individual elements. In common with the cat example we can remove information redundancy by describing

[30] As a matter of interest those who are numerically minded might notice that 1764 = 42^2, and that 74088 = 42^3, and that this would offer another method for making the description shorter still. "42^2" uses four characters, the same as "1764", however "42^3" uses four characters where "74088" uses five. For larger groups of colour the number of characters needed to write the description can be made smaller. If you can save one character per picture element you have removed 2073600 characters without losing information.

[31] The maximum cannot be reached in real world situations. It is an idealised state that is useful but not attainable. Like infinity.

the height and width once, but there are no further short cuts, not even when we use the description of the description of the image.[32] Unfortunately with a randomly generated set of pixels there is a very low likelihood of more than one adjacent element being the same colour. So we really are stuck with describing the entire image, element by element. Although we can apply the same techniques used in the cat example, we will not make a new list that is much shorter than our old list.

Chapter 2: What is computer art?

In the book "A Philosophy of Computer Art" Dominic McIver Lopes defines a computer art form as distinct from digital art in two aspects. While both can be considered art, only a computer art form holds the possibility of being interactive, and being interactive because it is running on a computer. (McIver Lopes 2010, 27) By contrast digital art might be displayed by a computer, but without the interactive element of allowing the audience to influence the program, and the program being able to adapt to the audience, digital art is not an art form. (McIver Lopes 2010, 3) It is interesting to note that while all ts of the computer art form are a type of digital art, not all digital art can fall within the classification of computer art form.

McIver Lopes also identifies four common critiques "retrofitted from broader critiques of mass art."(McIver Lopes 2010, 95) that are frequently applied to computer art, and to some extent new media art.

- Argument from the "creativity sink", which implies that computers because of their intrinsic nature, either impose artistic outcomes that are at odds with creativity, or limit creativity by standardizing artistic exploration.(McIver Lopes 2010, 85)
- The argument from the "vanishing work", an art works value is founded on its ability to afford the viewer an experience of its medium, but computer based art affords no such experience.(McIver Lopes 2010, 88)
- The argument from "critical distance", that computer based art, particularly when interactive, impedes active thought by engaging

[32] This is assuming that the instructions have been represented by a minimum of one character to designate the type of operation required to reconstitute the image. This is a matter of encoding effectively, and relates to the quote from Shannon mentioned earlier in the exegesis. (*See "A measure of information."*)

with the viewer in way that does not allow reflective thought about the art work.(McIver Lopes 2010, 90)

- The argument from “mind control”, that the nature of computer programs, particularly when they are interactive, prevent free thought by confining the options available to the viewer, while artistic value resides in a works ability to provoke free thought.(McIver Lopes 2010, 93)

Are the thesis artworks digital art, or a computer art form?

The single point of differentiation between digital art and computer art form lies in the issue of interactivity in the exhibition space. While none of the thesis artworks are interactive in terms of the definition of a computer art form provided by McIver Lopes, they certainly could not exist without a computer. By not using interaction within a gallery space, in the sense that a computer in the gallery is modifying the display in response to a viewers’ action, the work fulfils the definition of digital art work and not computer art form. Answering each characteristic in turn,

- It is art; it was made as part of a process of artistic enquiry.
- It is made on a computer, but it is also run on a computer using software that has been made as part of an artistic enquiry.
- It is only interactive, in that it allows engagement in a reflective manner.
- It is made using a common digital code but it is not interactive because it runs on a computer.

The thesis artworks in relation to the four common critiques.

Computer based artworks do not allow free expression.

The argument from “creativity sink”, implies that computers because of their intrinsic nature, either impose artistic outcomes that are at odds with creativity, or limit creativity by standardizing artistic exploration.(McIver Lopes 2010, 85). Creativity implies some type of novelty, which McIver Lopes defines in two ways, firstly personal creativity, where something is novel for an individual in that it is a creative act that hasn’t been performed by that individual before. Secondly, novelty from a historical context in that it is a creative act that has not been performed by anyone before.(McIver Lopes 2010, 86).

With the thesis artworks, commercial or freely available software was rarely used, and whenever possible software was written for a specific purpose, so influence from external sources was minimal. Creative use of programming can show traces from particular processes or from use of a particular type of data structure. In practice this variability of final appearance becomes part of the creative process, with the utilization of these properties being exploited in terms of an artistic outcome, as it would be with any traditional medium.

Figure 4 Same data, same algorithm, and different implementations.

The illustration above (Figure 4) shows the same video frame after different processing. On the left an implementation of the temporal sort algorithm (which will be discussed in more detail later) which used Java programming language class BufferedImage( ) to store the sorted data. Over many thousands of iterations, reading and writing to disk, small artefacts began to appear, and while the artefacts might have creative value, in the context of the work, the artefacts were problematic. The image on the right was created using an array of type Integer which was

populated with the numeric value of each pixel colour.[33] The sorting of the data took place in situ in this array, the sorted pixel values were then written to disk.

The data structure that holds the colour will influence the final appearance of the image, in an act of the abstract image description influencing the realized. However if the pixel colour is abstracted as something further removed from the image description and then processed, the quality of the reconstituted colour is crisp. The image on the left is part of a set of images that took approximately eight weeks to render; by comparison the image on the right took approximately two days using the same hardware.

Bearing in mind that for the argument from creative sink to be true there should be no creative choice available between implementations, (the computer by its nature supposedly removes the choice), then both images should be identical. In that the images are different fulfils the definition of creativity by McIver-Lopes. In terms of the first criteria, this was the first occasion this creative act was performed by the author, and secondly, in utilising a predefined data structure in manner for which it was never intended, giving results that were never anticipated, most likely satisfies the second criteria of historical novelty. That the images are different demonstrates the argument from creative sink false in the context where the artist is the software creator[34].

Computer based artworks lack materiality.

The critique from the "vanishing work" rests upon this assumption, an artworks value is founded on its ability to afford the viewer an experience of its medium, but computer based art affords no such experience.(McIver Lopes 2010, 88). It is argued that because of the universality of computer displays, and the way that the common digital medium can mimic many other media, computers and computing do not offer a unique experience. "an artistic medium is a material stuff

[33] Of interest here is that using an array of integers removes artefacts because the artefacts arise from characteristics of the BufferedImage class (which is a medium) and not from the information encoded in the image.

[34] This should not be seen as contradicting the idea of the separation of signal from substrate mentioned earlier. The artefacts' that arise from data structures are examples of our inability to accurately represent the information. The information is mapped into an indexical sign (the data structure) and the data structure modifies the information. This is analogous to a pencil line on different paper, the roughness of the paper will influence the perceived quality of the line, but subsequent roughness of the line is a quality of the paper (substrate), and not the line itself (the signal).

whose perceptible properties are the only appropriate focus of our attention on a work"(McIver Lopes 2010, 88)

However if we use a broader conception of material that accommodates the dematerialization of art works, to include installation with empty space as a material property, and performance where temporality is part of the medium, then computers and computing can be considered an artistic medium. In the context of the thesis artworks, they could not exist without data processing, and as such are a unique expression of computing as a creative medium where the viewer is free to experience and form an opinion of the medium for its unique characteristics.

A unique material property of computer display.

In relation to traditional media, the altered status of the mass produced physical material image[35], makes the original what it is, "the original". For there to be an original there must be copies (at least implied or potential copies). Each copy is an instance, an interpretation of the original, reinforcing the originals material position while diffusing its symbolic significance. The original can cease to exist physically but endless re-interpretations of it can continue to be created.

Each instantiation enhances the original in a way that "the original" on its own could not, a process of amplification. Multiplicity frees the original from one place at one time, to being in many places at many times, immediacy is sacrificed for expediency, and the audience approach the substitute with the same reverence that would be shown the singular original. Every multiple of an original is in the literal sense of the word "iconic", each copy is a manifestation of the original and represents the presence of the original at the place and time of display. The original is transformed into a template, a conceptual framework from which multiples are instantiated.[36] A printed copy of La Giaconda is rarely spoken of as a printed copy; instead it is La Giaconda.

Both computer and digital art works reconfigure this paradigm. Multiplicity is no longer implicit in the original; as the data is already free from being in one place at one time. As software or digital code the art work exists within a virtual

[35] It is worth noting at this point the difference between a medium and information, particularly in regard to their "material" properties. Throughout this research a distinction has been drawn between the "physical" material properties of any media and the non-physical "material" properties of information. Information is carried by physical media, but is itself not physical, as information only exists as a set of relationships between physical things.

[36] By way of contrast he computer based artwork might be materialised as a display at one place and time, or in many places at many times.

space where concepts of where and when are synesthetic impositions on the data. The artwork (comprised of digital code), stored on a computer, exists in two states, the logical and the physical. The physical state is the arrangement of individual memory elements within the computer that indexically represents the data; the logical is the potential interpretation of the arranged memory elements. The art work only exists (as a physical artwork) when the data is interpreted by the action of a computer and it is only interpreted by the computer when it is displayed. Therefore the artwork only physically exists as an artwork on its display, and that each display is the original. "Since the display you see on Flickr is generated from a digital file, the very same image can be displayed on countless different computers, and each one of these screen images is an authentic display of the work – not a reproduction"(McIver Lopes 2010, 3) This inbuilt plurality of computer based art works is a "material" property unique to computer based displays. Hence it is a property of the medium of computer based art works that can be experienced by its audience.

Computer based art is mind numbing.

"Active thought requires distance, a condition affording focused yet leisurely attention" (McIver Lopes 2010, 91) The argument from critical distance, implies that computer based art, particularly when interactive, impedes active thought by engaging the viewer in way that does not allow reflection about the art work.(McIver Lopes 2010, 90). Most commonly this argument extends from the interactive property of some computer based artworks. However critical distance can also be acquired by repeated interactions and it is this repeated exposure that particularly suits the interactivity of a computer art work. Just as repeated exposure to a painting or sculpture might elicit a deeper understanding of the artists' intention, repeated exposure to interactive computer art works encourage the viewer to reflect on the work based on separate experiences over time. "Computer art works invite and indeed prescribe repeat encounters. Users expect something new with each interaction and are attuned to the differences between the displays they generate"(McIver Lopes 2010, 60).

The thesis artworks require no more interaction from the viewer than would be necessary with a traditional art form. Viewers are afforded critical distance, and are therefore able to reflect on the work as they would for any other art.

Computer based artworks channel the viewer's thoughts along predefined paths.

The argument from "mind control" implies that nature of computer programs, particularly when interactive, prevent free thought by confining the options available to the viewer, while artistic value resides in a works ability to provoke free thought.(McIver Lopes 2010, 93). The argument that computer based artworks control the viewer's mind shares many points with the argument from "mind numbing," both imply that somehow the action of a program on a computer robs the viewer of their independence. "Interaction externalises action and the responsibility that comes with it. The machine acts for us while giving us the impression that we act for ourselves." (McIver Lopes 2010, 93). That is, the viewer's thoughts are being directed by a function of the software, and because their thoughts are being directed, no original thought can arise, and hence no opinion about the artwork can be formed other than that opinion contrived by the software. This critique rests on the following three assumptions identified by McIver Lopes.

- That there are only so many possible displays that can be made by the artwork, therefore the range of options is constrained, and free thought is constrained.
- Secondly it is assumed that the multiple displays of a computer based artwork form interpretations of a work, in the same way that a musical performance might be seen as an interpretation of a melody. "The mistake is to suppose that generating displays through automation can replace interpretation" (McIver Lopes 2010, 95). [37]
- Thirdly, the interaction of the viewer would not be directed towards an appreciation of the artwork. "Since appreciation involves interpretation, users must try to interact so as to yield interpretive payoffs."(McIver Lopes 2010, 95) [38]

If the first assumption is true then all images prevent free thought. A painting can have only one display, and this restricts the options, therefore free thought is restricted. This is obviously false; therefore the first assumption is false. For the

[37] The displays of the artwork are not interpretations of the artwork, in the way a play by Shakespeare might be interpreted.

[38] Interpretation of the art work is the role of the viewer. Any interaction between a viewer and an artwork should be based on forming an interpretation, and hence appreciation. This is true regardless of whether the art work is computer based or traditional media.

second assumption to be true we have to confuse the display of a work with its interpretation, when as shown previously with computer based art the display is the original not an interpretation[39]. The third assumption can only be true if the viewer chooses not to engage with the artwork, and this argument could be used against any art. Therefore because it is not true for art in general it is not true for computer based art. In the context of the thesis artworks, the viewer is free to interpret the work, as they would any conventional artwork.

[39] When an original image has printed copies made of it, the copies are interpretations. Computer based art works have no "original" so any displays cannot be interpretations.

Chapter 3: Dematerialisation of media

Digital data is a type of universal medium, a formalised method of deriving abstract models or indexical signs, capable of representing almost anything, and encoding information from any source. The digital image has divested photography of its physical form, completely altering image production and consumption, and changing the privileged status of the photograph. Driven by forces of efficiency, the exchange of a chemical sensor for an electronic silicon sensor simultaneously swapped the photograph for a description of a photograph. "The pragmatic context of high efficiency is also one of generalized democracy, extended from production to consumption. The ubiquitous engine driving the process is the possibility, indeed necessity, of human emancipation from all possible constraints"(Nadin 1997, 602).

The use of chemical film carried the expense of raw materials and an accompanying limitation on the number of photographic images that could be produced. Digitisation, allows the abandonment of dark rooms and complex chemical film processing, in favour of the desktop PC with photo editing software. Coupled with cheap digital storage one is free to take as many photographs as opportunity can allow, and if you are unhappy with the outcome, you can erase the evidence, unlike single use chemical film.

The contemporary digital camera is a hybrid device that exists as a physical arrangement of optics, and an equally important virtual software component that surreptitiously impersonates its mechanical/chemical ancestor.[40] Its relationship to our expectations of a camera mirrors the relationship between the digital image and the chemical photograph. The digital photograph describes a chemical photograph, and the digital cameras virtual components describe physical mechanisms. The physical nature of photographic media once dematerialised, exists as a set of logical rules encapsulated in the structure of a universal digital system, at once sacrificing concreteness in exchange democratic liberation.

One medium to rule them all.

"computers are so useful partly because they're all purpose representation devices. They deal with information in so many different formats- text, numbers,

[40] The software component of the contemporary digital camera impersonates the physical processes of the chemical film camera, giving the user the expected experience of using a camera with chemical film. The digital camera does not need nor have a physical shutter, and yet the digital camera faithfully reproduces the click that signifies a shutter has moved. The functional camera has been dematerialised and now exists as an information capture device that represents a camera.

images, sounds- by converting them all into a common digital code" (McIver Lopes 2010, 2)

As media are replaced and redefined by digitisation, the acquisition of multiple skills for many media is likewise replaced with one digital skillset. The immediacy of traditional art materials also speaks to the limited range of accessibility. "Concreteness, i.e., closeness to the object, is also symptomatic of the limited shared universe."(Nadin 1997, 102) Implicit within the acquisition of skills is a type of exclusivity, only so many individuals can spend extensive time and the resources of a society to become skilled in an endeavour. The universality of digital code evaporates exclusivity, democratising creative expression, now anyone with a computer and paint emulating software can explore their artistic potential. Coupled with the internet a personal computer gives the sort of creative reach that was until recently the exclusive domain of wealth and mass media "Successive forms of communication came about when the scale of interactions amongst humans expanded from one to several to many"(Nadin 1997, 92). New forms of communication arise, vlogs, blogs, and tweets, all defined within the previously mentioned digital skillset.

The separation of the signal/information from the substrate, vinyl, paper, and light sensitive emulsion, and replacing the physical medium with an indexical sign enables data processing, and for a digital computer to manipulate the captured information encoded in images, audio or text.[41] A simple transformation feature in photo editing software that allows an image to be reconstructed as a fisheye projection accomplishes with an algorithm what would previously have required costly specialist lenses. Altering the description of an image in place of altering the actual image is an act of substitution at the core of digital media. By rearranging the medium (the data) we can rearrange the encoded information, presenting it in ways that reveal previously hidden features[42].

Photography along with other media is dematerialised and removed from its privileged position of capturing reality in an unbiased manner, to become one of many methods of creating data, no different to video, audio, or text. The common digital code absorbs and remakes the old media in terms of itself (Bolter and Grusin

[41] The key phrase is "data processing" not "meaning processing" data is a medium, and it carries information.

[42] This revelatory potential of digital media will be dealt with in more detail later in this exegesis (*see footnote 52 and "A digital revelation."*).

1999, 45). Digitisation challenges and transforms our understanding of what constitutes media, and like other forms of expression before it, alters how we see our world, seductively encouraging us to perceive everything in terms of itself.

Described by Deleuze as an "internal qualitative relation"(Deleuze 1993, 46) it is the difference between elements, in binary, the changes from zero to one or vice versa that form the medium through which information is encoded and carried. Whether by alterations in an electrical signal, changes between one pixel and it's adjacent neighbours, or changes in paint on canvas from one area to another, it is the relationship of all different parts of the whole, to itself that carries information.

Dematerialised media as art or art medium?

Twentieth century art tested the boundaries of established genre, sculpture moved from physical object to installation, to performance, as an exploration of dematerialisation and space. (Krauss 1979, 31-44) Painting shifted in response to a redefinition of the image by photographic mechanical means. Both sculpture and painting converged on artistic creation as an event, as a performance that is fixed in time. In the action painting of Jackson Pollock, the canvas and the deposition of paint, as a physical object, became a recording of the artists' movements, an imprint of a performance. Image production through paint was redefined, discarding the implicit mimicry of figurative art, its emphasis shifted from the tradition of representation of a subject to include a discourse on the meaning of the process.[43] The inclusion of process as a suitable art subject encompassed the act of display; exhibition was no longer seen as an instant, but as a chain of events. The experience of sitting through the creation of a piece of work became part of the artists' repertoire, and in some instances the work itself.

With the boundaries of permissible art expanded to include events, it seems hardly extraordinary that mechanical processes[44] would fall within legitimate artistic practice. The use of computers and software are natural extensions of these stances. The different artistic disciplines, after centuries of investment in their own media

[43] Sculpture about sculpture and painting about painting, the 20th century saw genre art grow from representing the other to representing itself.

[44] The futurists and cubists steered painting on a new course from representing the physical world as something static to representing the process of motion. Movement and dynamism, as a reflection of the modern age became an acceptable subject.

converged on the dematerialisation of art from object to process retaining one crucial element, the artist and creative choice.[45]

Dematerialisation leads to the question, can a description of an artwork be an artwork? With software as art, the code that describes the artwork is the artwork, the two aspects tightly bound in a pragmatic embrace of instruction describing a process, and the process itself. In a dematerialised world the physicality of paint occupies the role of defining the materiality of an artwork, and as an information carrying medium, in much the same manner as binary digital code. Art manifests itself by its own description, bootstrapping into existence, thus transcending the sum of its parts.

Following a reductionist paradigm, dissecting the image into small pieces (*see "A short exercise in manipulating information.")* we can see the informatic nature of the image is not intrinsic to its medium. Instead the understanding of an image is brought about by information encoded through changes in colour or texture at different places in the image, in relation to the image as a whole.

Just as a "specific photograph is never distinguished from its referent"(Barthes 2010, 5) in place of perceiving information in its naked form, as information, we only see our interpretation. The medium is mistakenly identified as being the information when from the viewpoint of Shannon's information theory; the medium is the communication channel. While this channel might have its own McLuhanesque message, the channel is not the information; we are as blind to this sleight of hand as we are to mistaking a photograph for what it represents.

Accidental identification.

Information that has no intrinsic symbolism can still only be understood via the pathways of symbolic interpretation. Accidental resemblance leads into the domain of unrestrained pareidolia, and apophenia, fitting what we perceive to what we already understand in an attempt to make sense of something that has no sense. Hence the reduced information complexity of the noise paintings (*see Figure 5*) fools us into thinking that because the information content has been presented in an expected manner with a suitable degree of complexity, it must have meaning.

[45]It could be argued with the shift from object to process, a paradoxical distillation occurred; art is something that involves an artist making creative choices. It may be possible that art cannot be made without creative choice, because the artist that chooses to create art without creative choice has in fact already made a creative choice. The art that has no artist has to be created by an artist.

During the course of this research the ability to understand visual information was revealed to be less about the initial assumption of the limits of the bandwidth of the human nervous system, and more about previous experience. When information more or less resembles something we have already experienced, pareidolia results in us finding familiar patterns amongst the strange and unique. (*See Figure 8,Figure 9 and "Graphite1-027-004"*) We can try interpreting our perceptions for what they are, but we can only interpret things that are novel (in that they have not been seen before) in terms of the patterns we have already experienced. Our new understandings are amalgams of previous understanding.

The system as a medium of expression.

As we have already seen, the use of computing as a medium for artistic expression finds its origin in the expanded scope of twentieth century art practice and the inclusion of the process or dynamism of systems as subject matter. "The merging of cybernetics and art must be understood in the context of ongoing aesthetic experiments with duration, movement and process"(Shanken 2003, 21)

This interest and experimentation was provoked in part by the development of photography and the work of Etienne-Jules Marey, whose chronophotographs captured movement of subjects on a single image. The influence of the "decomposition and captured movement"(Dagognet 1992, 149) of Marey's images is evident in the work of Marcel Duchamp. The best known example is "Nude Descending a Staircase" from 1912 where the inclusion of a series of dots in an arc shape "come straight out of Marey's chronophotographs"(Dagognet 1992, 150).

The visual aesthetic of the Marey's functional dots appear purely as symbols of motion, rather than recording markers. With movement displayed as a still image, multiple instants are collapsed to a single moment, showing not only the physicality of the subject, but also the physicality of the movement; the subject's intent, is revealed as thought externalised as action. "The spatial- temporal dimensions of consciousness were likewise fundamental to Italian futurist painting and sculpture, notably that of Giacomo Balla and Umberto Boccioni, who were also inspired by Bergson"(Shanken 2003, 21)

Giacomo Balla in the painting "Dynamism of a dog on a leash" depicts the dog and its motion as a three dimensional physical presence, portraying an understanding of the dog and its owner as a presence in motion, occupying not just a

place, but a series of places, at a series of times. Viewed from a position outside the subject's time, the dogs' presence is fixed within a temporal bird's eye view, the time of the viewer. With attention fixed on the dog and owner, the background is in motion, dissolved into blurred colours; the viewer is placed in a privileged position outside the time and space of the image.

Drawing from the representational work of Marey, Duchamp emphasised the decomposition of forms "in order to present an absolutely static expression of movement in terms of its relationship with a succession of two dimensional spatial planes"(Moure 1988, 13). In contrast, Balla as part of the futurist movement was drawn to the mechanical, cinematic effects. The common factor for both was the introduction of time and motion, and the associated concept of process. The two dimensional representation of form, moving through a three dimensional space, the process or steps of the physically real nude descending a staircase, and the form, or multiple forms of the tiny dog as it hurried to keep pace next to its owner.

Representation of a system in motion marks a point where the concept of a system has become grounded in the minds of people as a substantive thing.[46] Balla articulated what was previously invisible, hinted at by Marey, using paint to display the motion of the subject and the viewer, frozen in an instant as the image on canvas. Cinematic motion, with multiple states made of multiple images, and multiple points of view.

More recently Jim Campbell re-invigorated the idea of the fixed image representing movement and change. Campbell's approach takes video of differing lengths and averages the frames, each in itself a separate image, to create one final image that contains information from the multiple sequence.(Campbell 2010, 145) Averaging, as a numerical process mirrors the condensation of movement into paint of Balla. In a similar approach to Campbell's averaging, the temporal sorting art works included in this thesis are the product of treating the individual frames of the source video not only as an information channel, and therefore amenable to alteration using numerical methods, but also as discrete marker points of a continuous whole.

[46] For the first time an intuitive understanding of the reality of cause and effect, as described by post Newtonian physics, that all events have causes, and that all things are universally bound by this assumption, entered the public imagination.

The system as artistic method.

The work of Chuck Close is heavily invested in the paradigm of reductionism, and stringent systems of production. The dissection of large scale images into small elements which are then reconstituted into a new image offers a systematic approach of creative enquiry.

The idea that the whole can be understood by an intense analysis and documentation of its parts is a reductionist methodology, Close has used through his entire working practice. "From an early age, he learned to break information down into small bites that could then be incrementally reassembled into a whole that was in fact a fresh synthesis"(Finch 2010, 19) Dividing the image into smaller cells, and using a system of metrics, a grid to determine the spatial position, and an analysis of colour within each cell, Close captures the essence of the subject. His system provides a method of encoding visual information, resynthesizing the image by following a predefined process. Grids within grids increase the number of samples and hence increase the amount of information recorded.

With images that subdivide the whole into smaller patches of colour in an attempt to fully understand the subject from the sum of its parts, Close's body of work is an expression of art production as the outcome of a stringent procedure.(Finch 2010, 92) The resulting aesthetic prefigured many aspects of digital media, the use of coordinate systems in arranging pictorial elements, quantization of colour and position, all part of the process as a method of recreating the image. By deconstructing the whole image into sub components each part is made into an abstract entity that describes just one small aspect, amongst many small aspects. Close's subdivision of the human portrait disassembles the whole to find the detail that speaks to the individuality of the subject, and in doing so identify atoms of meaning. The stringent system that Close elected to use explores, "the potential inherent in meticulous, as opposed to improvisatory, fabrication" (Finch 2010, 42)

Subdividing data, permutations and possibilities.

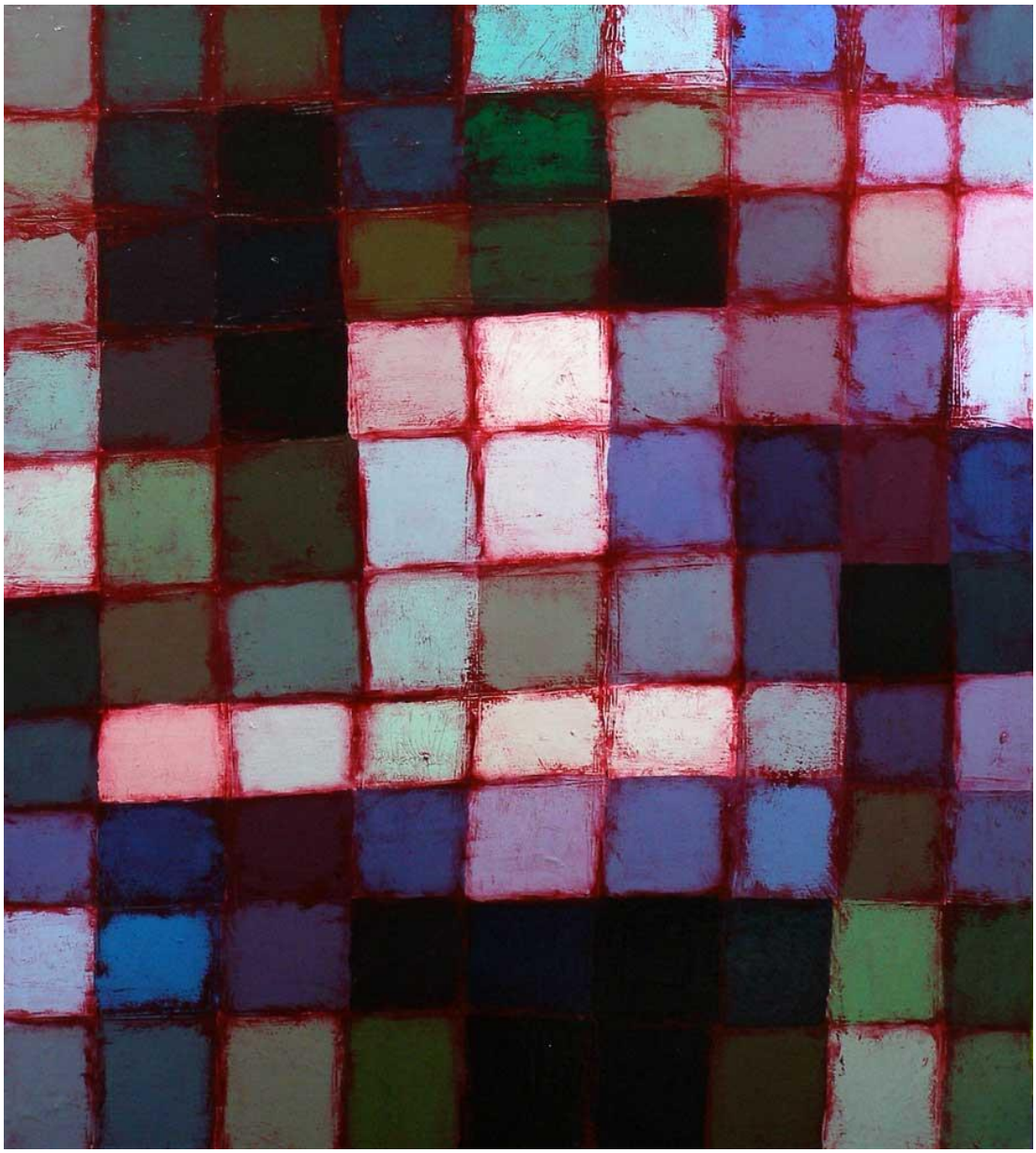

Figure 5 Reduced information painting.[47]

Our viewpoint is constructed. How we understand information from the external world is contingent upon a cognitive model utilising the encoded information carried from our senses by minute variations in electrical nerve potential. We are not cameras, we have two eyes, but our viewpoint is distinctly singular, and camera like. Our cameras are engineered to generate images that mimic our singular internal viewpoint, this vantage when externalised becomes a cultural construction.

[47] The reduced noise paintings were an exploration of reducing information in a picture composed of random coloured pixels. Each cell was made by averaging the colour of its four corners, thus reducing the number of sample points. The reduction of information content makes the cells seem not as accidental, as if they have some purpose.

The counterpoint to the camera, the displayed image, is again a cultural fabrication designed to reflect how we believe we see. Our images reflect our internal world view, and through our images we understand the world around us. A displayed image is a remediated screen of the mind, complete with an introduced threshold of the edge, symbolic of the divide between self and other.

Perception is not only about information from our senses, but also the collective impressions of our previous experience. Identifying the object in an image requires a type of projection from our memories onto the sensory input, overlaying our personal significance or meaning onto the external reality, Projection of our memories form the basis of all our new experiences.

A digital image is a particular arrangement or combination of elements,[48] contrived to mimic the screen of the mind. With all the elements in just the right order, a recognisable object is visible; however just as important as the represented image are all the possible images. For a digital image which is a universal representation device, a soft machine made of code, there are all the possible combinations of pixels that could occur, of which the actual image is only one.

We build systems that make images with a certain degree of complexity; this is why compression of visual data is so heavily focused on removing information redundancy to achieve results that appear as though no compression has taken place.[49] These systems are built upon all previous methods of representation, consuming and replacing them, but built into these systems are our assumptions, prejudices, and cognitive shortfalls. We don't really have a singular viewpoint, nor does linear perspective really reflect reality, try looking through a camera obscura, straight lines become smooth curves, and whichever direction you look there is a vanishing point. Nor do we exist in a frozen moment of time, we have a past, a present, and a future, and our consciousness exists across all three.

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[48]For any array of pixels, there are a finite number of possible combinations of colour that can occur, it is a very large number but it is not infinite. If those permutations are ordered by some means, then a progression from one state to the next (or adjacent state) would become apparent. The different permutations become a sequence, and in describing the sequence, it seems unavoidable that a narrative arises. (Video is a sequence of possible combinations of colour and shape). Only this narrative would never repeat; starting from any of the possible combinations of pixels traversing the adjacent combinations traces a path through the possible permutations.

[49] e.g. mp3 audio selectively uses frequencies that are central to human perception of sound, discarding frequencies and information that is not needed in favour of smaller file sizes.

Bergson's small instants.

In Ambrose Bierce's "An Occurrence at Owl Creek Bridge" the liminal moment of death, of transition from life to after life, space and time is revealed as being intimately tied to perception. The protagonists' moment of execution, is expanded, and filled with perceived activity that leaves the character sure he has avoided death.(Bierce 1995)

Subdividing experience can continue infinitely, with each subdivision, itself being subdivided. In "Time and Free Will" Henri Bergson proposed an understanding of time that is without discontinuity based on the logical reasoning that "numbers are provisional units, which can be subdivided without limit, and that each of them is the sum of fractional quantities as small and as numerous as we like to imagine"(Bergson 1913, 81) The expansion of time between video frames used in the thesis artworks is distilled from this model. Each frame of the processed video is treated as a data point, a point in time where a sample of data has been taken and stored. As Bergson points out "No doubt, when you equate the number 3 to the sum of 1+1+1, nothing prevents you from regarding the units which compose it as indivisible: but the reason is that you do not choose to make use of the multiplicity which is enclosed within each of these units"(Bergson 1913, 81)

As has already been demonstrated information is carried by the relationship between pixels (*see "A short exercise in manipulating information."*), and this idea can be extended to include a sequence of images, where the relationship between pixels on different frames carries information about motion over time. Each frame like Bergson's number analogy is a marker point, and as information about the passage of events is not stored in each frame, but instead in the liminal relationship between the frames, we can likewise keep subdividing the interval between them. The number of subdivisions between the frames/numbers/data points can continue indefinitely, surpassing the largest number we can think of, and points towards infinity.

Time within Time.

"The framing by some kind of border device—whether as limen (threshold) or limes (path, boundary-line, and distinction, difference)—signifies that "this is a picture." The border separates the image world from the "real world.""(Kiilerich 2001, 321)

Just as the border or threshold framing an image separates the picture from the rest of reality, a digital image forms a threshold between the viewer and the subject, not only in space but also in time. Layers of abstraction act to remove immediacy, remaking, representing and alienating, reifying the familiar. Each abstraction forms a conceptual boundary separating the image, a sign, from its object; and the image itself, from its indexical digital description. Removing the viewer from direct experience, immediacy is sacrificed for the freedom of representation.

Time is disjointed by the process of video recording and playback. Firstly there is the time of the video camera operator; this time is captured at the moment of recording. Secondly there is the time of the viewer; this time is marked by the process of reconstruction and playing of the recording. Viewer time may include more than one "operator time" and is non-linear as the operator time of recording can be reorganised so that events no longer happen in the order that they occurred.[50] Thirdly there is the time of the editing, the time taken to edit, and the associated time of any video processing. Finally the data processing time, the period of time measured in milliseconds and CPU cycles that are required for the video data to be processed.

In the thesis artworks involving temporal sorting, all four aspects are woven together; time and motion are collapsed like the cinematic frames of movement are collapsed in "Dynamism of a dog on a leash"[51]. The captured movement information from each video frame is an indication of conscious intent that is re-temporalized, expressed as chiaroscuro, the light to dark or dark to light of the processed images. Each moment of the new video contains aspects of all the images, redrawn on the spatial coordinates of the Cartesian plane. The background grid of Muybridge's photographic sequences is replaced by the abstract grid of the pixel address.

[50] For example the video might be played back in reverse, so the events that occurred near the beginning now occur at the end.

[51] Dogs have special relationship with liminality, long associated with the ancient goddess of the liminal Hecate "Young dogs were presented to Hecate at crossways, and persons who required purification were touched with them;"(Bury 1889, 417).

A digital revelation.

Revealing hidden information through photography[52] can be traced back to the pioneer of kinetic photography Etienne-Jules Marey. Photography gained a reputation for being able to capture without emotion, the fleeting moment, things that might be visible for only a fraction of a second. Photography because of this status became associated with spiritualism and the occult, with experiments performed in capturing the essence of ghostly apparitions. (Wesely and Harten 2010, 21) The camera through the work of Marey and Eadweard Muybridge had shown itself to be a superb device for revealing hidden motion, and in doing so had made plain the limitations of human vision, the unaided eye unable to capture with certainty the movements of a galloping horse.

The digital video camera is not a mechanical device, but like the digital still camera, a hybrid, a virtual mechanical device. The software inside the camera describes the operation of a mechanical system, and via various sensors the digital video camera impersonates the functionality of a mechanical movie camera. Instead of moments being captured on light sensitive chemical film, the light is registered on an electronic sensor, and a description of the properties of the light, the colour, and intensity, are written to a solid state memory, no moving parts required. Instead of chemical sensors, and chemical memory in the form of film sequences, we have the substitution of electronic sensors and electronic solid state memory.

The "chemical revelation" (Barthes 2010, 10) becomes a digital revelation. By settling for a description of the light as it might act on film we dispose of the deferred action of light reflected or transmitted from chemical emulsion, and gain a new understanding of immediacy. If the alienating distance between the subject and chemical film posed the question, what does the camera see? (Wesely and Harten 2010, 21) Film, replaced with a narrative about a film that had a mechanical camera been present, would have been made; the question is rephrased, what story about seeing does the digital device record?

A series of instants stand in for one continuous whole, capturing information at a resolution of 25 frames per second, resulting in the representation of physical reality complete with a cinematic illusion of kinetic motion. Like the paintings of the

[52] Since digital media have replaced chemical photography this applies to digital video. Ghostly apparitions might have been captured on film but it has taken digital video and YouTube to turn this from a quaint, rare occurrence into one of daily significance.

futurists and kineticists inspired by the chronophotography of Marey, (Dagognet 1992, 152) video is figurative, and only one step removed from reality, but gives a gods' eye view of physicality in motion frozen into a sequence of single moments.

Temporal sorting.

Acting at the level of the description of each image, the processed data moves us one step further along the path of abstraction making possible a god's eye view of the process, the dynamism, as a reified before, now, and after, that follows different rules of causation. In place of a figurative representation, the image is described by different criteria; time is reordered as a function of chiaroscuro. The futurists showed dynamism as the motion of energy, the energetic nature of movement, energy in motion. The thesis artworks describe dynamism as the motion of information, the informatic nature of movement, the flow of information in motion.

Where the time lapse images of Michael Wesely offer depictions of the system we call society, revealing hidden physical patterns of the system, so it is that the thesis artworks reveal the hidden pattern of information exchange that lies within that system. Articulating the broader sense of the term computation, includes things and events that happen in the real world "how nature and people in real interactive situations compute"(Cooper 2012, 77)

Expanding time becomes a strategy for making visible what is normally below the threshold of perception. The video frame rate like Bergson's numeric markers can be moved further and further apart. Like zooming in on a detail in a still image, it is a focussing action, the viewer's attention drawn to a small instant – the moment made into an experience of hidden activity. The reconstructed video no longer at a resolution of 25 frames a second, is now any number of frames per second.

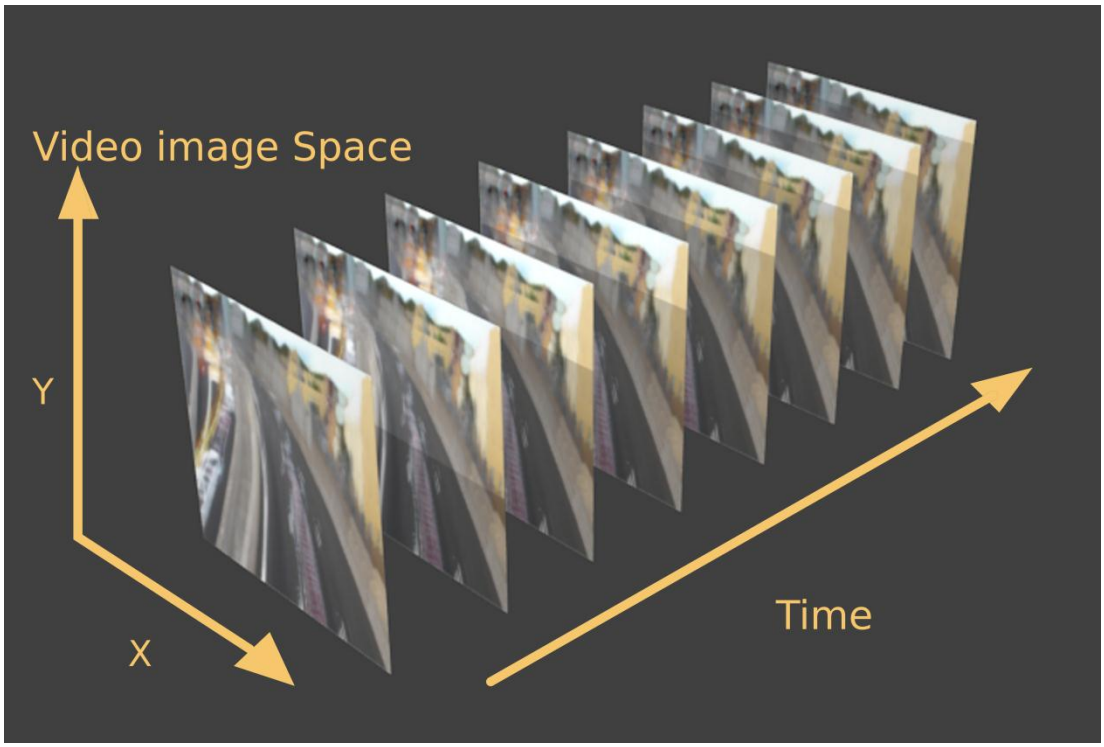

Figure 6 Video images over time

Interpolating between frames as data points is equivalent to interpolating between pixels; the information is continuous but grainy defined by the frames per second. Just as scaling a still image can change the properties of the image expanding time takes the information from the virtual realm, and rescales the video frame by frame. New decisive moments are brought into existence.

The slow transition is the externalisation of a meditative process, of calming the viewer, letting conscious attention focus on the small alterations, the subtle transfer of information. If the viewer doesn't stop, then they would never understand what is happening, being busy is a type of shield against having to pay attention to where you are. In this context the art works are meant to encourage mindfulness.

Computation in the expanded field

Rosalind Krauss's "Sculpture in the Expanded Field" describes the redefinition of sculpture during the 1960's (Krauss 1979, 31-44) as the adaptation of the term "sculpture" to accommodate various creative pursuits. "The new is made comfortable by being made familiar, since it is seen as having gradually evolved from the forms of the past. Historicism works on the new and different to diminish newness and mitigate difference."(Krauss 1979, 31) This adaptation with its associated dematerialisation of artistic media mirrors the contribution of Alan

Turing's model of computation as a disembodied machine. "This playing down of the distinction between information and process has been taken further, and become a familiar feature of programming and theory" (Cooper 2012, 76)

As a disembodied machine is a system, the expansion of the term computation can be made to include the blurred distinction between process and information in the real world. "Now even biology has become an information science, a subject of messages, instructions, and code. Genes encapsulate information and enable procedures for reading it in and writing it out."(Gleick 2011, 8)

The re-evaluation of the real world as a set of processes forms the subject in Michael Wesely's time lapse images, where the energetic functions within a physical system are captured and laid bare, and their time based activities compressed to the instant of a still photograph. The thesis artworks holding in common the idea of society and broader reality as a system draws upon on the function of captured information, redisplaying it in a time based context rather than a still image. This information is a liminal material, and as such is best observed and captured in liminal spaces, places or points of intersection.

In reference to the cut up technique Burroughs said "The points of intersection are very important certainly. In cutting up you will get a point of intersection where the new material that you have intersects with what is already there in some precise way, and then you start from there"(Burroughs 1989, 32) The train platform, an escalator, or a crossing are all thresholds that whilst being places themselves are also neither once place nor another, but instead spaces of possibility. The liminal space becomes a symbol of the gap between the bits that carry information, the medium, and the message itself.

The representation of time and motion in the chronophotographs of Marey provoked a definitive shift of subject matter for the artist, from object to process, similar to the blurred distinction between information and process in computing. As mentioned previously Duchamp's interest was non cinematic, instead emphasising periodicity, in contrast to the futurists who were enticed by the sequential nature of mechanical cinematic images, all were engaged in the collapse of time, of the materiality of process, condensed down to a descriptive instant.

When confronted with a time lapse image the viewer is given all the information gathered from a period of time instantaneously. This is not just capturing movement; time is captured, and frozen, put on display. The thesis

artworks take a different approach, time is not frozen, instead it is reconfigured and the information implicit in the recorded process is not presented to the viewer at once; rather it is presented in different aspects at different times. A viewer looking at "Rapture" (*see Figure 16*) for five minutes will only have seen some aspect of the total, a viewpoint along a particular axis.

Chapter 4: The thesis art works

The thesis artworks are divisible into two separate groups, firstly those that focus on the reduction of complex visual information to achieve an aesthetic outcome. These works use software as a systematic method of production and include “Graphite1-027-004”, Shifting cubes”, and “Signal” (*see Figure 7, Figure 10, Figure 11*). These artworks are more of a generative than representational nature, drawing raw material from abstract hidden sources. The raw material as atomic force microscope data, or randomly generated numbers, acts as a catalyst for the software (system) to generate a display.

Secondly those works using a broader understanding of the term computation, draw their information content from the real world, and reconfigure it in a new synthesis of colour as a time dependant property. These works include “Here to there = there to here”, “Rapture”, and “Mutatis Mutandis” (*see Figure 13, Figure 16, Figure 17*) and are more representational than generative, by visualising the flow and exchange of real world information.

The difference between the two groups is that the latter uses data that already has a semiotic object, whereas the first group’s data is entirely open to interpretation. Both groups follow in the tradition of media fulfilling a revelatory function. Like image creation in the early twentieth century responding to the revelatory aspect of photography, these artworks are a response to the impact of data/information processing in relation to image production.

All the artworks use data processing as a method of interrogating the role that information plays in visual understanding, partaking of two worlds, the scientific reductionist reality of computing and the liminal reality of the possible. Information is identified as a material that is carried by a medium, like data, not existing in the data points, but rather in the gaps between the zeroes and ones. Information then is a collection of relationships between marker points, the internal qualitative relation of Deleuze.

Graphite1-027-004

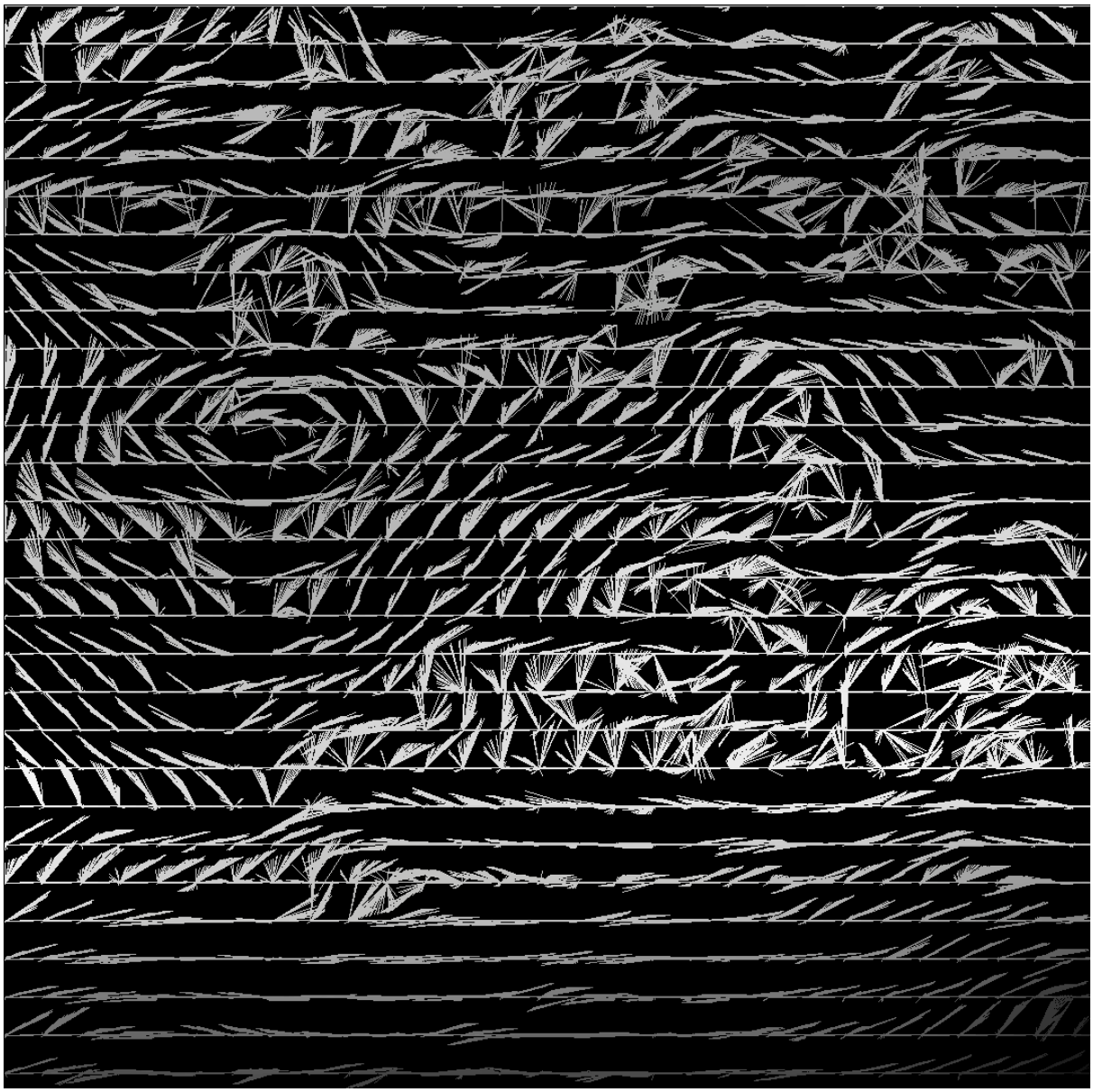

Figure 7 Still from "Graphite1-027-004"

Graphite1-027-004 is a video piece that arose from participating in the force/magnitude workshop in early 2010. The workshop gave an opportunity to use an atomic force microscope, which builds an image through touching the target surface. These discrete samples of data when assembled into an array form an information channel from the nano-scale to the macro-scale.

The target material of "Graphite1-027-004" was a line drawn in artists' graphite on a small piece of card. The re-imaging of a line, something familiar, into a foreign terrain of large structures, changes the line from a thing to a place, and literally redefines the limen or line as a liminal space. "It begins as a boundary, a

line or region that simultaneously marks intersection and separation. When the boundary is crossed, or opportunities are offered for its crossing—as in the discovery and negotiation of a pass over a range of mountains—it becomes a threshold"(Ellis 1993, 59)

AFM[53] data and the information it carries can only be experienced by means of the display methods of a computer. The scanning tip moving across the target material records the relative height of each contact point, slowly building up a collection of points which software then displays as an image. As we have seen previously, something that has been encapsulated in universal digital code is already in an abstract state. So in representing AFM data as an image we have a synesthetic approach of tactility as a visual phenomenon, a repurposing of touch as a way of "seeing"

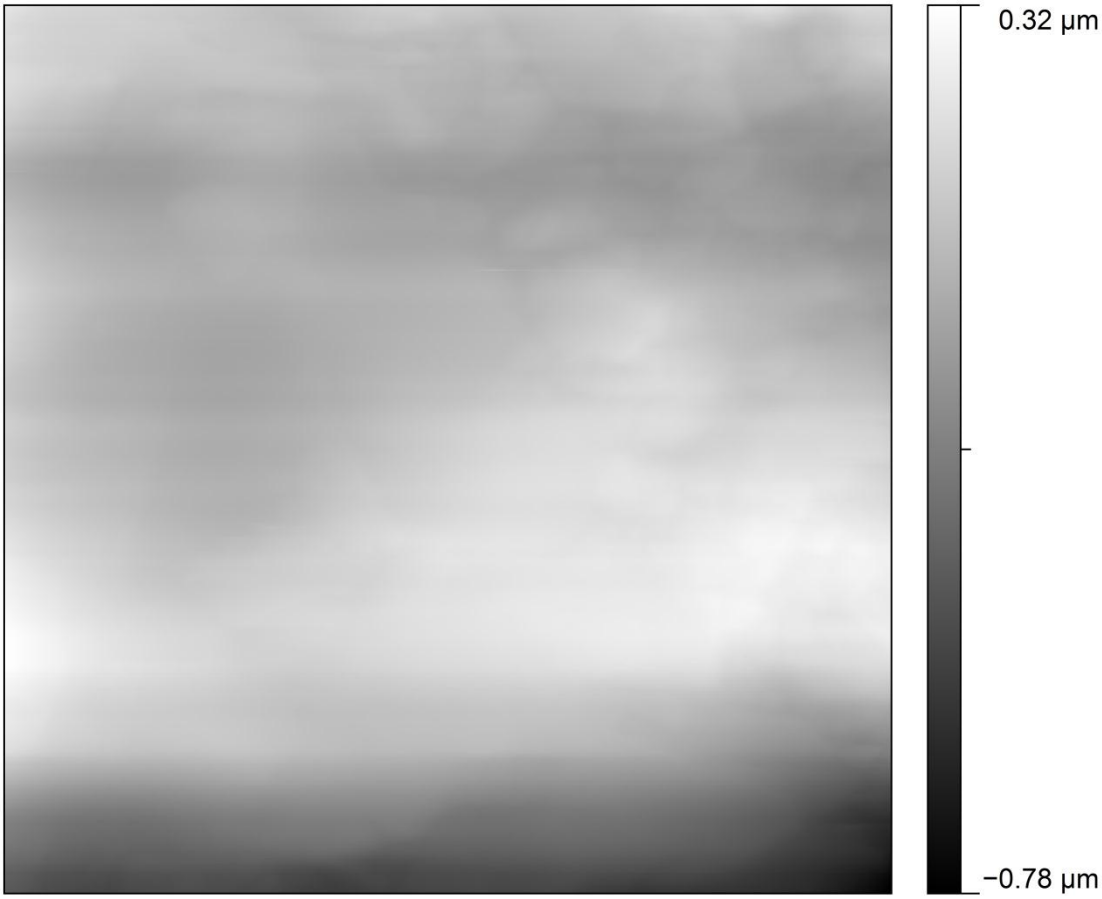

Figure 8 Unprocessed AFM image data

Initially the unprocessed data from the microscope seems to hold little in the way of interesting features; it appears smooth, but with repeated viewing subtleties in

[53] AFM (Atomic Force Microscope).

the variation of light and dark start to appear. Significantly this is not because the image is changing, but rather the raw perception adapts our understanding of the image. We begin to learn to "see" what is there. In comparing images (*see Figure 8 Figure 9*) we can detect features and things of interest that are present in Figure 8, but that were not necessarily apparent until Figure 9 had been viewed. That is Figure 8 becomes more understandable in terms of and in relation to Figure 9[54].

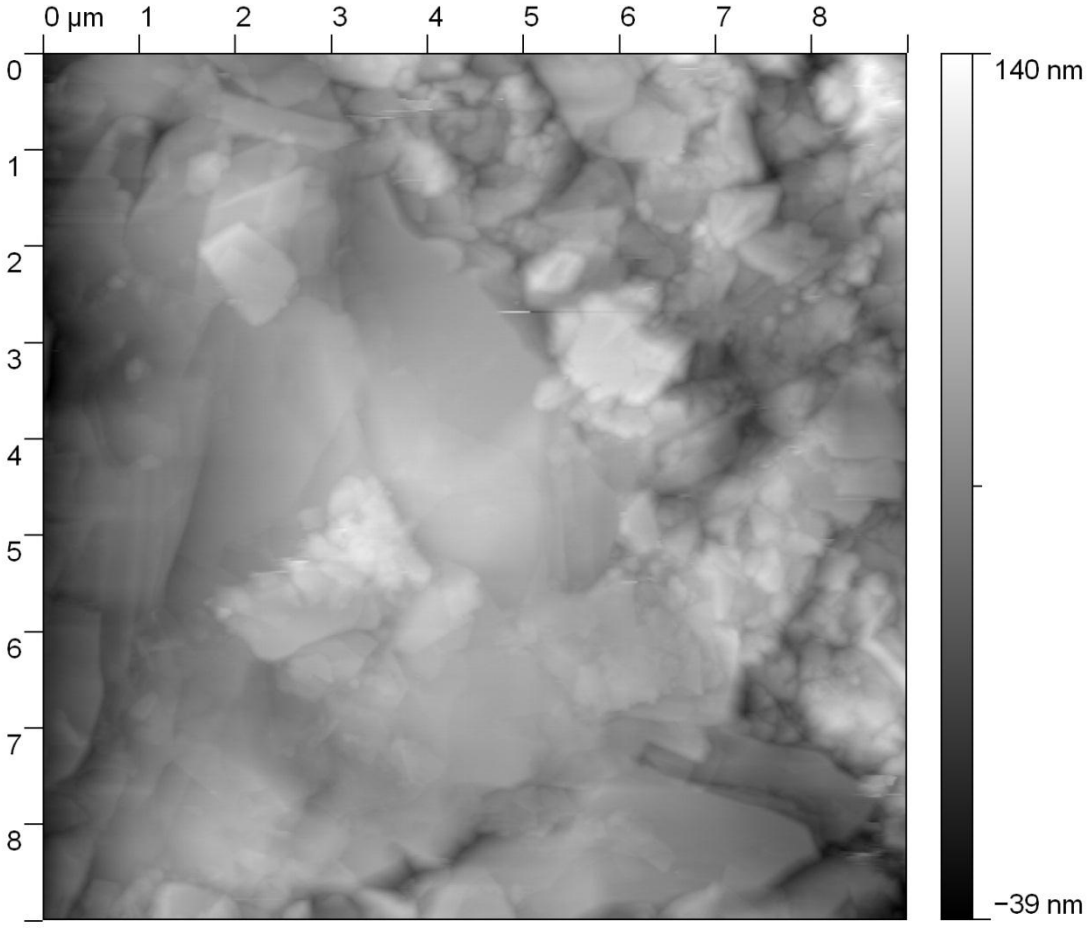

Figure 9 the same data as contained in Figure 8, this time filtered by deflection values

Raw unprocessed data (*see Figure 8*) offers the opportunity to interpret in terms of imagination. A line of graphite, revealed as a place rather than a thing, is re-presented, in terms of descriptive lines drawn by software. The detection of difference carries the information, so points were selected to form a grid on a picture plane. A computer program was written to find high and low points represented by light and dark in the images above, relative to those set positions. The program then

[54] As mentioned earlier the ability to recognise is more dependent on previous experience and observation than image complexity (*See Understanding: a process of compressing knowledge.*).

took a direction from each origin point and added 90 degrees so that the resulting lines from each origin would lie across the gradient from light to dark.

Each element of the constructed image is a simple line, a basic unit of mark making. Each line on its own carries a small piece of the information but when combined together the relationship between the collective lines communicates much more. Echoing the use of graphite as a mark making material, the line drawn on card, recorded by the atomic force microscope, becomes a small piece of the nano-scale, enlarged as a set of lines.

Information resides in the difference between two or more data points. It is the difference ratio, the relative change that ties the information to the data. The atomic force microscope acts as a revelatory device akin to Marey's chronophotography. A way of perceiving hidden information, the microscope transduces the impossibly small; and gives you information, in the impartial unbiased manner of the camera. In recording the information we have captured part of the subject, and in interpreting this information we are manipulating an autonomous part of the subject itself, a transformed aspect of a nano-scale reality. A line that comprises a space is in turn re-invented as a drawing.

Shifting cubes.

Figure 10 Still from "Shifting Cubes"

"Shifting cubes" is a generative artwork that explores where meaningful images might exist by accident, filtered down to us from the background noise of

reality. Using black and white cubes the artwork randomly cycles though different states. Each time a cube shifts exposing either a light or dark facet, there is the possibility that a recognisable image might spontaneously appear.

This art work gives a voice to the background randomness mentioned previously; the software as a system, acts as an interpreter converting that randomness into an image. The artwork takes the position that the creation of any image can be viewed as an absurdly unlikely event that is the end result of a long chain of preceding events, all of which are ridiculously unlikely. Given enough time and an infinite amount of space not only will unlikely events occur, but all possible events must occur.

The long chain of chances that led to any image coming into existence[55] is matched by the equally unlikely event that its unique pattern of information might accidentally appear in the form of a set of shifting virtual cubes. The laws of physical entropy [56] mean the chance of this happening is vanishingly small. Because of the noisy nature of our reality there are far greater numbers of random arrangements that make no sense, and the likelihood of one of these images appearing is very high. However this artwork symbolises an act of optimism, that despite the numerical odds, it is entirely possible that something sensible might appear.

"Shifting cubes" and the next artwork, "Signal" derive directly from earlier experimentation in reduced information paintings (*see Figure 5*), where images were reduced down to a small number of coloured tiles using a computer, and then painted. "Shifting cubes" reduces the level of complexity by reducing the resolution of the image, leaving larger areas of black or white, similar to the reduced information painting, but instead in a state of continual change. The mechanism of "Shifting cubes" is a universal representation device, and is capable of representing any image in terms of light and dark. As such each moment signifies one of the extremely large number of possible states, and thus only one of the extremely large number of possible images. Hence each moment implies all the images that could be

[55] For a painting to exist not only must there be someone to make the painting, there must be others to make all the materials available, and a long chain of preceding events leading all the way back to the big bang and the appearance of Fermions and Bosons, so that we can have matter to make our painting out of.

[56] not to be confused with information entropy

displayed, by contrast to the image that is actually displayed. (*See "Subdividing data, permutations and possibilities."*)

Signal.

Figure 11 Still from "Signal"

"Signal" is an artwork that uses computer generated images that were made in a particular sequence, prompted by random events. As previously mentioned this work is conceptually similar to "Shifting cubes", in that the presence of randomness is taken as not only a universal property, but a surplus of information. By implication if randomness is a surplus of information, then in amongst that noise might be meaningful messages.

In "Signal" the vertical lines in the image were assigned colours from a pseudo random source, and because they extend from top to bottom, the information complexity is diluted over the height of the image. From this reduction of complexity, unusual visual illusions arise. First that the colours were in some way coordinated to appear in the order that they do, because it seems from the viewer's vantage point as if the colours belong together by conscious choice. Secondly that the transitions from one image to the next appear to follow the pulsing note that the sound track provides. Both of these assumptions are false.

Artistic decisions were made in the choice of algorithm[57], and the rate of transition from one key image to the next, but no decisions were made over choices of colour and placement. Once the software had been designed the system produced the artwork using information recorded from the background noise of reality. "The responsibility of the Artist becomes inventing a system that produces his work rather than just producing the work" (Frost 2009)

The random data that generates the image is a found object, found material, a little piece of the hidden universal randomness, decoded and decompressed. The "Signal" is the decoded message from the back ground noise of reality, a message from the void.

The software system as revelatory process.

As previously mentioned the digital video camera is an information recording device, and as such it inherits from photography the concept of the passive impartial eye. The video camera dutifully records without any noticeable bias what is presented to its lens. Processing video captured from life meant that the creative process begins to accommodate images that like photographs are of things that once were, in contrast to computer generated images of things that never were. In the following art works the process of software in action is a way of understanding the recorded process of society in action. Sorting as method of reorganising data, when applied over time becomes a systematic way of throwing hidden information into relief.

Sorting as a metaphorical prism.

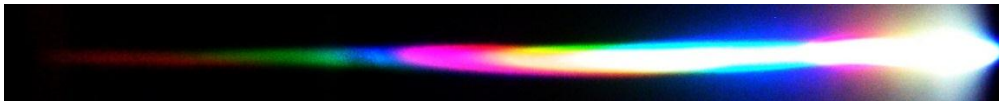

Figure 12 Sunlight through a diffraction grating

Sorting acts on the description of the image, but not the image itself, in terms of our cat example we would be sorting the list that describes the image (*see "A short exercise in manipulating information."*). However performing any type of process on the list will change the way the image it describes can be recreated. By changing that description we alter the image, and implicitly its relationship to its

[57] This is another example of software or a system as artwork, in that the entire display is generated by algorithmic (system) processes. The role of the artist is as creator of the system that generates the display.

semiotic object. This is equivalent to having a photograph of a cat, (*see Figure 3*) and by taking a felt tip pen and colouring in the photograph we could change the colour of the real world cat[58].

Analogous to a light spectrum sorted data is filtered and arranged in relation to some external value, with diffraction this value is the wavelength of light (*see Figure 12*), and in sorting pixels that value is the numeric colour of the pixel. Sorting reallocates data to new addresses, changing the description of the image and in the process erases some of the encoded information. [59] Sorting is also a process of filtering; the arranging of information as though it has passed through different sized sieves. The larger objects removed first, and placed in their own category, the remains further filtered by the next sieve, until eventually only the finest dust remains.

Temporal sorting (sorting pixels over time) preserves the spatial coordinate of each pixel within a frame, instead altering the context of pixels over time, with pixels being moved from one video frame to another[60]. An object travelling through the field of view still persists in the different spaces it originally occupied. All of these positions that were separated by time exist simultaneously; similar to the collapsed temporality of a time lapse photograph. The colour of the object determines the point in the reconstituted time when the object will appear. A sorted movie still contains the same elements; only their relative position-state is re-imagined.

In ““Here to there = There to here: Commutative Dynamism.” The motion of cars and their drivers still travel to their destinations, only they travel through all points and past the observer simultaneously. The assumption of there being a beginning of the journey, and a destination, is dismantled leaving only a pattern of conscious intention, and a continuous now.

Video attempts to overcome the death and fixation of the still photograph (Barthes 2010, 9) by creating the illusion of animation. Instead of one death mask we have many, all with slightly different expressions and if we glance at each in fast

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[58] Strangely this echoes the process of “playback” as described by William S Burroughs (Burroughs 1989, 19) It could also be argued that in making an image of the cat we are defining our understanding of a cat, and thus our image changes our subjective experience of a cat, changing our reality.

[59] If the adjacent neighbour pixels in a single image and their change in value is the property that carries encoded information, then altering the context of each pixel and its neighbours in a single image removes the information encoded in the relationship between separate pixel addresses; each pixel is moved to a new spatial coordinate and the encoded information erased.

[60] The video frame becomes a data sample point, and the sorting space no longer X and Y, but now X, Y and Z.

enough succession we can convince ourselves of the illusion of the process of life. But in spite of this performance the video is still a sequence of what was and will never be again. Reprocessing the information in a frame by frame manner, and then re assembling these new images into an animated sequence in essence takes the captured stillness and brings them to a new synthesised life. Each time the video is played and new viewers are present this cycle repeats[61].

Here to there = There to here :Commutative Dynamism.

Figure 13 still from "Here to there = There to here: Commutative Dynamism."

"Here to there = There to here: Commutative Dynamism" is the first of the temporal sorting art works, and follows a theme of information as a liminal material, manifest in a liminal space. This video is compositionally similar to Andre Derain's "Charing Cross Bridge" with a road sweeping up from the lower right. The source video was selected in keeping with a theme of information in a liminal space, the road, forming a boundary from left to right, whilst also being itself neither the start nor the destination of a journey, but an extended line of in between moments. The cars form recursive liminal spaces, small parcels of space travelling through a transitory set of locations, all directed by the conscious agency of their occupants.

[61] The passing of time, the past present and the future echoes the mystical role of Hecate, goddess of the three path intersection, and in resurrection from the death of still photographs, video acts as transgressor, from the underworld to the world of the living, again in Hecate's shadow. Hecate as the liminal goddess, the goddess of the threshold, and the "goddess of the underworld"(Bury 1889, 416)

The importance of liminality in the relationship between information and its medium, is metaphorically reflected in mythology by the division of space or time symbolised by “Rivers, roads, seashores, mountain ranges, twilight—in short, anything that separates one time or space in the physical world from another—have represented to cultures world-wide the point at which the realms of the natural and supernatural collide.” (Ellis 1993, 59)

Figure 14 A video still frame, prior to sorting

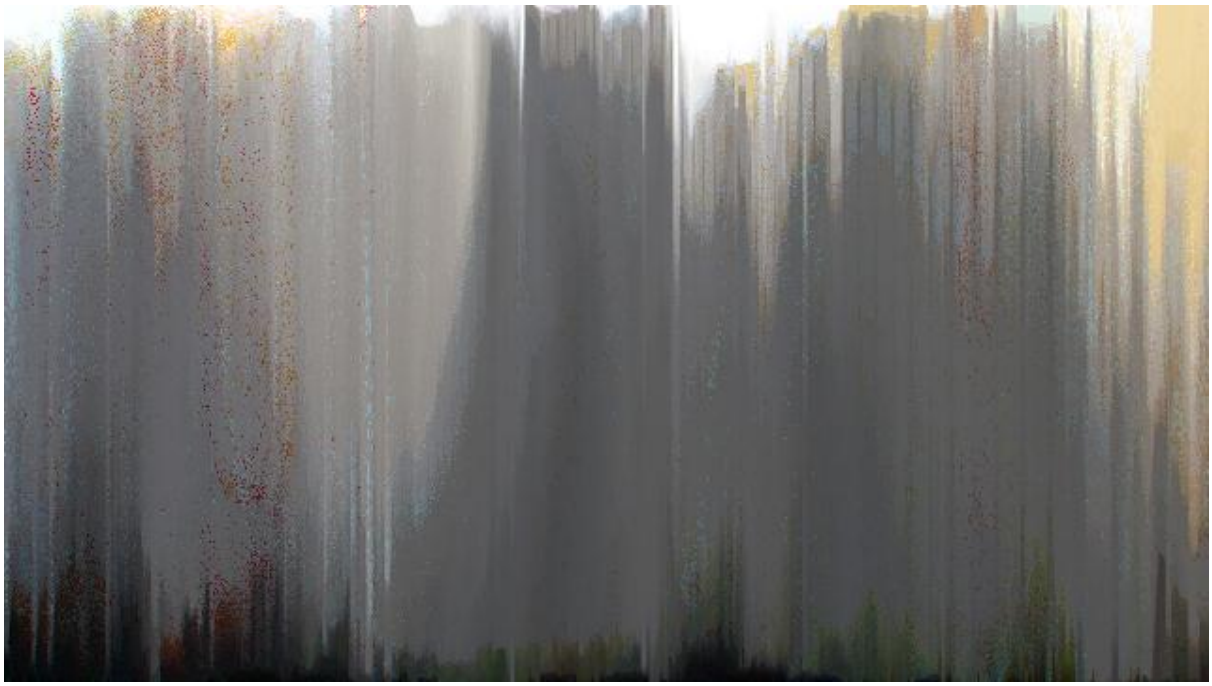

Figure 15 Column sorted video frame (see Figure 14)

Early sorting experiments preserved the X or Y coordinates and sorted the data in columns or rows, with varying degrees of success. (*See Figure 14*, *Figure 15*). Simple column sorted images were recompiled into video form, and it was observed that motion in the video was preserved across one axis, while the movement on the other axis was altered, no longer the motion of the original video, instead movement based on colour value. The preserved linear motion describing the movement of vehicles under the control of their drivers changed position from left to right. This linear motion was representative of agency, displaying consciousness as a system in action. This experimentation drew attention to the recorded actions of individuals and the larger (computational) system of which they are a part.

In the approach taken by Henri Bergson's model of time and duration "As duration and states of consciousness implicate one another, to spatialize the latter is to mistake space for duration" (Crawford 2008, 2). To represent conscious action as only spatial in nature would be to ignore the crucial aspect of the action of consciousness over time.

This is where temporal sorting started conceptually, that it is the position of actions in time that belies conscious intention. The slowly evolving image which in earlier videos like "Graphite1-027-004" and "Signal" represented the interstitial nature of information was repurposed to signify time and consciousness, where the instant of now, could be expanded to include many instants. The change from extracting information from computed data, to extracting information from real world data had introduced consciousness into the scheme.

Information captured in the video as a whole is rearranged by processing the data stored in each frame. Implicit in the temporal sorting artworks is the broader understanding of the meaning of computation mentioned earlier, (Cooper 2012, 77) where computation can include the interactions amongst people, nature, or machines. Temporal sorting reveals the informatic exchange in a system in contrast to the energetic exchange of the time lapse image, and is a visualisation of the exchange of information states.

Implicit in this notion is the possibility that this broader understanding of computation is the process that filters background randomness, and distils what we perceive around us, the reduced complexity of quantum indeterminacy.

Rapture.

Figure 16 Still from "Rapture"

Extending the theme of liminal spaces, "Rapture" is a temporal sorted artwork created from captured video of people ascending from below ground. Passengers using an escalator are a metaphor for souls ascending from the underworld, in a process of being raised from the sub-liminal. "Rapture" in the archaic sense of the word is to be transported. Conscious action and machine action

combined to produce a meta-act, a third state, the motion of individuals transformed into smoke like traces, echoing spiritualist photography. The merging of two identifiable systems into one "undivided wholeness in flowing movement"(Bohm 1980, 14).

The escalator, a device that is a threshold between one place and another, composed of small segments in continual motion, is situated within the broader transitional space between floors. The actions of the people are channelled into a ghostly smear of upwards motion, the patterns revealed by temporal sorting making visible the social constructs implicit in acceptable behaviour. People positioning themselves on the moving steps to avoid transgression of the personal space of others while engaging in the transgression of the divide between underworld and world of the living[62].

The shift in colour tones from dark to light evokes a metaphor for the elevation of consciousness, to a higher level of understanding. Thus the transgression of the boundary of above and below becomes a psychological journey, and an informatic process in action.

Mutatis Mutandis

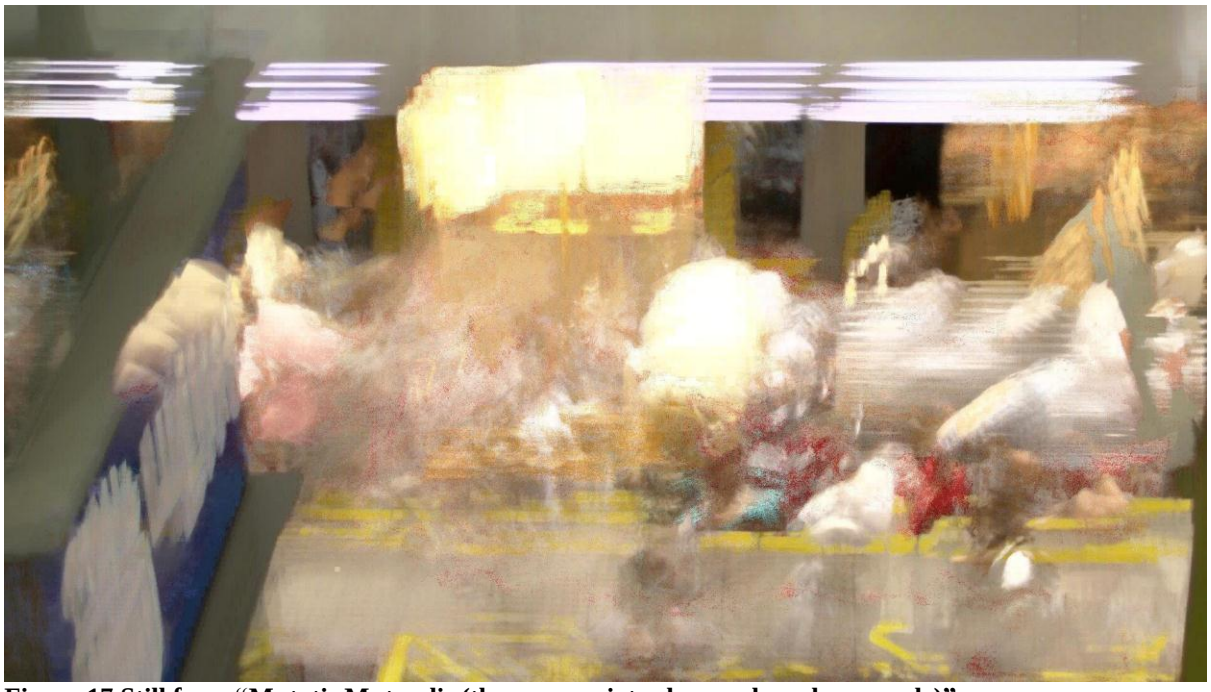

Figure 17 Still from "Mutatis Mutandis (the appropriate changes have been made)"

[62] The underworld symbolically represented as an aspect the mind, the dangerous practice of transgression from liminal to sub liminal only tried by the foolish. "probing of the deepest parts of a person's mind, seemingly a fearful process one should avoid at all costs."(Clifton 1986, 220)

In common with the preceding works “Rapture” (*see Figure 16*) and “Here to there = There to here: Commutative Dynamism” (*see Figure 13*), “Mutatis Mutandis” is a portrayal of not only mechanical physical motion, but also the dynamism of information flow. Data processing reveals and represents the agency of people interacting within a larger system. The human figure is a part of a greater whole that involves an exchange that occurs while a commuter train sits at the platform. It is humans and machines in motion, with conscious agency indicated by the patterned forms that slowly shift over time.

This calls into question the agency of the individual, and the agency of the larger system. How much of the movement of the figures was driven by free thought, and decision, and how much was predefined by the context of train, platform, and timetable. As mentioned in the discussion of “Here to there = there to here”, Bergson’s model of time and consciousness, where duration and consciousness implicate each other (Crawford 2008, 2), Bergson’s principle is manifest; conscious agency can only be understood in terms of duration. The consciousness of the collective passengers is revealed via sweeps of colour that mutate and change over time.

Taking on board the broader sense of computation, each figure is absorbed into the pattern of the whole, as separate informational agents carrying unique states perform logical operations through movement. Both the agency of the individuals, and the machines, combined into the overarching larger system are visible as patterns of information, the larger system revealing its agency in the regulation of movement and flow. Of the three, humans, machines, and combined system, only the individual humans are aware of their immediate actions, whilst oblivious to forces at the larger scale of the crowd.

The liminal space of the train station, a destination that is itself only a way point along a journey is the setting for this exchange of information states. The station like the role of the frames of video, the sample points of data, and Bergson’s small instants, serves only as a marker of progress, something to identify difference between the start and the end.

In this underworld context the “Mutatis Mutandis” reveals itself to be about death, the multiple deaths of the video frame (Barthes 2010, 9), and dissolution of the notion of human autonomy. In terms of the larger system, humans are the currency,

animated by the flow of energy and information. The video looks down onto the platform during the moments when one group disembark and another wait to embark, the exchange, a form of barter, the appropriate changes once made, the video ends.

Conclusion.

The computer based artwork takes the language, techniques, methods, and logic of computer science and transforms them into a discursive space for the creation of art. It would be a mistake to assume that this space is one constructed around the dry logic of computer science, as has been shown information, the stuff that exists around us is a slippery substance with a liminal character[63]. Information is carried by data, but then data is one among many types of media. The information itself is both a physically real thing, and simultaneously intangible, only tied to a medium by a set of relative differences. The thesis artworks develop a symbolic interpretation, blurring the division between information and process, manifesting its properties as a system of temporal change.

Each time the viewer looks at the artwork they are creating new sample points, constructing their own unique engagement with the artworks. Expanding the time taken to change the image, forces the viewer to confront the transitional, liminal nature of information. Change only becomes noticeable after close observation, or once a discernible difference between moments of observation has been accumulated. The passage of time needed to become conscious of change is amplified, illuminating the close relationship of consciousness and temporality.

The choice of subject matter in the later sorting videos symbolically represents the liminal nature of information, in the form of liminal space a place where the natural and supernatural worlds, the seen and unseen collide. The spaces of the train platform and the escalator replace the space that exists within a single graphite line, or the void that is filled with potential randomness. Confronted by representational images reconfigured by sorting processes, the viewer is caught in the

[63] In folklore the suspicion of liminal places finds a voice in stories of duplicitous entities, whose interactions with humans are fraught with deceit.
"Trickster is the hesitant avatar of this region of thresholds and boundaries, this "realm of pure possibility". He embodies the fantastical, bewildering mixture of order and disorder that is its trademark."(Ellis 1993, 56)

tension between the image as an image, and the image as a medium, a channel which carries information.

As we have seen computation does not only reside in a computing machine, it occurs anywhere information is exchanged, and processes enacted. This is inclusive of creative acts, the artistic process is one predicated on the exchange of information between the artist and the artwork, and the artwork and the audience. Without the exchange of information, there would be no exchange of meaning, and without meaning there would be no art.

The framework of computer science utilised as a suitable theoretical, discursive space for artistic investigation becomes, in combination with art practice a hybrid endeavour. It has characteristics of both art and science, and in turn redefines both, bound by the commonality of information.

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Illustrations

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