From Connected Digital Art to Cybernetic Ecologies

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ABSTRACT

This thesis is concerned with the development of art systems, and in particular digital art systems. That is, digital artworks that are able to interact with each other, as well as their human viewers or participants. The communication may be over distance via the internet, or in a shared space via sound, light and movement. The concept of the connected digital artwork is defined, together with a framework for analysing the connections between artworks and viewers in a connected art exhibition. Three full practice-based research cycles of Theory-Create-Exhibit-Reflect are described (together with an analysis of foundation work), over which the core concept was developed and refined. At each cycle knowledge was generated through the creation and exhibition of new digital artworks followed by a process of reflection. The core contribution of this work is the *Framework for Connected Digital Artworks* for use in the production and analysis of collections of interacting digital artworks – something that is further referred to as a cybernetic ecology. The connected digital artwork and cybernetic ecology concepts, together with the supporting framework, the new digital artworks and the underlying technical infrastructure, are a contribution to knowledge that will be of benefit to artists wishing to create similar connected artworks and for participants and theorists wishing to understand and contextualise such work. In the concluding discussion, proposals for further cycles of Theory-Create-Exhibit-Reflect are discussed.

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ACKNOWLEDGEMENTS

I would like to thank my supervisors and colleagues at the Institute of Creative Technologies at De Montfort University in Leicester – particularly Martin Rieser for enabling me start this research and Ernest Edmonds for helping me to finish. Thanks to my creative collaborators, Nicola Schauerman and Tim Pickup from Genetic Moo, Ernest Edmonds, Esther Rolinson for their inspiration and feedback. Thanks also to Adam Kirk at Fabrica for allowing me to set up The Interact Gallery and the Phoenix, Leicester and LCB Depot, Leicester for hosting my other exhibitions. Special thanks to my wife Corinne, sons Nathan and Anthony and my colleagues at Cuttlefish Multimedia Ltd for their ongoing support and understanding during the PhD research process.

CHAPTER 1: Introduction

This programme of practice-based research took place primarily between 2010 and 2016 and was focused on developing a systems-based understanding of how digital artworks can communicate with each other and their human viewers and participants. It is grounded in an understanding of systems thinking and digital arts practice.

1.1 Aims of the Research

The primary aim of the research was to develop a framework that would provide a set of tools to enable the connections between a collection of digital artworks and their audiences to be described and represented visually. Such a framework will be of benefit to digital arts practitioners, arts theorists and audience members.

The supporting aims were: 1) to produce a set of case studies of the framework being applied to artworks from the author's own creative practice; 2) to produce a body of new work based on the principles the framework contained; and 3) to produce a demonstration of how such artworks can communicate using internet technology.

1.2 Background

This work takes place in the dual context of systems thinking and digital art. This combined context has an important antecedent in the work of Cornock and Edmonds, described later in this introduction, and this thesis looks to build on this earlier research.

Systems thinking, as described by Fritjof Capra (2014; p80–81), refers to a method of enquiry that shifts the focus of the enquirer from "the parts to the whole". Emerging

from the fields of Systems Theory (Ludwig von Bertalanffy, 1968) and Cybernetics (Norbert Wiener, 1948) it encourages the thinker to consider the whole system as well as the relationships and processes taking place within the subject being studied and to make use of the work of the many systems theorists across the field.

Of particular interest to this process of enquiry is the theory of "autopoiesis" by Humberto Maturana and Francisco Valera (1987). In their work, initially concerned with the organisation of biological systems, they identify the relationship between a living system's internal processes and its internal structure as being a key element of how living systems function. It is proposed in this thesis that this distinction – between process and structure – is highly relevant to the analysis of digital artworks and can be used to identify artworks of different types, as well as offer insights in to their creation.

The use of computer technology in the arts has a long history. The first widely attended exhibition of computer artworks, *Cybernetic Serendipity*, took place at the ICA in London in 1968 (Reichardt, 1968) and many of the artists featured in the exhibition, including Ben Laposky and Desmond Paul Henry, had been creating images using computers as far back as the mid-1950s. *The Computer Arts Society* was formed soon after Cybernetic Serendipity and began publishing its own newsletter, PAGE, in 1969[1]. Pioneering artists such as Frieder Nake, Paul Brown, Manfred Mohr, Georg Nees and Ernest Edmonds helped establish the new medium of "computer art" in the late-1960s

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[1] PAGE. http://computer-arts-society.com/page (retrieved 23rd August 2018).

and early-1970s and have recently been recognised in exhibitions to mark the fiftieth anniversary of both *Cybernetic Serendipity* and the Computer Arts Society[2,3].

Many early computer artworks were presented as printouts, plotter drawings, photographs or animations. However, early computer artists were also attracted by the *interactive* potential of the computer and as the cost of computers fell, and their capabilities increased, the exploration of interactivity became a core part of many computer artist's creative practices.

With the development of interactive artworks based on computer technology, the opportunity for computer artworks to be conceptualised as *systems*, that is collections of interacting *parts* and *wholes*, became possible. This was identified surprisingly early in the development of computer art by Cornock and Edmonds in their paper *The Creative Process Where the Artist is Amplified or Superseded by the Computer* (Cornock and Edmonds, 1973; first circulated in 1970).

In this work, Cornock and Edmonds identify that an interactive artwork and its participant are in a dynamic relationship with each other and their environment and that such artworks can be conceived as "art system". This thesis identifies the work of Cornock an Edmonds' work as an important reference point for the research and uses the term "digital art system" to describe a digital artwork that operates as, or is conceived as, a whole consisting of a set of interacting parts.

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[2] Chance and Control: Art in the Age of Computers. https://www.vam.ac.uk/exhibitions/chance-and-control-art-in-the-age-of-computers (retrieved 23rd August 2018).

[3] CAS50: Fifty Years of the Computer Arts Society. http://computer-arts-society.com/cas50 (retrieved 23rd August 2018),

1.3 Personal and Artistic Aims

A research programme of this type is invariably intimately connected to the interests and background of the artist. Hence, as well as research aims there are personal and artistic aims that, while less formal, provide motivation and context for the work. These are presented below in the form of a personal biographical and creative statement:

> An interest in the connected and emergent nature of the world around us has been a constant through most of my life. Even at school in the 1980s I was fascinated by how simple elements could be combined to produce complex forms. I would spend hours on the school's BBC Micro computer writing programs to draw repeated circles, squares and lines with small variations in size and orientation in order to watch moiré patterns appear. I had not written these patterns in to my code, but they were often the most interesting part of the image. Likewise with Conway's 'Game of Life', just four rules and a program I could type in to the computer in 10 minutes would produce a seemingly infinite world of possibilities.

> Going on to study computer science at Loughborough University gave me access to faster computers and the knowledge needed to make use of them. Combined with an interest in the newly-popularised 'Chaos Theory', I would spend late evenings drawing fractals and other image-making algorithms on the department's graphical workstations.

> While computer graphics remained a big interest, it was Human Computer Interaction (HCI) that was to dominate my early career. The boundary between the human and computer domains – the human-computer interface – was becoming a major focus of research and in the late 1980s and early 1990s a digital revolution was taking place. Computers were moving from being predominantly keyboard-driven to having graphical user interfaces with pointing devices. Even more advanced interaction concepts, involving gesture, speech and even Virtual Reality were also being imagined and I eventually became a researcher at Loughborough in order to explore these developing technologies.

Whilst at university in the late 1980s I also began to read about something that was typically called 'Systems Theory'. Whilst masquerading as a single thing, it was in fact a whole collection of concepts, theories and practices that had a surprisingly long history. It seemed to deal with the very questions that had long puzzled me. How do simple rules lead to something complex? What really happens when two processes interact with each other? How to new things emerge from familiar things? In fact, what does the word 'system', that computer scientists are so fond of using, really mean?

In the mid-to-late 1990s I was caught up what was to be another digital revolution (or perhaps part of a single revolutionary decade), the growth of Internet. While this would ultimately lead to me stepping out of academia for a period of time, the idea that one day everything would be connected via the Internet was very clear to me from the start. I knew the world would be different from now on, and I suspected that 'system thinking' would be part of my attempt to make sense of it.

My early Internet skills were in demand and a relatively short, but important, move to the School of Art and Design at Derby University in 1994 put me in touch with artists and creative people who were interesting in using them. I began as an arts-aware Internet-evangelist, but by the time I left a year later I was on a journey to becoming an artist in my own right. Importantly, I had realised that I could use the skills I had obtained through my previous activities to create things that could be contextualised simply as 'artworks'.

For the next five years I combined a commercial role in an early Internet company with developing creative practice. My commercial work was featured extensively in the press and I contributed to, and edited, a number of news-stand magazines. My creative work was focussed around the creation of websites and CD-ROMs, installations at festivals and events, and live multimedia VJ performances.

I naturally began to bring my interests in system theory in to my arts work. This was initially seen in the video material I used, typically nature inspired and highly layered, and later in a visual style that combined different ways of seeing, such as the 'mechanical', Cartesian world-view with the more 'intuitive', systemic view. Even then I approached the creation of new works critically, with reflection an important part of my creative process.

My first gallery installation was in 2000. This year also marked my departure from company I had joined in 1995. In order to bring my arts work in to my 'day job' I formed a company that would look to do both. Basing myself in a local arts organisation, the business grew in to something, ironically, not too dissimilar to the one I had left in 2000. However, arts projects remained a priority and I was able to develop my practice further through exhibitions, multimedia performances and more gallery-based installations. I was also successful in obtaining arts funding.

In 2005 I was becoming aware that my artwork was not getting to the core of my systemic interests and questioning. There was something missing. Then it struck me during a period of reflection that if I really wanted to create artwork inspired by systems then the artworks should actually *be* systems, not be *about* systems. This was initially a revelation. I though that I may have invented a new type of art. However, this delusion was short-lived, especially when I discovered that an exhibition *Open Systems: Rethinking Art c.1970* had just closed at the Tate.

I clearly needed to learn more and broaden my creative context if I was going to create the artwork I knew I wanted to make. After connecting with current research thinking, I knew that my process would need to be a formalised 'practice-based' one. I then began a research-based MA in Digital Arts at Camberwell School art in 2006, a process that would ultimately lead to me undertaking a practice-based PhD at De Montfort University. A process that would prove to be highly satisfying and lead to the production of many new artworks exploring and embodying the systemic principles that have long inspired me.

1.4 Research Process

The research makes use of Donald Schön's *Reflective Practitioner* approach (Schön, 1983) and Candy's trajectory model (Candy, 2011) together with Scrivener's iterative research process of reflection-in-action and reflection-on-action (Scrivener, 2000, 2002; Scrivener & Chapman, 2014). It is a "practice-based" programme (Candy, 2007) based around three cycles of Theory-Create-Exhibit-Reflect with each cycle feeding an

updated theoretical position in to the next. The starting point of the first cycle was an initial theoretical position developed through an analysis of my earlier artworks.

1.5 Outcomes

During each of the Theory-Create-Exhibit-Reflect research cycles a collection of new digital art systems was created and exhibited and then documented. This resulted in a large body of new digital artworks and supporting materials.

The first cycle concerned the creation of an exhibition space called *The Interact Gallery* that operated in Leicester between 2011 and 2012 and the exhibition of new artworks, including *Memory Mirror aka One Living Thing*, *Dropsketch* and *Moving Pictures*. These artworks were designed to incorporate a set of "properties of digital art systems" identified following an analysis my earlier artworks. The key insight generated following this first research cycle included the observations that the gallery is a system in its own right and that digital artworks of different types can interact with each other as well as their human participants.

The second cycle involved the creation of a joint exhibition at Phoenix Square in Leicester titled *Symbiotic* with arts group Genetic Moo that was focused on investigating the key observations highlighted above. These were collected into a set of "principles of digital art systems". Six artworks, three by myself (*The Whale*, *Red Spinner* and *Blue Spinner*) were designed to interact with three artworks by Genetic Moo. Video evidence is presented to show that the artworks interacted with each other

as well as an audience and that the nature of these interactions can described in terms of the multimedia materials being exchanged.

Following the first two research cycles, a *Framework for Connected Digital Artworks* was produced that combined the properties and principles identified earlier, together with additional insights produced following the *Symbiotic* exhibition. The framework includes both terminology and a visual notation for analysing digital art systems. The visual notation was then demonstrated by applying it to the work produced during the first two research cycles.

The final research cycle involved a radical reworking of my creative practice to focus on the exchange of multimedia materials between generative images. This work was exhibited in at the LCB Depot Lightbox gallery in Leicester in 2016 as the *A Cybernetic Ecology* exhibition. As well as resulting in the creation of a collection of new digital artworks, this work also resulted in the creation of a new type of infrastructure for connecting digital artworks using Internet of Things technology.

It is argued in this thesis that the framework and its application to a series of new artworks, together with the infrastructure for connecting digital artworks represent a contribution to knowledge as described in the aims of the research above.

1.6 Structure of the Thesis

The thesis is divided in to nine chapters plus references and appendices. There is also an accompanying USB stick that contains the images, videos and documents that are referenced in the main body of the text.

1	Introduction	An introduction to the research programme and a summary of outcomes.
2	Digital Art Systems	The research context presented in detail.
3	Research Process	The methodology used in the research programme.
4	Foundation Work	Presentation and analysis of work undertaken prior to the research programme.
5	The Interact Gallery and Symbiotic	Presentation and analysis of *The Interact Gallery* and *Symbiotic* research cycles.
6	A Framework for Connected Digital Artworks	Presentation of a new framework for understanding connected digital artworks featuring terminology and a visual notation.
7	A Cybernetic Ecology	Presentation and analysis of the *A Cybernetic Ecology* research cycle.
8	Results	Presentation of the results of the research.
9	Concluding Discussion	Concluding remarks and future work.
	References	Research sources used in this research programme.
	Appendices	Additional material concerning the work being presented.

Table 1.1 The structure of the thesis.

CHAPTER 2: Digital Art Systems

The foundation for this research programme is the dual context of systems thinking and digital art. Both fields came to prominence in the 1960s and consequently they both have over 50 years of history. Of particular interest to this thesis are the concepts of "autopoiesis" from Maturana and Varela and "art systems", as presented by Cornock and Edmonds. These concepts were identified early in the research process and we first brought together by the author at the EVA London 2011 conference (Clark, 2011; included in Appendix V);

2.1 Systems Thinking

The first context for this research is the application of a *systems approach* to the topic of interest. Such an approach, comprehensively described by Ludwig von Bertalanffy in his book *General System Theory* (1968), encourages the investigator to analyse the subject of study in terms of the *systems* it contains and the relationships between the various *parts* and the *whole*. It should be noted that while the term "system" may be in common use (for example, a computer system, the solar system, the nervous system or even simply *the* system) in this case it takes on a meaning defined by von Bertalanffy (ibid 54-88). This description is presented in largely mathematical terms. However, for non-mathematicians von Bertalanffy also included the simple statement that, "a system is a set of elements standing in interrelations." (ibid: 55).

Other non-mathematical definitions of system often paraphrase this definition by saying that a system is "a set of things working together as parts of a mechanism or an

interconnecting network; a complex whole" (Oxford English Dictionary) or "a regularly interacting or interdependent group of items forming a unified whole" (Merriam-Webster Dictionary). Von Bertalanffy notes that the concept of a system has pervaded all fields of science (ibid: 3) and devotes the body of *General Systems Theory* (which is based on publications by von Bertalanffy dating back to the 1940s) to an argument that not only can the *term* system be applied to many different disciplines, but that the *properties* of such systems are consistent across disciplines too. Von Bertalanffy uses the term "systems approach" (ibid: 4) to describe the application of the systems concept to an area of study and many other authors (including Checkland, 1981; Capra, 2002; 2014) have contributed to the development of the approach.

Terms such as "system theory" and "system science" are often used to describe the more formal aspects of the methodology. My preference, though, is to use the term "systems thinking", as used by Peter Checkland (1981), when describing the approach I have taken. I use the term systems thinking throughout this thesis because it allows me to refer to the full body of systems thought without being tied to a specific systems theory or systems science method. I consider myself as a *systems thinking artist* who applies a systems approach to the creation and evaluation of their artworks. Consequently, I would not describe myself a systems theorist or systems scientist.

Although I take a broad systems perspective to my work, I should add that I have a particular interest in the application of systems thinking to the understanding of living things. I find that this domain presents me with a rich source of inspirational, audiovisual and conceptual material that continues to inform my developing personal

aesthetic. Additionally, as Maturana and Varela demonstrate in *The Tree of Knowledge: The Biological Roots of Human Understanding* (1987), living systems exhibit a great many levels of system-like organisation, from the operation of the cell, through multicellular organisms, collections of organisms, interactions between different types of organisms and so on. As such, any systems view of life must be acutely aware of the often subjective nature of the boundaries we draw when analysing a system. I believe that this resonates with my creative approach, where my focus often shifts between different levels of understanding within an artwork. The systems view of life, and Maturana and Varela's in particular, also provides a rich language to with which to describe the relationships and behaviours within and between living systems. Some of these terms may be in everyday use (such as "environment" and "ecosystem") and I often use biological terms throughout this thesis to illustrate many of the systemic properties and states identified within the artworks. I am, however, careful to define my use of these terms where necessary. It should also be noted that the use of biological language is predominantly illustrative and metaphorical. It is not argued that any of the interactive digital artworks I have created or analyse are living systems, only that they have properties like living things.

In *The Systems View of Life* (2014) by Fritjof Capra and Pier Luigo Luisi, the authors provide a comprehensive integration of ideas, models and theories that demonstrate the application of systems thinking to a wide range of disciplines. They also define the characteristics of systems thinking in detail (ibid; p80-82). These characteristics are summarised below in Table 2.1.

Characteristics of Systems Thinking
Shift of perspective from the parts to the whole
Inherent multidisciplinary
From objects to relationships
From measuring to mapping
From quantities to qualities
From structures to processes
From objective to epistemic science
From Cartesian certainty to approximate knowledge

Table 2.1 The characteristics of systems thinking (Capra and Luisi, 2014; p80-82).

Behl and Ferriera (2014) survey the field of systems thinking and define the three key elements identified in Table 2.2.

Element Name	Definition
Understanding the whole system	Understanding the whole system means comprehending the system holistically, taking into consideration all its elements, subsystems, assemblies and components.
Understanding interconnections	Understanding interconnections means having the knowledge and ability to understand relationships and interdependencies between system elements at various hierarchical levels of the system, along with the results of interactions between system elements.
Consider and use multiple perspectives	Considering and using multiple perspectives means understanding the system from diverse and several points of view.

Table 2.2 Systems thinking elements and definitions (Behl and Ferriera, 2014)

2.2 Systems Terminology

In order to represent a subject of study as a system it is first necessary to identify the whole (the system), the parts (it's elements) and the boundary between the system and its surrounding environment. As identified above, the wholes should be "a set of elements standing in interrelations".

While the position of boundaries may at times appear obvious, their identification is always made from the perspective of the observer. Maturana and Varela call this process as an "act of distinction". They refer to the system as a "unity" and the environment in which it sits as the "background" (Maturana and Varela, 1987). Throughout this thesis the identification of systems boundaries is seen as a subjective process and, in line with the principles of systems thinking above, multiple perspectives are considered.

Systems can be classified in terms of the nature of their boundaries and what they allow to pass through. This classification is commonly done in terms of a system's ability to exchange matter and energy with its environment.

As illustrated in Figure 2.1 (Benton, 2016; 117) three types of basic system can be defined. First, an isolated system where no matter (mass) or energy can pass through the system's boundary. Second, a closed system where energy can pass through the boundary, but matter (mass) can't. Finally, an open system where both matter (mass) and energy can pass through the boundary.
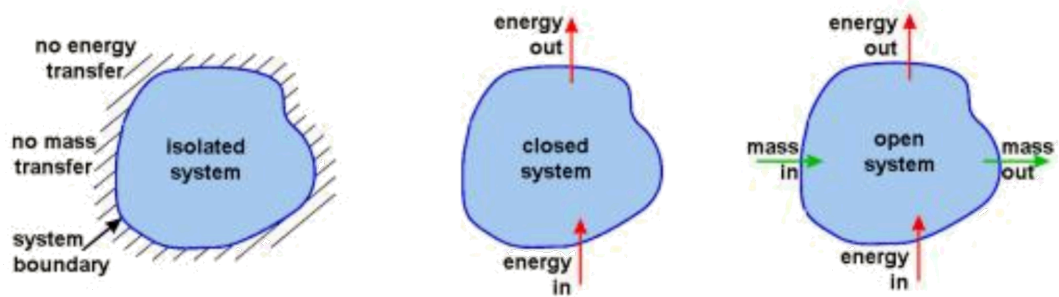
Figure 2.3 Isolated, Closed and Open systems. (Benton, 2016; 117)

This classic 'thermodynamic' classification of different types of system is used throughout this thesis. It is important, therefore, to be clear about the difference between an isolated and closed system. A closed system does not allow new material to pass through its boundary, but it can be influenced by the outside environment through the passing of energy. An isolated system is completely unaffected by changes in its environment.

As the arguments contained within this thesis develop, it will be seen that the 'thermodynamic' terms 'energy' and 'matter' used above are seen as *analogous* with the *triggering* of changes within a digital artwork, or network of artworks, and the exchange of multimedia *material*. Consequently, it is not argued that digital artworks should be understood in purely 'thermodynamic' terms. The value and potential further uses of this analogy is discussed in *Chapter 9: Concluding Discussion.*

When looking *within* the system the focus within this thesis is on interrelationships between the parts (or "components") and how these work together to produce the whole.

From a systems perspective the whole is not simply seen as the sum of the parts but is a result of the interactions between those parts.

2.3 Organisation, Structure and Autopoiesis

In Maturana and Varela's *The Tree of Knowledge* (1987) the authors are concerned with the organisation of complex systems, in particular biological organisms. They identify an important distinction between a system's internal organisation and its structure, something that is particularly relevant to the artworks presented in Chapter 7. They state:

> *Organization* denotes those relations that must exist among the components of a system in order for it to be a member of a specific class. S*tructure* denotes the components and relations that actually constitute a particular unity and make its organization real. (ibid, p47)

The identification that the system is defined by the *organisation* of the parts, not the parts themselves, has an important implication for all non-static systems. That is, in order to remain a member of a particular class, the system must be able to continuously reorganise itself in response to inputs an outputs so as to maintain its organisation.

In this thesis, the desired organisation of a system is referred to as its "pattern of organisation". The process of maintaining the pattern is referred to as a "process of organisation". For a digital art system, the pattern of organisation may be defined as a set of rules or conditions that must be maintained in order for the artwork to be in the state intended by the artists, or for it to be coherent. The process of organisation may be

the algorithm or computer program that reorganises the components of the artwork in order to satisfy the rules.

Maturana and Varela also define the term "autopoiesis", or self-creation, in which the pattern and process of organisation are closely bound. In *Autopoiesis and Cognition: The Realisation of the Living* (1973; p78) they write:

> An autopoietic machine is a machine organized (defined as a unity) as a network of processes of production (transformation and destruction) of components which: (i) through their interactions and transformations continuously regenerate and realize the network of processes (relations) that produced them; and (ii) constitute it (the machine) as a concrete unity in space in which they (the components) exist by specifying the topological domain of its realization as such a network.

The concept of autopoiesis, and the idea that it might be possible to create a digital art system that functions in this way, has been an ongoing influence in my artistic work and is referred to regularly throughout this thesis.

Maturana and Varela developed the idea of autopoiesis to describe the unique properties of living organisms. The 'autopoietic machine' in their 1973 definition would typically be a living system, but they – and other authors – have expanded its use to include other systems, such as social and economic systems. Examples of this can be found in Maturana and Varela's *The Tree of Knowledge* (ibid) and Fritjof Capra and Pier Luigi Luisi's *The Systems View of Life* (2014).

Some authors have criticised the theory. For example, Swenson (1992) has noted that the apparent reusability of the theory suggests that, by definition, that its ability to describe the 'unique' properties of living things is undermined. The author goes on to

say, "the whole concept of autopoiesis is contrived at its foundations where it is miraculously decoupled from the physical world to promulgate a solipsistic epistemology with abhorrent social consequences."

While acknowledging this debate, this thesis is not concerned with presenting an argument as to the philosophical merits, or otherwise, of autopoietic theory. The value of the theory this research has been is in how it has provided a rich source of concepts and terminology for use both the creation of the artworks and the formation of the theoretical framework.

2.4 Digital Art

At its simplest, "digital art" can be seen as simply art made with digital technology, such as the computer. However, as Christiane Paul notes, "the terminology for technical art forms has always been extremely fluid and what we know as digital art has undergone several name changes since it first emerged" and "the term 'digital art' has itself become an umbrella such as broad range of artistic works and practices that it does not describe one unified set of aesthetics" (Paul, 2003; p7).

Within this thesis I will generally use the term "digital art" to describe any artwork made with digital technology such as computers, screens, cameras and other input and output devices, and "computer art" to describe a subset of such work where the algorithmic processes used in their creation are as seen as a primary element of the work. I include works on paper as well as works on screen within this definition.

I will also use the terms "digital art system" to describe any digital artwork that is able to (intended or otherwise) interact with humans or other digital artworks. Finally, I will use my own term "connected digital artwork" to describe digital artworks that are created to interact with multiple humans and other digital artworks and are able to form "cybernetic ecologies". These three terms are defined later in the thesis.

2.4.1 History

The use of computer technology to make art is almost as old as the computer itself with artists as Ben Laposky and Desmond Paul Henry making work with computers as far back as the 1950s. Indeed, Henry's work even predates the use of digital technology, using a Second World War analogue "bomb sight" computer with attached pens to draw complex images (O'Hanrahan, 2018).

The first widely attended exhibition of computer artworks, *Cybernetic Serendipity*, took place at the ICA in London in 1968 (Reichardt, 1968). The work displayed included computer generated images, electro-mechanical artworks and installations and human-machine performances. The interest surrounding the exhibition led to the formation of the *The Computer Arts Society* and the publication of their newsletter, PAGE, in 1969[4].

The field of computer art was then pioneered in the late-1960s and early-1970s by artists such as Frieder Nake, Paul Brown, Manfred Mohr, Georg Nees and Ernest

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[4] PAGE. http://computer-arts-society.com/page (retrieved 23rd August 2018).

Edmonds, all of who have recently been recognised in exhibitions to mark the fiftieth anniversary of both Cybernetic Serendipity and the Computer Arts Society. [5,6]

Early computer artworks were presented as printouts, plotter drawings and photographs, and it is largely these that have found their way in to collections, such as those found in the Victoria & Albert Museum in London. However, many early computer artists were also attracted by the *interactive* potential of the developing technology and *Cybernetic Serendipity* featured many interactive and responsive works. As computers have developed over the past 50 years, the exploration of interactivity became a core part of many computer artist's creative practices.

Cybernetic Serendipity was very clear in contextualising itself within the field of cybernetics. As well as the reference to it in the name of the exhibition, it featured quotes from cybernetician Norbert Weiner's books *Cybernetics: Or Control and Communication in the Animal and the Machine* (Weiner, 1948) and *The Human use of Human Beings* (Wiener, 1950). It also included an artwork by British cybernetician Gordon Pask called *A Colloquy of Mobiles* (Reichardt, 1968; p34).

The connection between cybernetics and art in the 1960s is discussed further by Edward A. Shanken in *Cybernetics and Art: Cultural Convergence in the 1960s* (2002). The pioneering artist and writer Roy Ascott has long used cybernetic theory in his work, from the 1960s to the present day (Ascott, 2003).

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[5] Chance and Control: Art in the Age of Computers. https://www.vam.ac.uk/exhibitions/chance-and-control-art-in-the-age-of-computers (retrieved 23rd August 2018).

[6] CAS50: Fifty Years of the Computer Arts Society. http://computer-arts-society.com/cas50 (retrieved 23rd August 2018),

2.4.2 Art Systems

Given that early computer art was aligned with cybernetics, a field closely aligned with system theory, it was perhaps not surprising that computer artists would at some point begin to explore the idea that their artworks might be seen as "systems".

However, this conceptualisation occurred very early in the development of computer art with Cornock and Edmonds' paper *The Creative Process Where the Artist is Amplified or Superseded by the Computer* (Cornock and Edmonds, 1973; first circulated in 1970). In this paper, a systems-centric analysis of the interactive artworks is presented in which different types of "art system" are presented. These are shown in Figure 2.3.
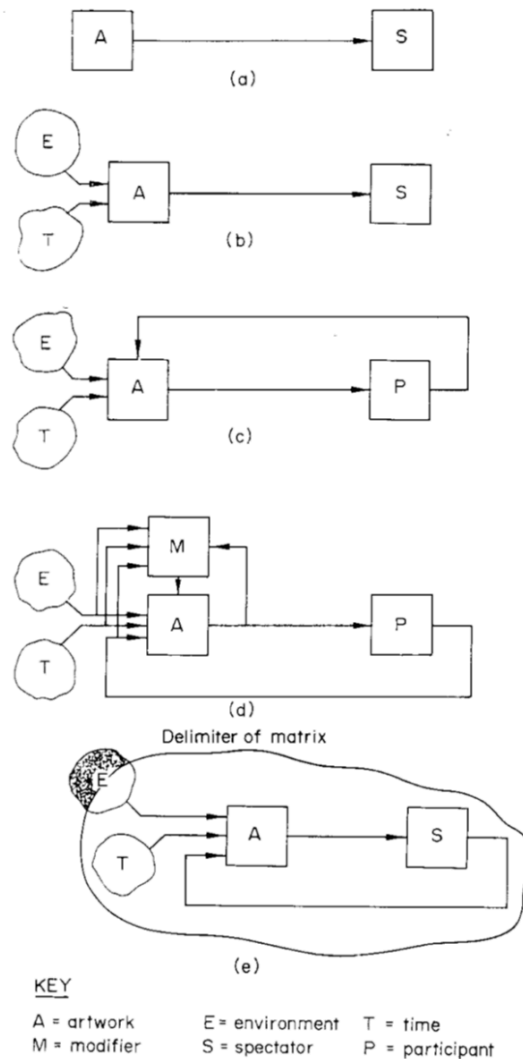
Figure 2.4 (a) Static system. (b) Dynamic-passive system. (c) Dynamic-interactive system. (d) Dynamic-interactive system (varying). (e) Matrix. (Cornock and Edmonds, 1973)

The Cornock and Edmonds model shows how the artwork, environment, spectator and participant exist within a systemic relationship which, as the nature of the computer artwork becomes more complex, can involve multiple feedback and modifier loops that exist over time. They refer to this expanded view of the artworks as the "art system".

The use of systems concepts in the contextualisation of artworks had taken place prior to Cornock and Edmonds. Notably, the theorist Jack Burnham discussed how the artwork can be seen as a system in *System Esthetics* (1968) and *Real Time Systems* (1969), however, their model is of particular relevance to this research since it introduced specific terminology for the analysis of art systems and a visual notation for thinking about artworks from a systems perspective.

By looking at a digital artwork as a system, and not simply an object or collection of objects, other opportunities become available to the artist.

The first of these begins with the realisation that the human component is an *integral* part of the artwork. All of the cases presented by Cornock and Edmonds in Figure 2.4 require a human spectator or participant in order for them to be complete. Even the static system requires a spectator and in the more complex examples the participant is an integral part of the work. The artwork (art system) literally *does not exist* without the human participant. Hence, a vital part of the artist's creative intent has to concern how the spectator or participant relates to the digital artwork.

The second concerns the nature of the connections between the parts. While one might assume that the parts of a digital art systems need to be co-located, this is not implied by the systems view. So long as the parts are able to connect with each other in some way their location is not necessary significant to the operation of the system. With the development of communications technology over the past 50 years the potential of digital artwork systems distributed over great distances and involving participants in different locations has been realised. This is illustrated in work such as *Cities Tango* by

Ernest Edmonds (Edmonds and Franco; 2013) and the telematic artworks developed and discussed by Roy Ascott (2013).

Finally, and this is not explicitly explored by Cornock and Edmonds but can be extrapolated from their systems diagrams in Figure 2.4, systems can themselves be composed of sub-systems and form parts of super-systems. Hence, multiple digital artworks, operating at different levels of organisation, connected over distance, and interacting with many participants could be constructed. It is this "connected" vision of the digital artwork that this thesis is ultimately concerned with.

2.4.3 Digital Art in the Gallery System

It is useful to consider the position of digital and systems-based artworks within the broader gallery context. The traditional gallery system is concerned with art objects that can be authenticated and traded as products. *Digital Art* could be seen as being in conflict with this. A digital artwork can sometimes be infinitely reproduced, or may be presented in ways more akin to performance. There are also many issues relating to the preservation of digital artworks that make use of ever-changing technological platforms.

While many of the artworks described in this thesis *have* been successfully presented in a traditional gallery context without complication, the broader position is not always so benign.

Ernest Edmonds (2019) interviewed experts in the field of digital and computer art about their experiences curating, collecting and exhibiting digital artworka. The interviewees reveal a range of issues that Edmonds summarised by saying, "So we see

from these many different points of view that computer-based art is still not fully part of the standard art scene. But is that such a surprise? Radical innovation normally takes quite a while to embed itself into its proper social context."

This thesis is not concerned with problems relating to the presentation of digital art within the gallery system. However, the research *does* make a contribution in the conceptualisation of the gallery as a 'system' in its own right. *The Interact Gallery* is described in Chapter 5 and introduces the idea that collections of "connected" digital artworks could be installed across multiple galleries simultaneously.

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CHAPTER 3: Research Approach

The research described in this thesis is a practice-based programme based around three major cycles of Theory-Create-Exhibit-Reflect with each cycle feeding an updated theoretical position in to the next. In *Practice Based Research: A Guide*, Linda Candy defines practice-based research in the following terms:

> **Practice-based Research** is an original investigation undertaken in order to gain new knowledge partly by means of practice and the outcomes of that practice. In a doctoral thesis, claims of originality and contribution to knowledge may be demonstrated through creative outcomes in the form of designs, music, digital media, performances and exhibitions. Whilst the significance and context of the claims are described in words, a full understanding can only be obtained with direct reference to the outcomes (Candy, 2006).

It is a Creative-production Research Project as described by Stephen Scrivener (2000; 2002; Scrivener and Chapman, 2004) involving multiple cycles of Reflection In Action and Practice (RIAP) and Reflection On Action and Practice (ROAP) as illustrated in Figure 3.1.
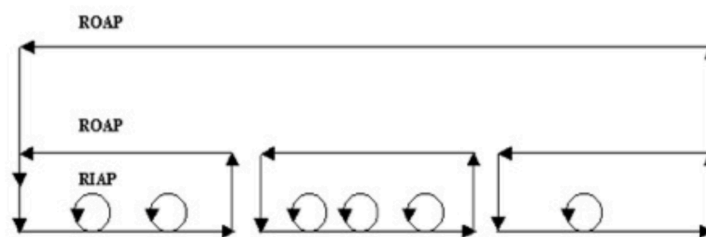
Figure 3.1 Reflection in (RIAP) and on (ROAP) design episodes and projects (Scrivener, 2000).

Scrivener (2000) bases his distinction between reflection-in and reflection-on on Schön's (1983) theory of practice, where *reflection-in* takes place *during* the production of the creative work and *reflection-on* takes place *following* a creative cycle and prior to the start of the next cycle.

During my creative process, reflection-in involved documenting my work through the production of audiovisual material and blogging on my website (see the appendices for photographs, videos, documents and a copy of *The Interact Gallery* website; these are also included on the attached USB stick). Consequently, while I remained fully engaged with the creative process, I would take opportunities to "stand back" and reflect whenever possible and I found that engaging in a process of on-going documentation was key to me being able to this. What's more, as a "systems thinker" I was always considering the relationships between the whole and the parts and applying the principles described in Section 2.1.

The reflection-on phases involved a detailed review of the materials gathered and their use in formulating and developing the theoretical starting point for the next research phase. This process began by turning my observations of the operation of my artworks in to a set of *properties* of interest, then in to a set of *principles* and finally in to the *Framework for Connected Digital Artwork*. The reflection-on processes was further applied in my publication and presentation of my research whenever possible (published papers are included in Appendix V and are on the attached USB stick).

The Theory-Create-Exhibit-Reflect process is based on Candy's Trajectory Models of Practice and Research (Candy, 2011). In this model, various trajectories through

Practice, Theory and Evaluation are discussed, together with an illustration the differences between of theory-led and practice-led approaches.

My use of this approach is illustrated in Figure 3.1. The research process begins at the centre with a starting position generated through my background research and artistic intuition and "spirals" out through the cycles of Theory, Create, Exhibit and Reflect with the theoretical position being expanded and strengthened at each iteration.

0: Foundation Work
1: The Interact Gallery
2: Symbiotic
3: A Cybernetic Ecology
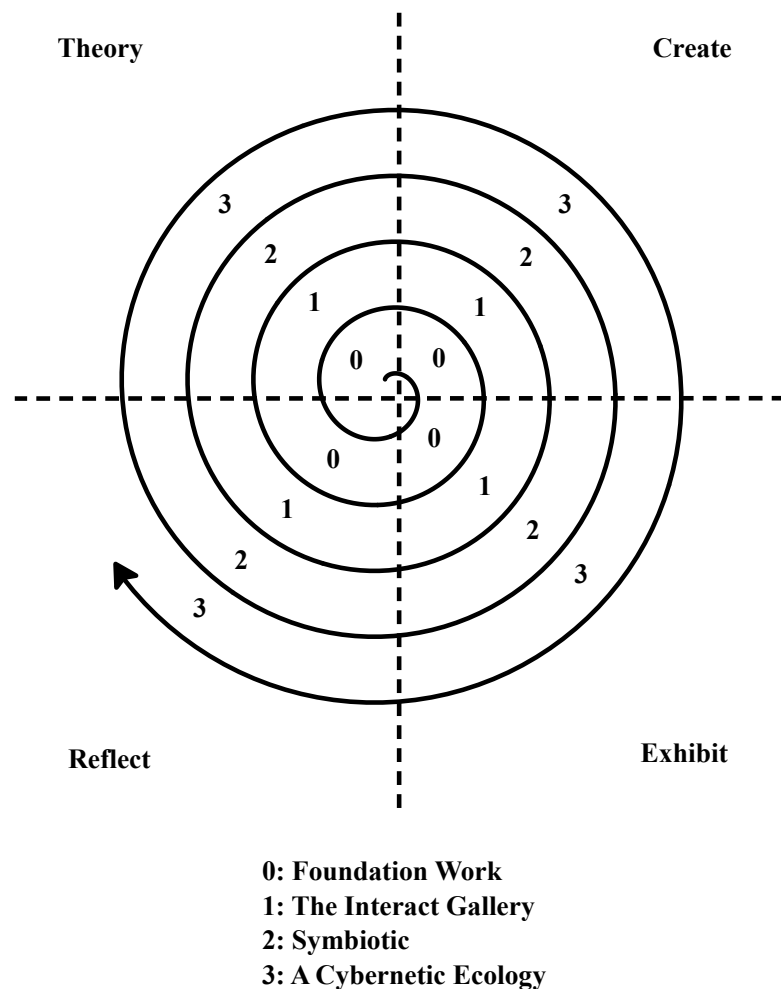
Figure 3.1 The iterative nature of my research process.

Within this approach I would not consider the research process to be specifically theory- or practice-led. While the starting position was partly theoretical it was also intuitive and did not become suitably formed until I had undertaken a significant amount of foundation work. Certainly by the start of this research programme it was no longer possible to say if the theory was leading the production of new artworks, or the artworks were leading the production of theory – the one feeds the other.

The Theory-Create-Exhibit-Reflect phases of each research cycle are detailed more in Table 3.1 together with references to their outputs and where they are documented within this thesis. The titles of the artworks produced are shown in the Create phases.

Cycle	Phase	Outputs	Chapter
0: Foundation Work	Theory	Background research and artistic intuition.	2
	Create	*I See You*, *ArtScanner*, *vLooper*, *Autopoiesis*.	4
	Exhibit	Trampoline (2007), Phoenix Digital (2008), MA Show (2008).	4
	Reflect	Identification of the properties of digital art systems and formulation of starting research position.	4.6
1: The Interact Gallery	Theory	The properties of digital art systems	5.3
	Create	*Memory Mirror aka One Living Thing*, *Dropsketch*, *Moving Pictures*.	5.4
	Exhibit	Curated gallery space. Multiple exhibitions and events (July 2011 - September 2012).	5.4
	Reflect	Observations including that artworks are able to communicate with each other as well as their human participants and other principles of digital art systems.	5.4.7

2: Symbiotic	Theory	The principles of digital art systems.	5.5
	Create	*The Whale, Red Spinner / Blue Spinner*	5.6
	Exhibit	Exhibition at Phoenix Leicester (19th November - 4th December 2012).	5.6
	Reflect	Confirmation of the principles of inter-artwork communication. Identification of "matter" and "energy" in digital art systems. Formulation of the *Framework for Connected Digital Artworks*.	5.7
3: A Cybernetic Ecology	Theory	*A Framework for Connected Digital Artworks*.	6
	Create	*System 1, ColourNet, Transformations, Cities Tango 2, Signal*.	7.4
	Exhibit	Exhibition at LCB Depot Leicester (6th December - 3rd December 2016).	7.4
	Reflect	New aesthetic direction with a focus on exchange of matter and energy. Confirmation of the usability of *Framework for Connected Digital Artworks*. Generation of new artwork ideas for further research cycles.	7.5 / 8

Table 3.1 An overview of the research cycles and phases.

It should be noted that the Create and Exhibit phases involve the reflect-in process and the Theory and Reflect phases are part of the reflect-on process, as described by Scrivener (2000) and Schön (1983).

As a practice-based research programme the artworks produced are central to the knowledge generated by the research. However, as Schön (1983) notes when discussing the creative practitioner:

He produces knowledge that is objective, in the sense that he can disconfirm it. He can discover that he has not achieved satisfactory change or that he ought to undertake change of a different order. But his knowledge is also personal, bounded by his commitments to appreciative system and overarching theory. (Schön, 1983; p166)

The *Framework for Connected Digital Artwork* has a pivotal role within the research presented. While it a *product* of the earlier research cycles, it becomes a *tool for reflection* in the final research cycle, together with a method of communicating the knowledge generated in the practice-based research process to others. It is the method by which the personal knowledge generated is made external and shared publicly.

CHAPTER 4: Foundation Work

Between 2006 and 2008 I undertook a programme of exploratory research entitled *Autopoiesis: The Art is in the Interaction* as part of a Masters of Arts at Camberwell School of Art and Design, University of the Arts London[7]. During this period of research I produced a number of new digital artworks that were intended to behave in systems-like ways. The motivation for this work was initially driven by an intuition that this would be an interesting line of creative enquiry. By the completion of the masters programme I had developed a clearer idea relating to how systems thinking and digital art could be combined.

In this chapter, I describe each piece before identifying the properties of the foundation artworks that went on to inform the development of the theoretical basis of the artworks in the later studies. These properties were identified through a process of reflection and analysis of the documentary materials produced during the production and exhibition of the works.

Despite being actively involved in the creation of digital artworks since 2000, and having used systems concepts as a key source of inspiration, I am only presenting work created after 2006 as part of this chapter. Upon reflection, this year marks a clear transition point where my artwork shifted from being *about* systems and the systems world-view to being an attempt to create artworks that *explicitly contained systems-like properties* and engaged with Maturana and Varela's concept of "autopoiesis".

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[7] The process was documented at http://www.seanclark.me.uk/static/autopoiesis/autopoiesisblog.html (retrieved 23rd August 2018).

4.1 I See You

I See You was produced for the Trampoline 10th Anniversary event at the Broadway Media Centre in Nottingham in 2007[8] and was then shown in various locations in 2008 and then at UK Systems Society conference in Oxford in 2010. An image of the piece can be seen in Figure 4.1 with an additional image in Appendix 1 and a short video on the accompanying USB stick.

Figure 4.1 *I See You* at Broadway Cinema and Media Centre in Nottingham in 2007.

The artwork took the form of a large screen driven by a computer with a video camera attached. Software on the computer was programmed to search for faces in the incoming video stream. When a face was identified a still image was extracted from the video and

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[8] Trampoline. http://www.seanclark.me.uk/static/autopoiesis/mada3exhibitions.html (retrieved 23rd August 2018).

displayed in a random position on the screen. The screen would start off empty, but as more faces were found it would begin to fill, eventually reaching a state in which no part of the video screen was uncovered.

Individual face images would only remain on screen for a fixed period of time, so that if replacements could not be found fast enough then the screen would return to the empty state. It was imagined that once the artwork had initially filled the screen with faces then it would be able to attract a steady flow of new people/faces to maintain a full screen. When reflecting on the system-like properties of *I See You* in 2011 I made the following observations shown in Table 4.1.

A1	It starts as an empty screen and it requires interaction from a visitor in order to wake up, or come 'alive'.
A2	It self-constructs using material (faces) taken from its environment. No pre-generated material is fed in to the system.
A3	It reaches a state of dynamic equilibrium (a screen is full of faces). Once in this state visual structure remains broadly the same despite the detail forever changing.
A4	The material gathered (faces) is used to attract more material (more faces).
A5	Without the input of new material the artwork returns to the empty screen state.
A6	Despite sharing the same starting conditions, no two installations would ever be the same due to the unpredictable nature of the inputs.

Table 4.1 Observations made on *I See You* in 2011.

4.2 ArtScanner

ArtScanner was originally created for the Phoenix Digital programme in March 2008[9]. It was exhibited simultaneously at the Phoenix Art Centre and the LCB Depot in Leicester for a one month period. Between August 2011 and September 2012 an enhanced version of the artwork was also exhibited at *The Interact Gallery* in Leicester as part of the *Art Systems* exhibition (Chapter 5). An image of the piece can be seen in Figure 4.2, with additional images in Appendix I.

Figure 4.2 *ArtScanner* at Phoenix Arts in Leicester in March 2008.

The artwork was created to be a hybrid online/offline piece that used technology to create a system of interactions. I specifically saw *ArtScanner* as an "empty vessel" that would be filled through the users' engagement.

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[9] Phoenix Digital. http://www.seanclark.me.uk/phoenixdigital (retrieved 23rd August 2018).

ArtScanner featured a website that a contributor could use to upload an image. In return for their upload they would be given a 2D barcode. They were then told that they could print the barcode and place it near the *ArtScanner* installations at Phoenix Arts or the LCB Depot, or both. The installations contained a barcode scanner and an LCD screen (powered by a computer connected to the internet) and when a visitor scanned the barcode they would see the contributor's image.

Once the system was installed, it was allowed to grow organically. The publicity about the project was the necessary trigger needed to activate the system – encouraging the initial uploads to the website, then visits to the installations to deposit barcodes, barcode scans by visitors, and so on.

The artwork was physically limited by the space available around the screen and the length of the cable connecting the barcode scanner to the computer. I hoped that once the space was fully covered with barcodes that people would start to place newer barcodes over older ones and decorate them in order to make them more distinctive.

Given the relatively short run of the initial exhibition the artwork, it did not reach such a saturation point. However, over 200 images were uploaded and some interesting structures were starting to emerge, such as contributors creating small groups of their own barcodes and starting to illustrate them to make them stand out from others. When reflecting on the system-like properties of *ArtScanner* in 2011 I made the observations that are shown in Table 4.2:

B1	I saw my role as the artist being to create a system that had the potential to grow in to an artwork. It began as an empty vessel and would fill through a process of interaction.
B2	The artwork had a number of weeks to construct itself. I would visit both installations regularly and tend them – re-attaching barcodes that had fallen to the floor and testing the scanners to make sure they were functioning correctly.
B3	I saw the key feedback loop within the work involving a process whereby a person experiences the installation as a viewer, then leaves the space to upload an image of their own, then returns to the add their barcode, thus becoming a contributor, and in turn helping to encouraged more such transformations.
B4	The physical and conceptual space in which the artwork operated was more complex than *I See You*. It included an online and offline element with processes that took place potentially over weeks not seconds or minutes. Identifying where the artwork was located was similarly more complex. Was it the website? Or the installations? If it was the system itself then at what point did the potential of the empty vessel become an artwork?
B5	Without the input of new material (image uploads) the artwork would not grow and it would soon become uninteresting to potential viewers and contributors.
B6	The two installations of *ArtScanner* created for the first exhibition took on very different appearances despite sharing access to the same website of raw materials.

Table 4.2 Observations made on *ArtScanner* in 2011.

When creating *ArtScanner* I saw it in biological terms. It was a multi-tentacled organism that was able to reach out over the internet in order to attract new material, which it then pulled to the centre and integrated in to its form. It's survival was dependent on the ability of the system to create something that was able to attract regular viewers and turn them into contributors.

4.3 vLooper

vLooper was first shown at Phoenix Digital in March 2008, as part of the same exhibition programme as *ArtScanner*. It then appeared at many events under various names, most notably as *Active Mirror* during the *Sparking The Imagination* event at Phoenix Square in June 2011[10]. An image of the piece can be seen in Figure 4.3, with additional images in Appendix I and a short video on the accompanying USB stick.

Figure 4.3. *vLooper* aka *Active Mirror* at Sparking the Imagination in Leicester in June 2011.

The artwork consisted of a computer with an attached video camera that was connected to a large projection screen. The computer maintained a total of six video buffers, each

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[10] Sparking the Imagination. http://www.seanclark.me.uk/static/interactgallery/ sparkingtheimagination1.html (retrieved 23rd August 2018).

one delayed by two seconds from the previous one, and overlaid them to form a single image on the projection screen. *vLooper* works best in a performance space with a single spotlight focussed on the stage area, people are then encouraged to enter the light and interact with the artwork. Children were particularly attracted to the playful nature of the piece – especially when props, such as balloons, were included.

4.4 Autopoiesis

Autopoiesis was submitted as my final piece for my MA and exhibited at the MA Digital Arts Show at Camberwell in June 2008[11]. Unlike the previous three pieces it contained pre-generated video material, with the presence of the viewer being used in part to add new material but primarily as a trigger to remix the video playback.

The artwork consisted of a triptych image on an LCD screen being controlled by a hidden computer. A camera in front of the screen was used to detect movement as well as send a video image to the program controlling the artwork. An image of the piece can be seen in Figure 4.4, with additional images in Appendix I and a short video of the artwork is on the accompanying USB stick.

Two banks of audiovisual material were available to the artwork. When movement was detected in front of the screen, playback of this materials was triggered in the left-hand and right-hand panels of the triptych. The centre panel combined the pre-recorded materials with live video of the viewer. When there was no movement there was no playback.

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[11] Autopoiesis. http://www.seanclark.me.uk/static/autopoiesis/ (retrieved 23rd August 2018).

Figure 4.4. *Autopoiesis* **exhibited at the Camberwell MA Show in June 2008.**

The audiovisual material was captured in Leicester city centre in early 2008 and featured video footage of people walking and going about their daily business together with ambient city sounds. It was shot low so as to focus on their movements rather than faces and played back in slow motion. In the artist's statement accompanying the exhibited artwork in 2008 I wrote:

> **[C1]** *Autopoiesis*, is a gallery-based installation that uses a video projector for 'output' and video camera for 'input'. The artwork contains two recorded video streams and two recorded audio streams, with the video camera being used to produce a third, live, video stream of the viewer/participants. As a viewer/ participant moves in front of the camera they cause a hybrid recorded/live video image to be generated according to simple rules embedded within the art-system.

> **[C2]** As well as looking to represent a 'systems-aesthetic', *Autopoiesis* specifically engages with the idea of cities as organisms, or 'systems', in their own right. The

footef of people walking has been prepared in such a way as to encourage the viewer/participant to focus on the rhythms and flow of colours. When interacting with the artwork the video image of the viewer/participant is placed at the heart of this flow and their movement changes it, demonstrating our role as an integral part of an interacting whole. When living or working in a city you are part of it, changing and influencing it as well as being changed and influenced by it. The shapes and structures that emerge are the result of millions of seemingly everyday interactions.

[C3] *Autopoiesis* should be seen as an ongoing work. It will be added to over time to eventually become a series of interactive and interacting artworks that explore the interconnected world around us through the construction of digital art-systems.

4.6 Discussion

While not initiated in these terms, the foundation work can be seen as a cycle of Theory-Create-Exhibit-Reflect. All four pieces engaged with systems concepts, in particular the idea of autopoiesis, or self-construction and (with the exception of *vLooper*) underwent a process of artistic reflection, either following exhibition (*I See You* and *ArtScanner*) or as part of their initial contextualisation (*Autopoiesis*). While *vLooper* did not undergo such a detailed reflective process, it is included because of its significance in the development of future artworks that form part of the thesis argument.

When looking at the characteristics of each artwork, a number of common properties emerge. These relate to the properties of systems described in Section 2.1.

All of the artworks described allow for inputs and outputs and can be described as open systems, in that they incorporate material from their environment in their internal structure through some sort of internal process. By describing them as 'systems' a

boundary is suggested, with materials and processes that are with that are *within* the boundary being part of the artwork, and those that are not being outside of it.

I See You, *vLooper* and *Autopoiesis* use a video camera to capture visual material from their environments (as identified in [A2], above). An internal process then recombines this material and displays a visual structure on a screen or projector (see [A3]). The viewer then responds to this image, creating a feedback loop that influences the further development of the artwork (see [A4]).

ArtScanner is constructed differently, with the inputs being images uploaded to the website and the outputs being the QR codes that are placed at the installation locations. Manual intervention was required in order to keep the art system running (see [B2]). The work is responsive in both the way it attracts new images, and how it is used by viewers (see [B3]). The visible structure of the work is driven by the engagement of the image uploaders and feedback is necessary for the artwork to grow (see [B3] again).

I See You, *ArtScanner* and *vLooper* all start in a state that I have referred to as an "empty vessel" that is filled through a process of interaction (see [A1], [B1]). Consequently, without *any* interaction the artworks would not be realised (see [B5]). In the cases of *I See You* and *vLooper* lack of interaction results in a return to a blank, non-realised and empty state (see [A5]). These three pieces all reach a maximum state after a certain amount of interaction. These limits are imposed by the physical size of the computer screens or installation space. When in a fully-realised state, where any new material added replaces existing material, the artwork could be seen in systems terms as being a state of dynamic equilibrium (see [A3]).

Autopoiesis is the only piece that begins with pre-existing multimedia material within the artwork. However, interaction is necessary in order to animate the work, as well as generate new video material to be included in the video mix. As with *I See You* and *ArtScanner,* without interaction the artwork returns to a non-realised state, albeit one with the pre-existing multimedia material still held within the work, but not visible.

In *I See You* and *ArtScanner* there is a clear sense of the works being constructed of parts and wholes. Within *I See You* these are the video grabs of faces and the resultant collage. In *ArtScanner* these are the images that are uploaded, the QR Codes and the installations constructed at each location. While the resultant 'wholes' for each system are constructed using the same rules, and are visually similar, I noted in my reflection that the details of the individual artworks will always be unique (see [A6], [B6]). Hence, it is not the parts of the system that identify it as being part of a particular class, but the relationships between them. With *ArtScanner* I also reflected on the complex nature of these relationships and raised a number of (rhetorical) questions about the nature of systems-based artworks (see [B4]).

In *vLooper* the parts and wholes are less-immediately apparent, but they exist as multiple video clips (the parts) and the resultant video collage (the whole). The role of the viewer in the generation of the video clips and feeding back on previous clips is clearer.

The contextualisation of the artwork *Autopoiesis* made clear the piece was intended to be seen as an 'art-system' (as mentioned in paragraph [C1]) and identifies the notion of a "system-aesthetic" (see [C2]). The written work also introduces a social context for

the artwork - that of the city being a system - and considers that the work may become part of a series of "interactive and interacting" artworks (see [C3]).

This final point, that of the digital artwork that is both *interactive and interacting* with other artworks, is in retrospect a significant aspiration when framed within this research and is one that will be returned to later. Within the *Autopoiesis* artwork three subsystems can tentatively be observed – two consisting of banks of pre-recorded multimedia material and one live stream from the video camera. As such, the artwork is realised through the interaction of these parts, triggered by the viewer.

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CHAPTER 5: The Interact Gallery and Symbiotic

The Foundation Work described in Chapter 4 provides a starting point from which further explorations into the nature of systems thinking in digital art can be developed. As a prototype in the Theory-Create-Exhibit-Reflect cycle it also serves to indicate how the process of theory-based artistic practice can generate insights that are valuable in the creation of new artworks. The next two cycles of research investigate this further, with the aim of identifying areas that represent a unique contribution to knowledge in the form of a *Framework for Connected Digital Artworks*.

5.1 Artistic Goals

From an artistic perspective the purpose of these two Theory-Create-Exhibit-Reflect cycles was to create and exhibit novel artworks that embody systems principles and build upon the Foundation Work. I had a particular interest in developing the ideas present in *vLooper* and *Autopoiesis* further and exploring an alternative approach to the construction of a multi-user system in the style of *ArtScanner*.

5.2 Research Goals

The research goal was to generate a framework for describing and contextualising systems-based digital artworks. Such a framework would need to capture the nature of the relationships between the various parts of the exhibited artworks and their audience

5.3 The Properties of Digital Art Systems

As part of the reflective process described in Chapter 3, and implemented in Section 4.6, a number of properties of the foundation works were identified. These are summarised in Table 5.1.

Inputs and Outputs	Internal Structure	Boundary
Open and Closed	Internal Process	Environment
Parts and Wholes	Dynamic Equilibrium	Interaction
Feedback Loop	Autopoiesis	Responsive

Table 5.1 The properties of digital art systems.

During these two cycles of Theory-Create-Exhibit-Reflect these properties will be explored further in order to produce the *Framework for Connected Digital Artworks described* in Chapter 6.

5.4 The Interact Gallery

The Interact Gallery was a digital art gallery based in the Fabrika Independent Arts Centre in Leicester that ran between August 2011 and September 2012[12]. It was home to a rolling digital art exhibition and regular live events. From its inception it was intended to be an experimental space that would have a particular focus on art with a systems connection.

As I wrote in the introduction to the gallery on *The Interact Gallery* website (see Appendix II, included on the USB stick accompanying this thesis):

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[12] The Interact Gallery. http://www.seanclark.me.uk/static/interactgallery/ (retrieved 23rd August 2018).

The Interact Gallery started with my search for a space in which to exhibit the new artworks produced during my PhD research at De Montfort University. I have long felt that most galleries are not well suited to digital work due to lack of internal infrastructure and general inflexibility in accommodating technology and hadn't had much luck in finding a space that was both right for my work and available for an extended period of time.

Adam Kirk at Fabrika recognised the nature of my problem and suggested that he could modify his upstairs gallery according to my needs to become a new 'digital' gallery. Clearly, it would good to to consider using such a space for more than one exhibition and hence The Interact Gallery was born.

The gallery opened with an exhibition of artworks by myself on the theme of Art Systems that featured the existing artwork *ArtScanner*, two major new pieces *Memory Mirror aka One Living Thing* and *DropSketch*, a smaller new piece *Moving Pictures*, documentary materials related to *vLooper* and a new set of prints entitled *Reflections on Growth and Form*. A view of the gallery can be seen in Figure 5.1.

Figure 5.1 The Interact Gallery.

The solo exhibition ran for three months before pieces were gradually replaced by works from other artists. By the end of the one year period only *Memory Mirror aka One Living Thing, Dropsketch* and *ArtScanner* remained from the original exhibition.

In the attached Walkthrough Video (See Appendix II and the accompanying USB stick) I introduce the gallery space and discuss many of the artworks. I also talk about some of the ideas behind the development of my work at the time.

5.4.1 Memory Mirror aka One Living Thing

Memory Mirror is a development of the *vLooper* artwork with a more refined aesthetic and a gallery focus, rather than being aimed a performative space. It also has some properties in common with *Autopoiesis*, particularly when run in a configuration called *One Living Thing*. It takes the form of two large, vertically aligned monitors with a video camera placed between them and is powered by a mac Mini computer running the Max programming platform. An image of the piece can be seen in Figure 5.2, with additional images in Appendix II and a short video on the accompanying USB stick.

As with the the pieces *vLooper* (and *I See You* and *ArtScanner*) it begins as an empty vessel ready to be filled through viewer interaction. When a viewer walks in front of the artwork they are detected by the camera the user sees a highly stylised image of themselves. The image is intended to be dreamlike and playful to encourage the viewer to explore the visual effect and enjoy the experience. The effect was a combination of image processing and video feedback.
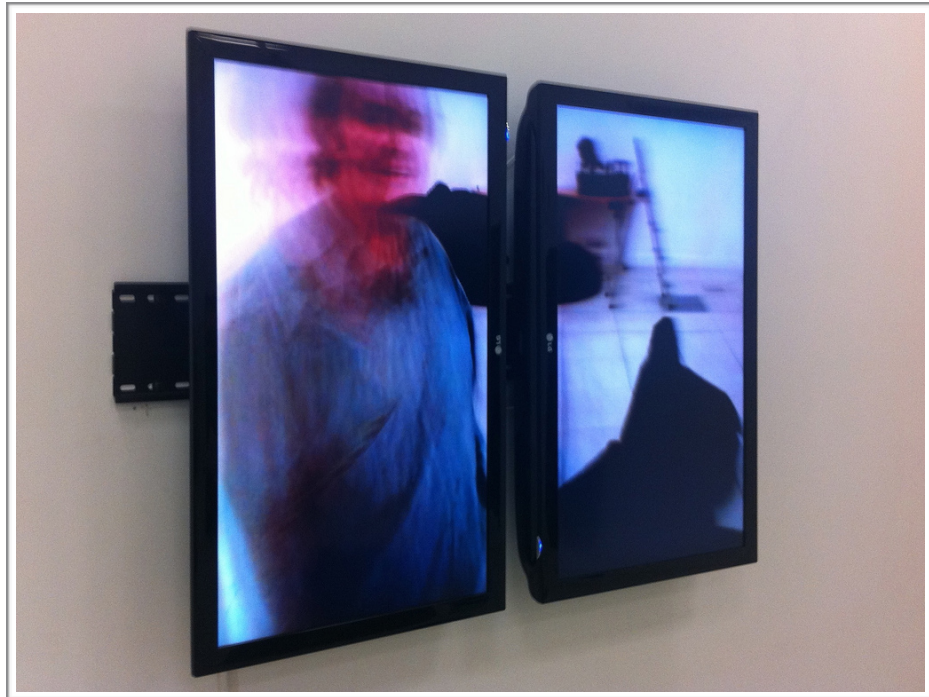
Figure 5.2 The *Memory Mirror* digital artwork.

As the viewer interacts with the work, they are also being recorded by the video camera. Viewers are warned prior to approaching the piece that their image may be recorded and become part of the artwork, but the nature of this recording is intentionally not made fully explicit at the start.

At some point during their interaction the viewer typically stands still for a short period of time. At this point the piece changes form showing a live image to showing recordings of previous viewers. Again, the videos were played back in a stylised way, with two recordings being mixed together at the same time to add to the dreamlike effect. After a period of showing the memories the screen fade to black in order to encourage the viewer to engage in further interactions.

The memories build up over time, resulting in many hundred recordings over a two or three week period. The first was first shown at the Phoenix Cube Gallery in Leicester in July 2011 and then at the Summer Sundae Music Festival in Leicester in August 2011[13], before being modified to become *One Living Thing* at the Art Systems exhibition at *The Interact Gallery* from September 2011[14].

In its *One Living Thing* configuration the artwork comes preloaded with video recording of natural footage – primarily trees blowing in the wind – that is mixed the the image of the viewer when the piece was running in the live, 'mirror' state. See Figure 5.3.

The title 'One Living Thing' was inspired by the Roman Emperor Flavius Claudius Julianus (c. 331 – 26th June 363 CE), also known as Julian the Philosopher or later by the Christian Church as Julian the Apostate, who wrote:

> "Is not the whole world one living thing — all and everywhere full of life and soul, perfect and made up out of parts likewise perfect?"[15]

This sentiment, very much part of a classical Romano-Greek school of thought about how the universe worked, perfectly captures the systems ideas being explored in this artwork and the others that formed part of the *Art Systems* exhibition.

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[13] Memory Mirror. http://www.seanclark.me.uk/memory-mirror (retrieved on 23rd August).

[14] One Living Thing. http://www.seanclark.me.uk/static/interactgallery/onelivingthing.html (retrieved on 23rd August, 2018, also on the attached USB stick).

[15] In "Upon the Sovereign Sun" (362). https://en.wikiquote.org/wiki/Julian_(emperor).

Figure 5.3 The One Living Thing variation of Memory Mirror.

The creation of *Memory Mirror* followed the process of reflection of the Foundation Work and therefore it was possible to construct it with clear systems-like properties in mind. The inputs are video clips captured by the camera, the output is the video screen, the boundary is defined by the physical extent of the artwork – the screens, the camera, the computer. Video material enters the artwork via the video camera, so it is an open system. When a viewer interacts with the artwork it responds, causing them to react, hence feedback was present.

There is an internal process present that combines the parts (video clips) and produces a whole that, while ever changing, has a strong sense of persisting over time. The work

self-constructs, and relationships between the parts are such that the whole retains its character even if all of the parts are different.

5.4.2 DropSketch

Dropsketch is a smartphone drawing system that enables users to anonymously create and share simple black and white sketches of their surroundings. The free app, available for iPhone and Android devices, contains an easy-to-use sketching tool and the facility to 'drop' completed sketches on a shared map. It makes use of the smartphone's built in positioning system to identify the location of the sketch. The app is used to drive the *Dropsketch Installation* that allows participants to interactively explore the ever-growing database of incoming sketches. It was first exhibited in the Interact Gallery in 2011 and later as part of the Creativity and Cognition conference and exhibition in Sydney in 2013 (Clark, 2013; included in Appendix V). Screens from the *Dropsketch* iPhone app are shown in Figure 5.4.

Figure 5.4 The *Dropsketch* iPhone app.

Whereas *Memory Mirror* built on the video pieces in the Foundation Work, *Dropsketch* was more related to *ArtScanner*. It's aim was to drive the construction of a geographically distributed set of interactions that would lead to the construction of a conceptual structure built of human relationships.

While notionally a drawing app, my primary goal was *not* to stimulate the construction of highly proficient drawings. Indeed, the drawing tool was extremely basic with only a black pen with four thicknesses, and eraser and an undo button. This simple approach to the creation of a drawing tool was inspired by work done in the early 1990s as part of the ROCOCO Project (Scrivener and Clark, 1994). The simplicity of the drawings can be seen in Figure 5.5.
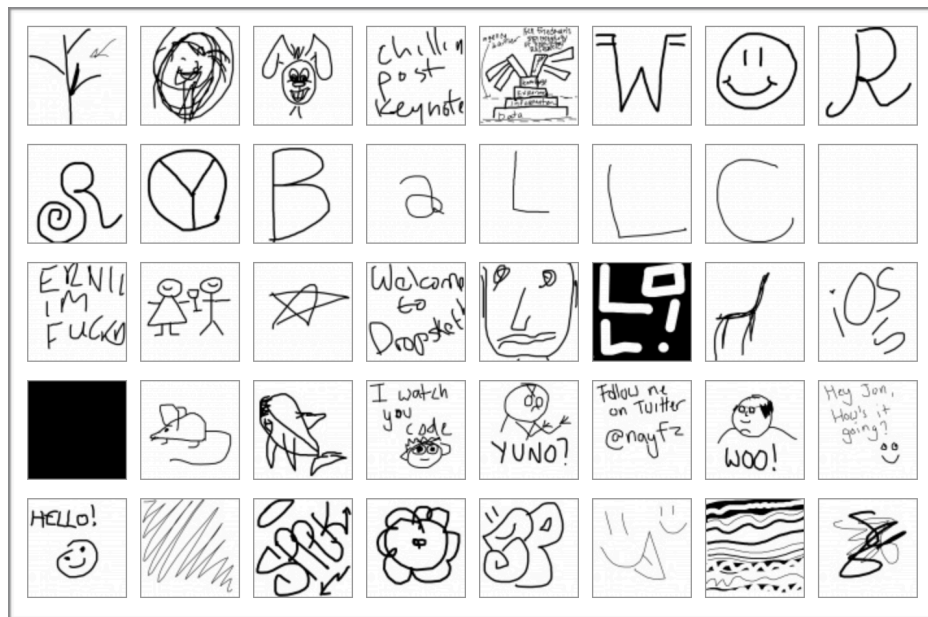
Figure 5.5 Simple drawings created as part of *Dropsketch*.

The drawings were primarily parts that would add to the *Dropsketch* whole. This whole could then be viewed as a feed of drawings make by all users of the app, or on a map. These views were available within the app itself, on a website (although drawing could only be made via the app), or at a *DropSketch* installation (an auto-updating kiosk view of the website).

The artwork was launched at the opening of *The Interact Gallery* in August 2011 and was soon featured in local news outlets, resulting in a steady growth in the drawings added. By the time the system was closed, with the app being removed from online stores in 2014, almost 1,500 drawing had been created.

As with *Memory Mirror aka One Living Thing*, *Dropsketch* was created following the reflection of the foundation work and so was made intentionally system-like. As mentioned above, the drawings were seen as parts, the *Dropsketch* system was the

whole, the website and installations had an aesthetic quality that would persist over time, despite new material being added as a consequence of it being an open system.

5.4.3. Moving Pictures

Moving Pictures represented a new creative direction compared the the above work. Still systems-based, and informed by the reflections on the foundation work, it took the form of a display with a 12 x 6 grid of symbols that rotated in response to the presence of the viewer. It was created for the Art Systems exhibition at *The Interact Gallery* and later shown as part of the *Intuition and Ingenuity* exhibition at Phoenix Cube Gallery in Leicester in October 2012[16].

When introducing the artwork in August 2011 on *The Interact Gallery* website (included on the accompanying USB stick) I wrote:

> "Moving Pictures" is my generic term for 2D images that respond to the viewer but don't incorporate their image. In this example you will find that the grid of shapes changes as you move in front of it. In turn the visual effects that appear to emerge change. The artwork encourages you to move in certain ways and requires your movement in order to reveal its true nature. Are you responding to the artwork or is the artwork responding to you? Moving Pictures are becoming a major strand of my artwork and at some point I will dedicate a whole exhibition to them.

The "true nature" of the work I was referring to was a hot spot the viewer could find that would lead to all of the symbols rotating in the same direction. The piece would

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[16] Intuition and Ingenuity. http://www.seanclark.me.uk/intuitionandingenuity (retrieved 23rd August 2018).

lead the view in identifying the best position to stand in and consequently I pondered, "Are you responding to the artwork or is the artwork responding to you?"

While the work had an input device – the camera – this was not used to grab material from the environment. Instead, the camera was solely used to trigger changes within the artwork. Therefore *Moving Pictures* represented the first closed system piece – open to 'energy' but not 'matter' – produced during this research programme.

5.4.4 Additional Artworks in the Solo Exhibition

For the opening of the solo exhibition at the Interact Gallery in August 2012 a version of *ArtScanner* was installed. There were also three sets of images. *Reflections on Growth and Form* was a set of images that gave an insight into my systems thinking at the time. These are shown in Appendix II. On *The Interact Gallery* website (included on the accompanying USB stick) I wrote:

> Throughout the development of the current phase of my work I have referred to the forms and patterns found in nature. From the self-organisation of growing ice crystals and leaves, through to the structures of plants and formation of clouds, nature demonstrates how complexity can emerge from often simple rules.

Memory Mirror Video and Images included video footage of *Memory Mirror* running at the Summer Sundae music festival (see Appendix II and the accompanying USB stick) in August 2011 and screen grabs from the gallery installation at Phoenix Square in Leicester in July 2011.

Active Mirror Prints was documentation from *vLooper* running at the Sparking The Imagination event at Phoenix Square in June 2011 (Section 4.3).

These additional artworks, together with *Memory Mirror aka One Living Thing*, *DropSketch* and *Moving Pictures* completed the *Art Systems* exhibition at *The Interact Gallery*.

5.4.5 Work by Other Artists

After three months as a solo show the work in *The Interact Gallery* was updated with work by other artists. A curatorial decision was taken not to simple replace all of the artworks with a new single exhibition but to gradually replace works as the opportunities presented themselves. A large number of pieces were shown over the year, two particularly interesting artworks – from the perspective of the development of the argument in this thesis - were Craig Clarke's *Simaesthesia* and Stuart Smith and Mike Gatt's *Sound Tree* (details on the website on the accompanying USB stick).

Craig Clarke's *Simaesthesia* is an interactive work. It consists of tubes of multicolour LEDs suspended from the gallery ceiling, a wide-angle video camera, speakers and a controlling computer. The wide-angle video camera monitors the space around the tubes and the computer generates light sequences and sounds in response to the participant's presence. The artworks can be seen in Figure 5.6.

Stuart Smith and Mike Gatt's *Sound Tree* takes the form of a wooden tree-like structure with numerous small speakers embedded on the branches. A computer algorithmically

generates a nature-inspired soundscape that plays back through the a multi-channel sound system connected the speakers. Each speaker plays a different part of the soundscape, creating a rich and engaging audio experience for the listener.

Figure 5.6 Simaesthesia (background) and *Sound Tree* (foreground right) at The Interact Gallery.

Stuart Smith and Mike Gatt's *Sound Tree* takes the form of a wooden tree-like structure with numerous small speakers embedded on the branches. A computer algorithmically generates a nature-inspired soundscape that plays back through a multi-channel sound system connected to the speakers. Each speaker plays a different part of the soundscape, creating a rich and engaging audio experience for the listener.

5.4.6 Interact Live Events

In addition to the exhibition, a series of live events and workshops were held at *The Interact Gallery*. These included four so-called *Interact Live* events, a *Bring Your Own Beamer* event and an international networked sound performance (details included on *The Interact Gallery* website on the accompanying USB stick). These took place both within the gallery and in the performance space in the gallery building.

Most significantly for the purpose of this thesis was the *Interact Live 2* event on the 13th January 2012. This event marked the launch of the *Simaesthesia* and *Sound Tree* artworks and coincided with a Max/MSP conference in Leicester and consequently it led to a very busy gallery with a great deal of active participation with the artworks.

In the *Interact Live 2* pictures in in Appendix II and video on the accompanying USB stick the layout of the gallery space can be seen, together with close-ups of some of the artworks in the space.

5.4.7 Interim Discussion

I wrote in the introduction to *The Interact Gallery* that its initial purpose was to provide a space for the exhibition of my new artworks, that went on to be called the *Art Systems* exhibition. At this point I was still thinking of the exhibition as a collection of individual artworks related to a common theme.

The first reflective outcome of this activity was an early realisation that the gallery itself was a system and that I would need curate it as such. Rather than thinking in terms of

multiple exhibitions and artworks, I soon introduced the "rolling" exhibition concept where artworks would be replaced over time, maintaining the gallery whole whilst changing the artwork parts.

Interactions both *within* the gallery and *outside* of it drove the development of *The Interact Gallery* art system with participants being attracted by the activities that took place within the boundary of the gallery by other participants and associated publicity.

Secondly was the realisation that interactive artworks can interact with each other as well as their human visitors. This insight was initially driven by my reflection on a single image from the documentation of *One Living Thing*.
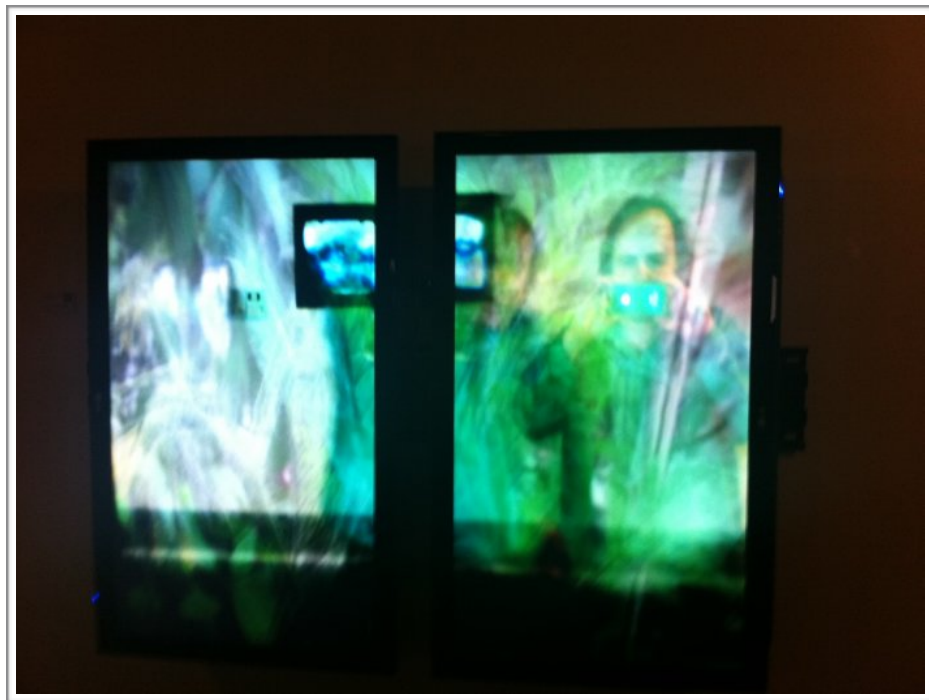

Figure 5.7 An image of a viewer and another artwork in *One Living Thing*.

As can be seen in Figure 5.7 not only is my own image present in the artwork whilst I am taking the photograph, but an image of another artwork is also visible (the rectangular screen spit across the two parts of *One Living Thing*). Moreover, even when there was no human participant present there was often sufficient movement on the other artwork screen to trigger a change in mode from mirror to playback mode within *One Living Thing*.

I observed further examples of this during the *Interact Live 2* event. Craig Clarke's *Simaesthesia* piece dominated the gallery visually. It's bright coloured LEDs illuminated the room such that any artwork that used a video images from the space would be influenced by it. As could be seen earlier in Figure 5.6, *One Living Thing* – which normally presents a largely green image due the the foliage video footage used – has taken on a blue palette due to the blue light from *Simaesthesia*. The colour relationship is actually more complex than this image suggests, since *One Living Thing's* internal process holds on to the captured footage for a long period of time. But the observation of one artwork influencing another is still valid.

Interactions also occurred in the sound space in the gallery. *Sound Tree* was the dominant auditory artwork and its presence altered how the gallery sounded. This was particularly the case with *Simaesthesia* whose more gentle sound was largely obscured in the gallery until the *Sound Tree* volume was reduced.

These later reflections led to a third realisation. Not only can digital artworks trigger changes in each other, but they can also intentionally exchange multimedia materials between them.

I reflected further on the relationships between parts and wholes, particular following the realisation that the gallery is a system and that a digital artwork can be systemically connected with another and concluded that the identification of parts and wholes within a digital art system is arbitrary and fluid. This is in fact a principle within the theory of Autopoiesis – it is the "act of distinction" that creates the boundary around a set of interacting parts to identify a whole (Maturana and Varela, 1998). What defines the boundary between one artwork and another? Why should this be fixed? Might two artworks come together and combine to be presented as a single artwork?

Finally, I observed that art systems composed of interacting artworks by different artists were not only possible, but seemed to result in more interesting artworks – so long as they were configured to coexist with rather than dominate each other. The presence of *Simaesthesia* in the gallery space added interest to the images produced by *One Living Thing* and *Sound Tree* enhanced the sound of the gallery, so long as it was not over loud.

Interestingly, *DropSketch*, while seen as a key artwork within this study, did not seem to generate the same level of insight as the other pieces. In retrospect this would seem to be as least in part down to the fact that it was not able to exchange triggers or materials with the other works. While an open system in terms of being able to accept new materials from participants, it was effectively a closed, or even isolated, system in the context of the gallery as a whole.

5.5 Principles of Digital Art Systems

A new set of new Principles of Digital Art Systems can now be described. As with the properties identified following the Foundation Works, these will feed in to the *Framework for Connected Digital Artworks* described in Chapter 6. The Principles of Digital Art Systems are summarised in Table 5.2.

1	The gallery itself is a system.
2	Interactive artworks can interact with each other *as well as* their human visitors.
3	Not only can digital artworks trigger changes in each other, they can also exchange multimedia materials.
4	The identification of parts and wholes within a digital art system is arbitrary and fluid.
5	Interacting artworks by different artists were not only possible, but can result in interesting artworks and exhibitions.

Table 5.2 The Principles of Digital Art Systems.

5.6 Symbiotic at Phoenix in Leicester

Over a one-year period *The Interact Gallery* had progressed my thinking from being based around individual artworks to that of collections of interacting artworks, potentially involving multiple artists. The following exhibition, entitled *Symbiotic*, took place at the Phoenix Cube in Leicester and enabled me to explore these ideas further.

The exhibition was a joint show between myself and arts collective Genetic Moo, who had participated in one of the I*nteract Live* events. Genetic Moo create interactive artworks with a strong living-systems aesthetic. Their work includes fully generative

pieces, as well as artworks composed of animated images of body parts. They were awarded the Lumen Founders Prize in 2013[17].

The work in the exhibition was co-developed over the summer of 2012 with regular discussion and meetings. We agreed that we would produce three artworks each that would be able to interact with each other and gallery visitors via sound, light and movement. Included work could be new, a reworking of a previous piece.

During the development of the new exhibition I presented a new term, that of the "digital art ecology". This term was used to describe a set of digital artworks that are able to interact with each other via their inputs and outputs. The term was intended to capture not only the ideas behind this particular exhibition but to begin to present the concepts in a way that could be communicated to a wider audience. In the introduction to *Symbiotic* on my website I wrote:

> Digital Art Ecologies are a new way of curating and exhibiting interactive digital artworks. Rather than seeing a collection of artworks as individual pieces – with no relationships or connections to each other – opportunities for interaction between them are sought out and encouraged. Like ecologies of living systems, the relationships between the parts can take many forms, but the most sustainable are those that are mutually beneficial, or in some ways 'symbiotic'.[18]

This contextualisation captures many elements of the five key observations made previously.

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[17] Lumen Prize Winners 2013. https://lumenprize.com/edition/edition-2013/ (retrieved 23rd August 2018).

[18] Symbiotic. http://www.seanclark.me.uk/symbiotic (retrieved 23rd August 2018).

The result of the development process between myself and Genetic Moo was a new collection of artworks with the ability to respond to each other. *The Whale*, *Red Spinner* and *Blue Spinner* were created by myself and Genetic Moo presented *Cockatoo Squid*, *It's Alive! Ants* and *Starfish*. An additional piece *Animalcules* was displayed outside of the main exhibition space to help attract people in to the gallery. The individual artworks are now described, followed by a detailed description of the *Symbiotic* digital art ecology.

5.6.1 The Whale

The Whale (see Figure 5.8 and Appendix II for more pictures) was an iteration of *Memory Mirror* created to fit within the *Symbiotic* environment. It was described to the audience as:

> *The Whale* searches the deep ocean for sources of light. It particularly likes bioluminescence colours of the *Cockatoo Squid*, but it will also feed on the reflected light from other creatures it comes across. The Whale never forgets, remembering previous encounters as it searches.

The colour palette of the piece was changed to give it a bioluminescent quality and the abstraction of the images captured was increased to resemble a dark undersea look. Additionally, when a large amount of motion was detected it would call out with a voice composed of edited whale song.

Figure 5.8 The Whale.

5.6.2 Red Spinner / Blue Spinner

Red Spinner and *Blue Spinner* (see Figure 5.9 and Appendix II.IV for more pictures) represented a new class of screen/camera-based artwork. Both were light-responsive and required the generation of a feedback loop in order to construct themselves. As a viewer approached the artworks they would reflect enough light to the camera to wake the piece. The *Red Spinner* was particularly responsive to red light and the *Blue Spinne*r to blue light.

Both pieces responded to the presence of light by generating a spinning image in their preferred colour and producing simple sounds. As the viewer continued to approach the screen they would reflect this coloured light back to the camera and once the levels

reached a certain point the image would reach a maximum spinning state that the viewer could explore by move their hands or body near the artwork. The aim was to create a sense of being locked in a form of "embrace" with the artwork.

Figure 5.9 The *Blue Spinner.*

The artworks were described to the audience as:

> Red Spinner and Blue Spinner are simple colour responsive organisms that are activated by the presence of their particular colour. As the the amount of colour increases they becoming increasingly excited, making enthusiastic sounds and calls.

5.6.3 Cockatoo

Genetic Moo's *Cockatoo*, or *Cockatoo Squid*, was created especially for the *Symbiotic* exhibition (see Figure 5.10). Equipped with a camera and a microphone, a large rendered image of the creature would respond to its environment in two ways. Firstly, "chromatophores" on the creature's skin would change according to the colours it saw before it. A large animated eye would indicate what it was looking at before the changes took place. Secondly, it would sing back in its own voice any sounds that it heard in the exhibition space. The image would also move around the projected screen space to give it a sense of swimming underwater.
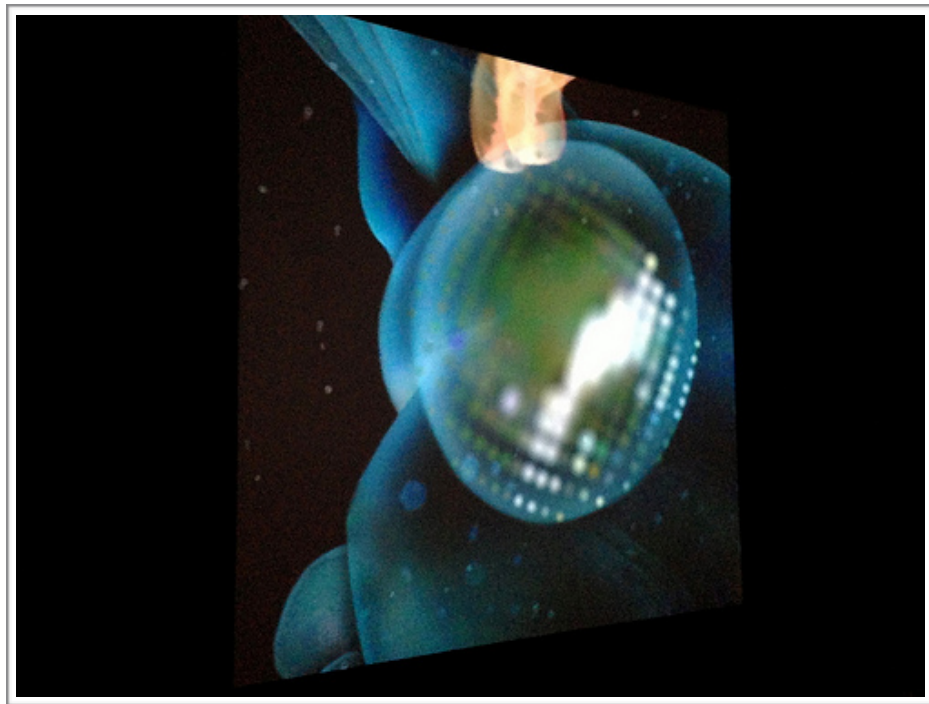

Figure 5.10 The *Cockatoo Squid* by Genetic Moo.

5.6.4 It's Alive! Ants

It's Alive! Ants was developed by Genetic Moo over a two year period. In this variation red and blue computer-generated ants, projected on a large screen, would grow and reproduce in response to coloured light detected by a video camera. The ants' colour preferences were indicated by a coloured circle, out of which they emanated.
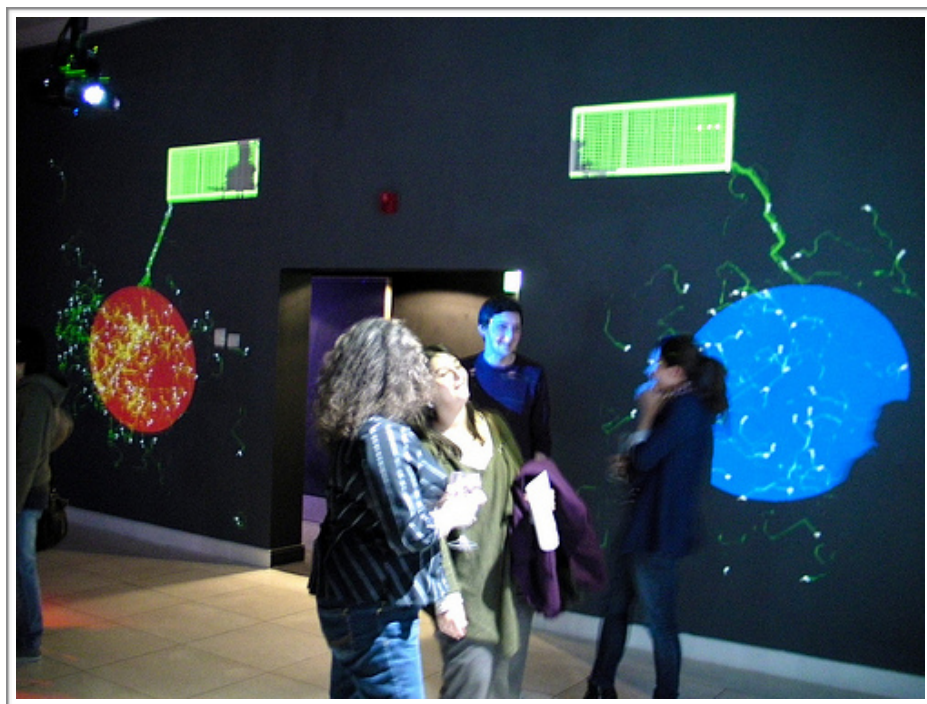

Figure 5.11 *It's Alive! Ants* by Genetic Moo

As the ants explored their environment in search for light they would leave pheromone trails behind them that would encourage other ants to follow them. As the environment changed the ants' attention would shift to different parts of the video image, resulting in a tangle of trails and ants being left behind.

5.5.5 Starfish

Genetic Moo's *Starfish* is one of their more classic animated pieces that enables the viewer to control an interactive 'starfish' with legs and body composed of images of human body parts. As the viewer approaches the artwork they discover that they are able to control the legs of the starfish using their own limbs. This is done using a Kinect sensor to recognise the human's body position.
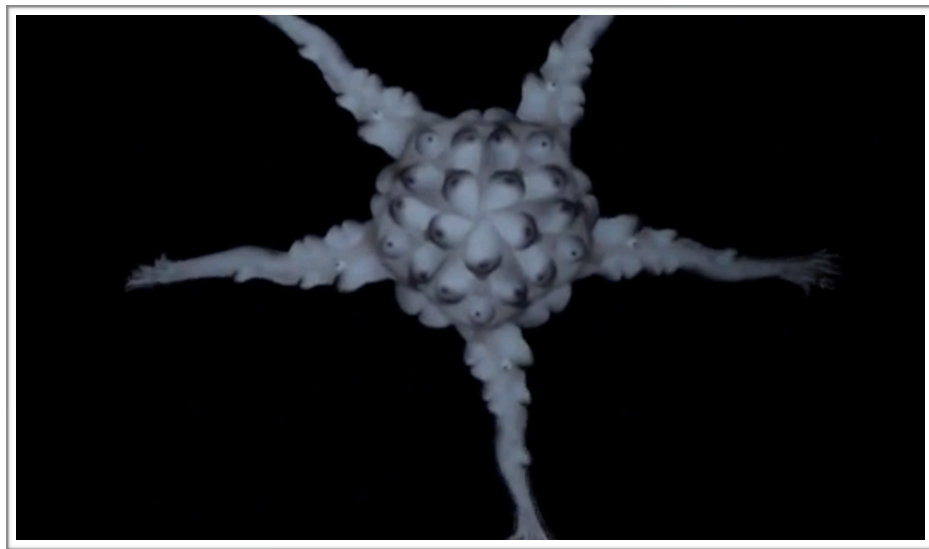

Figure 5.12 *Starfish* by Genetic Moo.

5.6.6 Symbiotic Exhibition

The *Symbiotic* exhibition was created to be seen as a complete system in its own right. Be that a single artwork composed of many parts, or a collection of artworks forming a coherent whole.

As such the layout of the exhibition was an important part of how it was intended to be perceived. As a viewer entered the exhibition space they were first attracted to the Starfish that was located on the wall directly across the room from the entrance. Either side of this were *Red Spinner* and *Blue Spinner*. On the viewer's left wall was *The Whale* and to the right was *Cockatoo*. One the wall either side of the entrance was *It's Alive! Ants*. The gallery was generally quite dark, but red and blue spotlights shone towards the floor. There are extensive pictures of the exhibition space in Appendix II and on the accompanying USB stick.

Figure 5.13 The *Symbiotic* exhibition.

Even without the presence of viewers, the exhibition space was rarely inactive. When standing outside of the exhibition entrance (as illustrated in the video below) it could be seen that while the spinners and *It's alive Ants* would go quiet when there were no people present the *Cockatoo* would generate enough light to occasionally activate *The Whale*, which in turn would generate sound and light that would cause the *Cockatoo* to respond by singing and generating a colour change.

As shown in the video discussed below, when a person entered the exhibition space *Symbiotic* would awaken and a number of addition connections would be made. If the

viewer activated the spinners then this would generate light that the would in turn activate *It's Alive! Ants*. By interacting with either *The Whale* or *Cockatoo* the viewer would inadvertently activate the other. Multiple simultaneous viewers would result in a multitude of interactions and responses.

This interactivity can be seen in the Symbiotic Walkthrough Video (Appendix II and on the accompanying USB stick) where at 0:57 the exhibition can be heard making sound without a viewer. Then as I enter the space the blue ants appear (01:24). The *Blue Spinner* starts (01:38) and I interact with *The Whale* (01:53). I then approach the *Blue Spinner* and it becomes more active (02:30) and I activate the feedback loop (03:00). I move to interact with the *Starfish* (03:25) and *Red Spinner* (04:00). This triggers the red light that activates the red ants (04:28). At 05:00 I move in front of the *Cockatoo* and we hear it responding to my whistle (05:47) and changing colour in response to to the environment (06:15). I then explain the *It's Alive! Ants* piece (06:50). At 07:06 I explain the difference between mine and Genetic Moo's artwork, making the point that their work is quite clearly living-systems based whilst mine is less obviously so. Throughout the video the exhibition can be heard and seen responding to my presence, as well as the artworks responding to each other.

5.7 Discussion

The work described in this chapter took place over an intensive two-year period of creative activity that included the production numerous of new artworks, exhibitions and live events. The reflective process following the *Art Systems* exhibition at *The*

Interact Gallery generated a number of valuable insights that went on to be explored further in the *Symbiotic* exhibition.

Symbiotic proved to be an important exhibition for Genetic Moo, because they used it as the basis of their *Microworld* series of exhibitions that have continued to explore the creation of digital art ecologies in many locations around the UK and worldwide[19].

The exhibition was successful in terms of exploring the stated creative and research goals in Sections 5.1 and 5.2. *Memory Mirror aka One Living Thing* had developed the *vLooper* and *Autopoiesis* pieces further and *Dropsketch* had presented a new form of multi-user artwork. The research process had uncovered the properties and principles of digital art systems that are presented in Chapter 6. However, it also pointed to quite a radical change in how I presented my creative work, as described below.

The creation of artworks that mimic the general system-like nature of living things is interesting to audiences, a demonstrated, for example, by Genetic Moo with the success of their *Microworlds*. However, the way in which the artworks were able to exchange materials and incorporate them in to their own forms was a different and important concept that the exhibition demonstrated.

This principle was identified in the reflection of the *Art Systems* exhibition (Section 4.5.3, Point 3) and written as "not only can digital artworks trigger changes in each other, they can also exchange multimedia materials". While this can be observed as happening in *Symbiotic*, most notably in the interaction between *The Whale* and

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[19] Genetic Moo. http://www.geneticmoo.com/ (retrieved 23rd August 2018).

Cockatoo, the complexity of the environment meant that the specific flow of content between artworks was not easy to track. In order to explore this idea more deeply the next phase of creative practice would look to clarify these interchanges.

This decision to focus on constant change and exchange of materials became the most significant outcome of my reflection on *Symbiotic*. Similarly, exploring this through a potentially less-complex audio-visual way would lead to a new phase of Theory-Create-Exhibit-Reflect that is described in Chapter 7.

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CHAPTER 6: A Framework for Connected Digital Artworks

Following the Foundation Works (Chapter 4) and the two cycles of Theory-Create-Exhibit-Reflect (Chapter 5) significant *properties* and *principles* of digital art systems have been identified. In this chapter these are developed further and presented as a Framework for Connected Digital Artworks.

This framework is composed of two main elements. Firstly, a set of Core Concepts and Terminology for describing the elements of connected digital artworks, and secondly, a Visual Notation for representing the connections, relationships and processes *within* and *between* such artworks.

The purpose of the framework is to provide a set of tools for developing a deeper understanding of the nature of a specific digital art system or of digital art systems in general. The tools enable a *systems analysis* of digital arts systems to be undertaken. Any analysis will always involve the person doing the analysis making decisions boundaries between systems and subsystems. Hence the results of an analysis of the *same* digital art system by two people may lead to different results.

As reported in Section 5.2.7, the boundaries between and within systems should be seen as fluid and will reflect the perspective of the viewers and participants and the intent of the artist.

Users of the framework may extend and rework it in order to create the most suitable set of tools for their intended uses. This flexibility does not undermine the core concepts the framework represents. Indeed, used in this way it serves to demonstrate the framework's value when making sense of digital art systems.

The framework is now presented in the form of a description of the Core Concepts and Terminology and the Visual Notation. Examples of its use with reference to the Foundation Works in Chapter 4 are provided, together with a detailed systems analysis of the two practice-based research cycles described in Chapter 5.

6.1 Core Concepts and Terminology

As identified in Chapter 2, systems theory and systems thinking has a wide variety of applications – from biological systems to economic and organisational systems. Across these disciplines the core concepts remain the same but the use of terms may be applied differently. The first contribution of the Framework for Connected Digital Artworks is a standard set of concepts and terms to be used when describing or reflecting on the nature of digital art systems.

The terms are divided into four sections: First, those related to core systems concepts; Second, those derived from the thermodynamic concepts of "energy" and "matter", both of which have a slightly different definition within this framework; Next, those related to structure and process and the concept of autopoiesis; Finally, those concepts and terms related to the creative exploration of the concept of connectedness.

The first set of terms relate to the different types of systems and their essential operation. It begins with an explanation of digital art systems, and then a description of the various human systems that can be connected with them – the artist, participant and viewer. The environment, the nature of boundaries, inputs and outputs are then explained followed by the definition of the term of feedback. These are shown below in Table 6.1.

1	Systems Concepts	
1.1	**Digital Art System**	A **digital art system** is any digital artwork that contains an **internal process** or is able to interact with its **environment**. The term "digital art system" can be used synonymously with "digital artwork". However, I reserve its use to descriptions of the interactions between the digital artwork and other systems in its environment. Hence, digital artwork *X* might be described as the *X digital art system*, or simply *X system* when its systems context is taken in to account.
1.2	**Artist**	The role of the **artist** within the **digital art system** is to define its parts, wholes and processes and to direct its aesthetic development. The artist should be seen as a system in their own right and an intimate part of the digital art system. The artist may set up the digital art system and then retreat from it or remain actively involved in its development.
1.3	**Participant**	Within a **digital art system** a **participant** is actively involved in the realisation of the artwork and its development. Participants are seen as systems in their own right and an intimate part of the digital art system.
1.4	**Viewer**	A **viewer** is a passive **observer** of the **digital art system**. While they are systems in their own right, they do not influence the development of the artwork in any way.

1.5	Environment	The **environment** is the physical and conceptual space in which the **digital art system** operates. It includes the exhibition space, other artworks, the **viewers**, the **participants**, the **artists** and all **connected** spaces. From the perspective of any system, the **external environment** is everything that is not part of itself.
1.6	Boundary	The **boundary** marks the dividing point between a **system** and its environment. The boundary may be physical or conceptual. Boundaries can also be fluid, depending on the perspective of the participant, viewer or intent of the artist. Boundaries cam be **semi-permeable**, allowing selected **matter** or **energy** (defined below) to pass through. A digital art system may contain **subsystems** that themselves contain boundaries.
1.6	Inputs and Outputs	**Inputs** are any materials - **matter** or **energy** - that can enter the digital art system. **Outputs** are any matter or energy that can be released by the **digital art system**. Importantly, the output from one system may become the input of another.
1.7	Feedback	**Feedback** occurs when an **output** of a **digital art system** connects back to its **input**, either directly, or by passing through one or more other systems. The **feedback loop** can involve **matter** or **energy**. All digital art systems are like to have, at least, a feedback loop involving their participant or participants.

Table 6.1 The core systems concepts within the *Framework for Connected Digital Artworks*.

As discussed in Chapter 2, in thermodynamic theory, open, closed and isolated systems are defined by their ability to exchange matter or energy with their environment. A distinction between "multimedia material" and "external triggers" is made in the Framework for Connected Digital Artworks. Multimedia materials are seen as matter that can enter the digital art system and the external triggers are seen as energy. Table 6.2 presents this terminology.

2	Matter and Energy	
2.1	**Matter**	**Matter** refers to all **multimedia material** that is able to enter the **digital art system** and add to its **internal structure**. This may be captured by sensors monitoring the physical **environment**, or enter the system in other ways, such as via a computer network. Digital art systems may release matter in to their environment where it may persist prior to entering another digital art system.
2.1	**Energy**	**Energy** is any external stimulus, or **trigger**, that is able to pass through the boundary and prompt a change within the **digital art system** but does not add to the **internal structure**. This may include representations of viewer interaction, or data captured from sensors. Digital art systems may also release energy in to their **environment** to trigger changed in other digital art systems.
2.2	**Open, Closed, Isolated**	A **digital art system** is regarded as **open** if it allows both matter and energy to pass through its boundary. It is **closed** if it allows energy but not matter to pass and **isolated** if it allows neither matter or energy to pass through. Digital art systems can be **observed** by a **viewer** no matter what type of system they are.

Table 6.2 Defining energy and matter and open, closed and isolated systems.

An important principle relating to the use of these terms is that a viewer, participant or artist is able to observe the state of a digital art system – be it visually, or via other means – without that system necessarily being open. Hence, within this framework even an isolated digital art system can be exhibited as an artwork and observed by a viewer.

All digital art systems are observable. However, multiple digital art systems grouped inside a boundary may not be *individually* observable by a viewer *outside* that boundary.

The viewer may only be able to observe a representation of the whole, not the parts. Additionally, a viewer, or any other system, cannot be inside two *overlapping* boundaries. For example, a visual generative artwork may be isolated but still observable by a viewer. If the viewer is able to trigger changes in the artwork it will have become closed and the viewer will now be a participant. If multimedia materials are able to enter the artwork it will be classed as open. Even if the processes within the generative artwork can be represented as a set of interacting parts, the viewer need not be made aware of them and may be presented with a single image, representing the whole.

When considering the open/closed/isolated state of a digital art system *all* inputs and outputs should be considered. Even if the viewer is not able to generate inputs, there may other sources of matter or energy.

The next set of terms relate to the presence of pattern and process within the digital art system. Digital art systems are often dynamic – changing over time. They need to have an internal structure that will persists even when the parts change. Without a coherent pattern of organisation the artwork may enter a state where it ceases to be the intended artwork. Similarly a digital art system needs an internal process, or process of organisation, that rearranges the parts in response to inputs and outputs in order to maintain the pattern of organisation. The identification of these two concepts is a central part of the *Framework for Connect Digital Artworks*.

The identification of dynamic equilibrium, when process of organisation is able to maintain a stable pattern of organisation in response to inputs an outputs follows on

from this. Likewise the concept of the autopoietic artwork, where the process and pattern of organisation are mutually defining. This final concept is hypothetical and is discussed in more detail in Chapter 9.

3	Pattern and Process	
3.1	Pattern of Organisation	The **pattern of organisation**, or **internal structure**, is the set of organisational rules - defined by the **artist** - that the **digital art system** must follow.
3.2	Process of Organisation	The **process of organisation**, or **internal process**, are the processes - defined by the **artist** - by which the digital art system is able to reorganise its structure in order to maintain its **pattern of organisation**. If these processes fail then the system is likely to cease being the artwork the artist intended.
3.3	Dynamic Equilibrium	**Dynamic equilibrium**, or **homeostasis**, is the state in which the process of organisation is able to maintain a stable pattern of organisation by responding to **inputs** and producing **outputs**. When in this state the artwork persists as a whole despite the individual parts forever changing.
3.4	Autopoietic Artwork	**Autopoiesis** (self-creation) is a term used by Maturana and Varela to describe a system capable of producing and maintaining itself. A digital art system would be autopoietic if its **internal structure** and **internal process** were mutually defining. In the context of this thesis the **autopoietic artwork** is regarded as hypothetical although it is discussed further in Chapter 9.

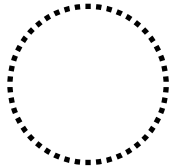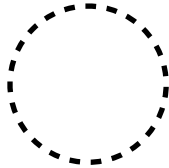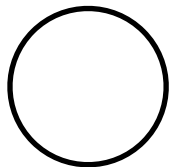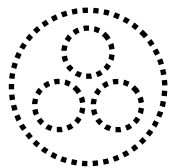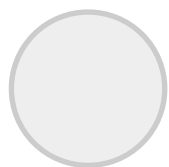**Table 6.3 Pattern and process within the *Framework for Connected Digital Artworks*.**
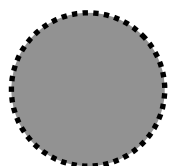
Finally, the connected digital artwork is defined together with its key property, that of connectedness, and its collective term, the digital art ecology.

4	The Connected Digital Artwork	
4.1	**Connected Digital Artwork**	The **connected digital artwork** is a **digital art system** that engages with the ideas and concepts contained within this framework and demonstrates a high degree of **connectedness**.
4.2	**Connectedness**	**Connectedness** is the core concept of the **connected digital artworks**. We ask questions relating to the world around us, including, but not limited to, "What is connectedness?", "Is there such a thing as a connected aesthetic?", "How do the connections seen in the natural world relate to those in the human-made world?". These are discussed further in Chapter 9.
4.3	**Digital Art Ecology**	A **digital art ecology** is the term for a collection of connected digital artworks in which **inputs** are connected to **outputs** and the artworks are entangled such a way that they are mutually supporting.

Table 6.4 Definitions of the connected digital artworks, connectedness and a digital art ecology.

6.2 Visual Notation

The second stage in applying the Framework for Connected Digital Artworks is to use the visual notation to map the systems, connections and flow of matter and energy. First, a representation of open, closed and isolated digital art systems is provided. Then there is a representation of collections of systems (super-systems) and subsystems. Next, the various types of human system are shown. These are all presented in Figure 4.5. This collection of representations a set of tools to enable the systems and boundaries associated with the digital art system to be identified visually. Systems can be labelled to provided clarity where needed.

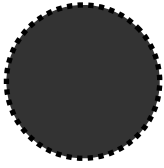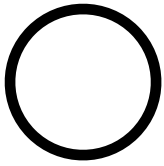| 5	Representing Systems	
5.1		**Open Digital Art System**. An open digital art system is represented by a dotted boundary. Both matter and energy can pass in through the boundary and energy and/or matter may pass out.
5.2		**Closed Digital Art System**. An closed digital art system is represented by a dashed boundary. Energy can pass in through the boundary and energy may pass out.
5.3		**Isolated Digital Art System**. An isolated digital art system is shown as a solid boundary. No matter or energy can pass in or out of the boundary.
5.4		**Subsystems / Super-systems**. Systems can be shown as forming a larger system by placing an additional boundary around the group. Depending on perspective, these may be seen as **subsystems,** or **components,** of a whole, or the whole is a **super-system** of resulting from interactions between **digital arts systems**.
5.5		**Viewer.** A viewer is represented as a light-grey system with a solid mid-grey order. It may not always be necessary to show viewers, particularly if the **digital art system** involves active **participants**. There may be multiple viewers with different perspectives for which identification is valuable during the analysis of the digital art system.
5.6		**Participant**. Participants are represented as mid-grey systems with either a dotted or dashed **boundary** (depending if they are a source matter or energy).. There may be multiple participants within the digital art system who take on different roles within the artwork.

5.7		**Artist**. The artist or artists are represented as a dark grey system with either a dotted or dashed **boundary**. If may not be necessary to identify the artist if they do not play a role in the development of the **digital art system** once it has been created.
5.8		**Environment**. The environment contains all of the systems associated with the digital art system. It is shown as an isolated system with a double thickness boundary.

Table 6.5 The visual representation of systems in the *Framework for Connected Digital Artworks*.

Unlike digital art systems, viewers, participants and artists can be represented in multiple locations in the visual notation in order to uncover interactions that may occur in different places in an exhibition. Human systems can pass through the environment boundary to enter the digital art system.

By placing one system inside another, a flow of matter or energy is suggested by the nature of the enclosed system's boundary. In a rudimentary systems analysis it may be sufficient to simply identify that this is the case.

However, to gain a deeper understanding of the flow, a set of directed paths can be used to show the type of few (energy and/or matter) and direction. Dotted lines are used to show a flow of both matter and energy and dashed line to show the flow of energy only. A light grey solid path indicates the observation of the system by a passive observer. These different types of path are illustrated in Figure 6.6.

Paths can pass through system boundaries and continue through to subsystems unchanged. Alternatively, they may pass through a boundary and be sent to multiple

subsystems in different forms. For example, a video stream may enter a digital art system and then pass unprocessed to a subsystem as matter, as well as becoming a source of energy for a different subsystem that does not accept matter.
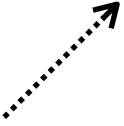
6	Representing the flow of Matter and Energy	
6.1		**Flow of matter and energy**. A dotted arrow indicates the direction of flow of multimedia materials (matter) from one system to another. If there are multiple sources of matter then these would be shown as multiple arrows connecting to the destination system.
6.2		**Flow of energy only**. The flow of external triggers (energy) is represented by a dashed arrow. A destination system may receive triggers from multiple source systems as well being a source of triggers for other systems.
6.5		**Observation**. While it is expected that all digital art systems are observable, it can be useful to explicitly identify what an observer may be able to view – particularly when multiple digital art systems are observable at any one time by different viewers. The line goes from the system being viewed to the viewer.

Table 6.6 Representing the flow of matter and energy.

The final part of the visual notation allows a distinction to be made between static and dynamic systems. A static artwork, such as a digital print or 3D printed object, may be presented as part of an exhibition (such as *The Interact Gallery* in Chapter 5) and insight may be gained by including them in the systems analysis.

While both a static and dynamic artworks will have a pattern of organisation and internal structure (the artworks will be composed of parts organised in a certain way) only the dynamic artwork will have a process of organisation. If a given artwork is

dynamic then arrows are placed on it's system boundary. This also applies to an isolated system since, even through it may not be able to exchange matter or energy with the environment or other systems, it can still be observed by a viewer. The addition of arrows to a boundary indicate an internal process is shown in Table 6.7
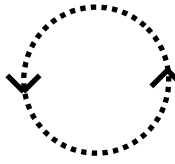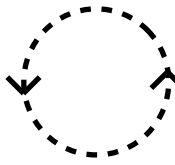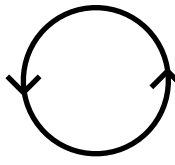
7	Representing Pattern and Process	
7.1		An **open digital art system** with a **process of organisation**. All open systems will have at least a rudimentary process of organisation - otherwise their pattern of organisation would be lost amongst the inputs or outputs.
7.2		A **closed digital art system** with a **process of organisation**. All open systems will have at least a rudimentary process of organisation - otherwise their pattern of organisation would be lost amongst the inputs or outputs.
7.3		An **isolated digital art system** with a **process of organisation**. Even though an isolated digital art system does not allow **matter** or **energy** to pass through its **boundary**, the result of the internal process may be visible to an observer. The outer most isolated system – the **environment** – should not be shown with boundary arrows since there cannot be an observer. If it was, however, introduced in to another environment as an isolated system then arrows would be added.

Table 6.7 Representing pattern and process.

Labels and annotations should be used with the visual framework in order to clarify the systems and connections identified. The user may also undertake multiple cycles of analysis from different perspectives as part of their process.

6.3 Applying the Framework

Having familiarised themselves with the core systems concepts and terminology in Section 6.1, a user of the framework can then begin to map out the systems and connections within a digital art system. A series of such mappings applied to hypothetical and real artworks is now presented.

The first five examples (Sections 6.3.1 – 6.3.5) deal with single digital art system communicating with one or more humans – viewers or participants. The examples in Sections 6.3.6 and 6.3.7 deal with more complex digital art systems (the *Autopoiesis* and *ArtScanner* artworks from Chapter 4). In all of these cases the artist is not seen as an active part of the *development* of the artwork, so is not explicitly shown.

6.3.1 A Print of a Digital Artwork

If a digital artwork is static, then it can be shown as an isolated system without an internal process, this is shown in Figure 6.1. The viewer is able to observe the artwork within the environment, but not exchange matter or energy with it. The *Reflections on Growth and Form* and *Active Mirror* prints described in Section 5.3.4 can be represented in this way.
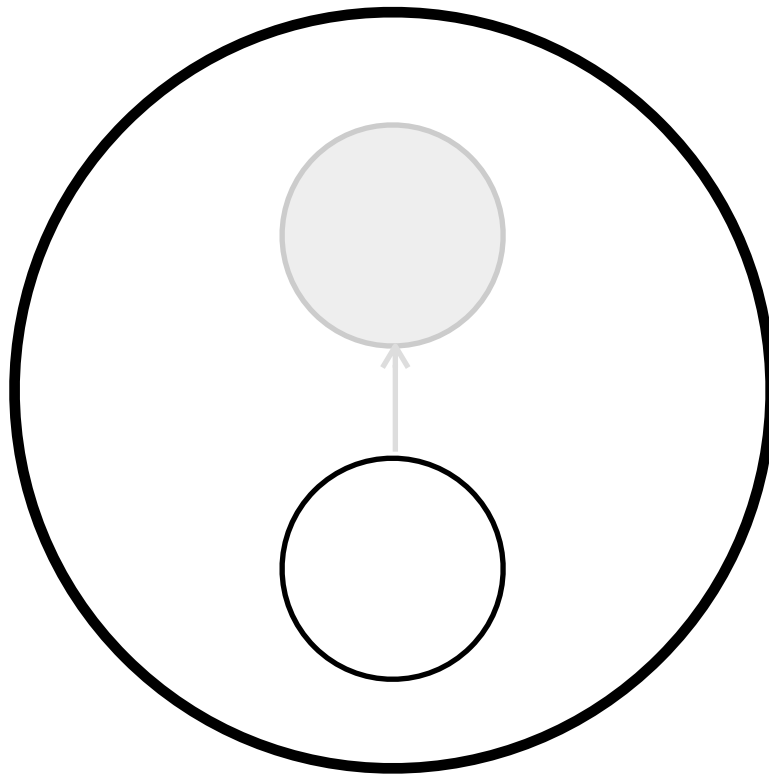

Figure 6.1 A print of a digital artwork.

6.3.2 A Generative Artwork

Figure 6.2 shows how a generative artwork can be presented. The artwork is still isolated, and the viewer is not able to exchange matter or energy with it, however the generative artwork has an internal process that is shown by adding the arrows to the system boundary. The viewer can observe the results of the internal process.

Time-based artworks, such as videos of music, should also be seen as containing an internal process – despite this process being pre-generated. Hence they they too should be represented as a system with arrows on their boundaries.
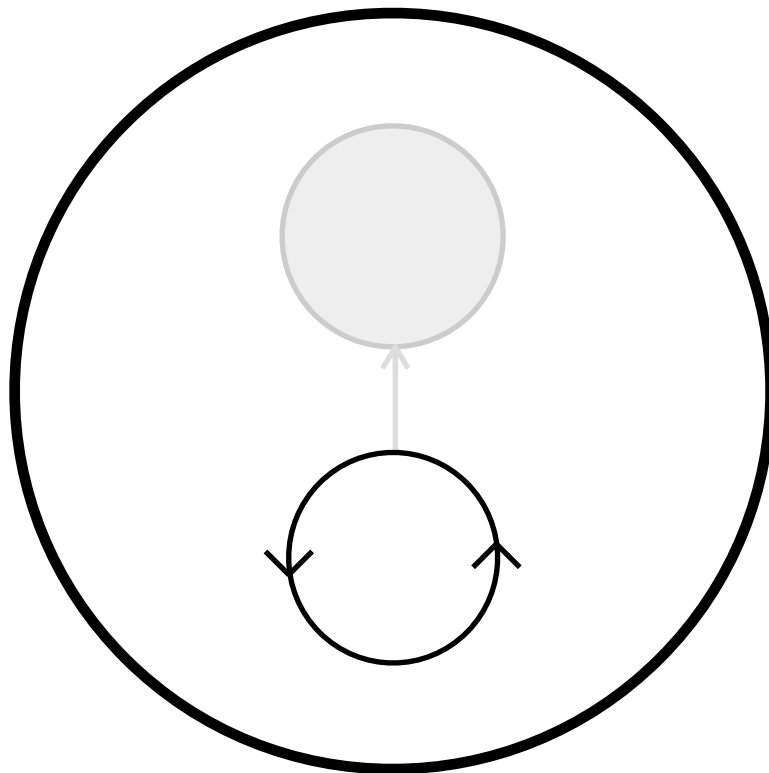
Figure 6.2 A generative artwork.

6.3.3 A Generative Artwork with an Environment Sensor

In Figure 6.3 the generative artwork now is able to respond to an environmental trigger, such as a light sensor. The generative process is influenced by the environment but multimedia materials cannot enter, so it is classified as closed and now has a dashed boundary. A dashed line showing the input of environment triggers has been added. If the viewer was able to control the input of the light sensor then this artwork would become more like Figure 6.4.
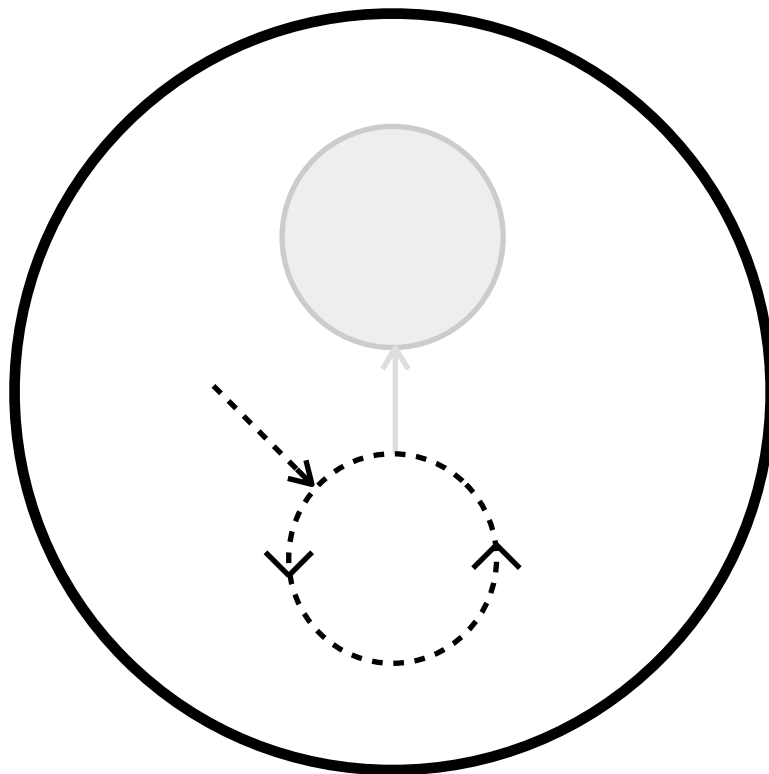
Figure 6.3 A generative artwork with a light sensor.

6.3.4 A Responsive Artwork

Figure 6.4 shows an artwork when the viewer has become a participant and is able to trigger changes within the digital art system. These changes are show to the participant, who can then react to them and generate new triggers. The artwork still closed (to matter) but a feedback loop is now present in which the participant and digital art system respond to each other. This describe the artwork *Moving Pictures* in Section 5.3.3. Note that the path from the artwork to the participant is dashed.
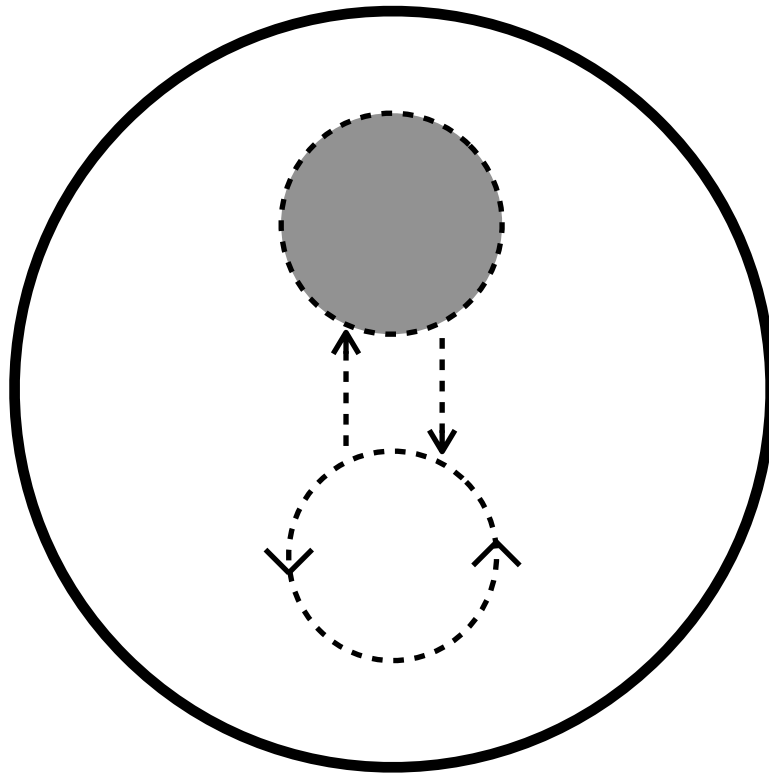
Figure 6.4 A responsive artwork.

6.3.5 An Interactive Artwork with an Audience

Next, in Figure 6.5 an analysis of an interactive artwork such as *I See You* or *vLooper* (described in Sections 4.1 and 4.3) is presented. The participant is now identified as open since they send matter (in the form of video images) to the digital art system, hence both systems have dotted boundaries and connecting line from the participant to the artwork is dotted. The participant receives triggers in return (dashed line). These may influence the behaviour of the participant and hence are another example of feedback. In addition, a viewer, or viewers, may observe this interaction from afar without exchanging matter or energy with the artwork.
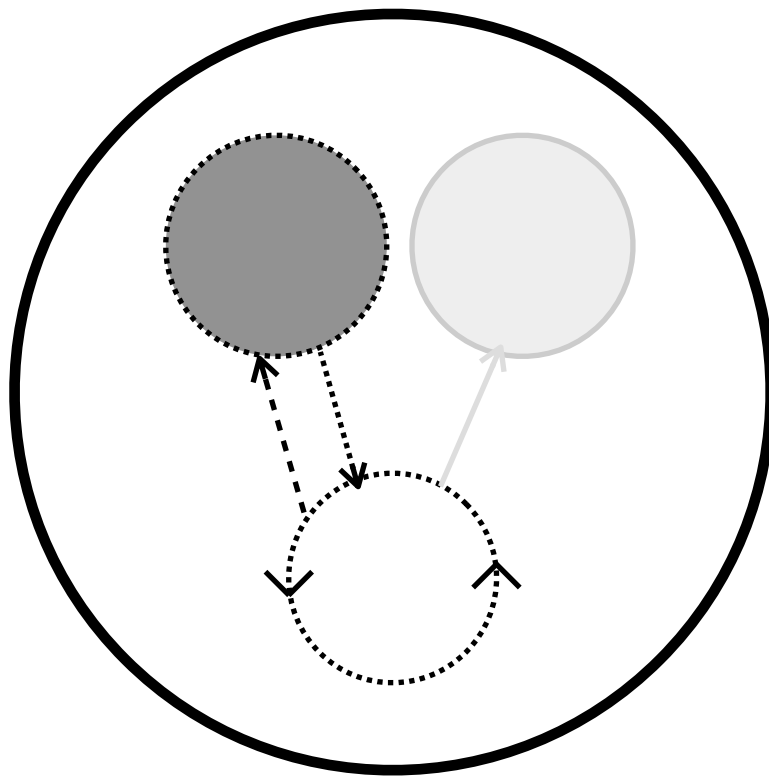
Figure 6.5 An interactive artwork with participants and viewers.

6.3.6 Autopoiesis

The *Autopoiesis* artwork is described in Section 4.4. It consists of two banks of images that respond to movement in front of work and an interactive element that constructs a live collage using video images from an attached camera. When presented using the framework as the *Autopoiesis Digital Art System* in Figure 6.6 the artwork is seen as consisting of three subsystems bounded within a single digital art system. The viewer is an active participant the development of the artwork, contributing matter to the collage and energy to the image banks.

Figure 6.6 A representation of the *Autopoiesis* digital art system.

The *Autopoiesis* digital art system may appear to the participant as the same as the artwork shown in Figure 6.4. The systems analysis allows the nature of the subsystems to be examined in more detail. The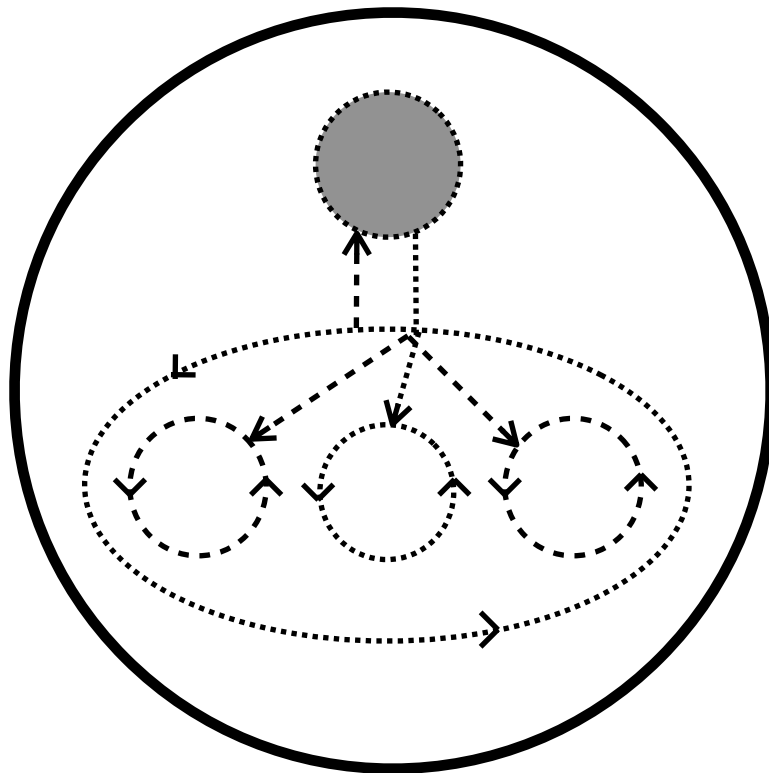 flow of matter in to the digital art system from the participant is shown to split in to a stream of multimedia material to the central collage and triggers for the left and right image banks. If identifying this split was not felt to be necessary by the person doing the analysis then the connecting lines need not be shown and the nature of the connections inferred by the type of boundary shown (dotted or dashed).

The boundary around the three components of the digital art system is shown as having a process in its own right. This process involves the distribution of inputs to the subsystems and the collection of outputs for presentation to the participant.

This presentation of the *Autopoiesis* artwork provides insights in to how the artwork is structured that would not be immediately apparent to a participant. For example, the fact that the artwork is composed of three main systems is not explicitly explained to a viewer of the artwork. However, it is a key part of how the work is composed. While it may not be necessary for a participant to know this in order to appreciate the artwork, it offers insights about the deeper structure of the artwork.

6.3.7 ArtScanner

ArtScanner (see Section 4.2) is another digital art system that can be broken down in to subsystems for the benefit of more detailed understanding. In this case different roles by the participants can also be highlighted using the framework, as can the relationships between the image uploading process and the installation-based barcode scanning process. This system is shown in Figure 6.7 and is annotated to make it easier to for the interpretation to be understood.
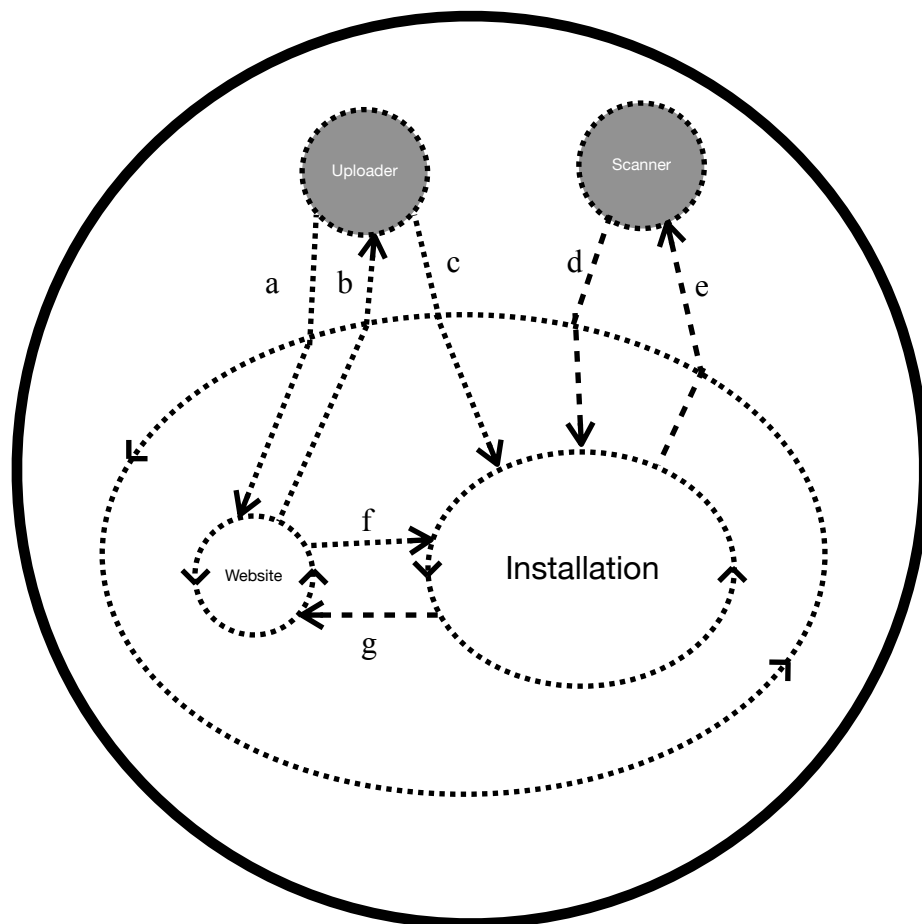

Figure 6.7 An analysis of *ArtScanner*.

In the analysis of *Autopoiesis* two types of participant can be identified – the "Uploader" and the "Scanner". The Uploader is someone who uploads work in to the system in exchange for a barcode. The Scanner is a person who visits the installation and scans a barcode in order to retrieve an image, Both interact with the digital art system, but in different ways. Path a shows the upload of images in to the Website part of the artwork by the Uploader. In return the participant is given a barcode, this is shown as Path b. Path c shows the Uploader placing the barcode at the installation site.

The second type of participant, the Scanner, is then able to scan the barcode (Path d). This causes the Installation to request the appropriate image from the website (Path f) and then incorporate it within the installation (Path g). Finally, the change in the installation generates a trigger (Path e) that causes the Scanner to scan a new barcode, and so on. The use of a dashed line connecting back to the Scanner emphasises that the Scanner is expected to respond to what they see by generating another trigger. This is an another example of a feedback loop.

6.4 An Analysis of The Interact Gallery

The Interact Gallery exhibition (Section 5.3) provides a more complex set of interactions and relationships than the previous artworks. As identified in Section 5.3.7, it was observed that were (unintended) interactions between a number of artworks and viewers in different locations. The purpose of the analysis, below, is to investigate these further.

The first step in applying the Framework for Connected Digital Artworks is to identify the various systems involved in the exhibition as a whole. Figure 6.8 captures a stage in the exhibition where Craig Clarke's *Simaesthesia* was installed (as described in Section 5.3.5), together with *Memory Mirror aka One Living Thing*, *Moving Pictures*, *ArtScanner* and various prints and a video. The placement of the artworks within the environment matched the physical layout of the exhibition.

The two sets of prints are shown as isolated systems without internal processes. The prints could be further expanded as in Figure 6.1. *Moving Pictures* is also isolated, but contains a process, so has arrows on its system boundary. This system could be expanded as in Figure 6.4, showing an internal feedback loop based on the exchange of energy between the artwork and the participant. The video is isolated but can be observed.

ArtScanner has already been analysed and is shown in Figure 6.7. It is not able to interact with the other works in any way, but unlike the prints it has an internal process so is shown as an isolated system with arrows indicating that it has an internal process. The three remaining works – *Simaesthesia*, *Memory Mirror aka One Living Thing* and the video – are shown as isolated for now and are the focus of the next analysis.
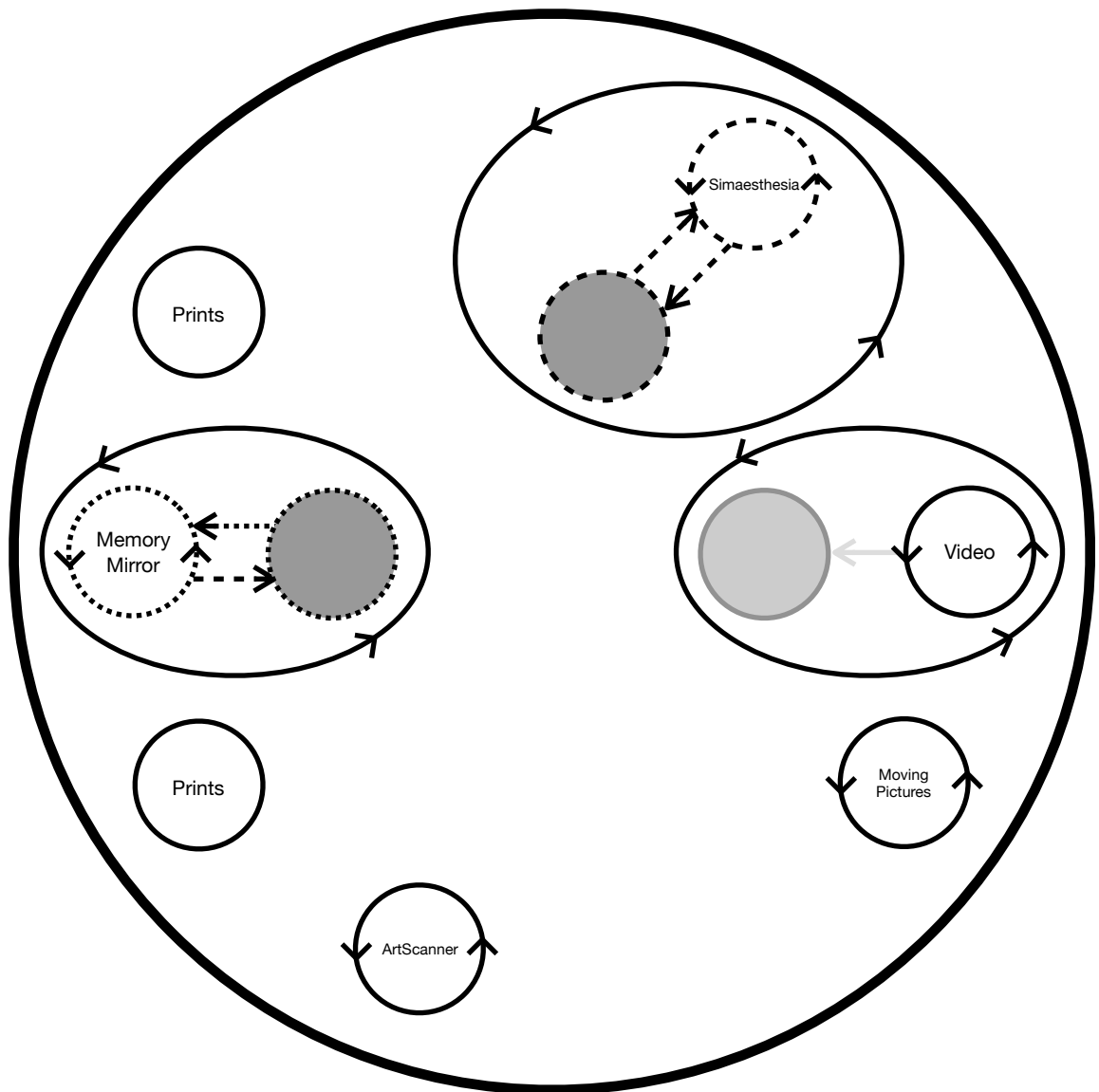
Figure 6.8 An initial systems analysis of *The Interact Gallery*.

The observations in Chapter 5 revealed that the artworks in *The Interact Gallery* exhibition art were not in fact isolated. This can be seen in Figure 6.8. The prior observation in Section 5.3.7 that *Memory Mirror* incorporated images of the video artwork across the gallery introduces a path of matter from the video to *Memory Mirror*.

This is represented as Path b. Similarly, a viewer of the video may also inadvertently become part of *Memory Mirror.* Hence the viewer in Figure 6.7 turned into a participant in Figure 6.8 and Path c is added.

Now focusing attention on Craig Clarke's *Simaesthesia*, it was also observed in Section 5.3.7 that colour responses triggered by its viewers were also captured and incorporated in to *Memory Mirror*. This leads to Path a being added to Figure 6.7 and *Simaesthesia* itself being seen as an open system – another source of matter for *Memory Mirror*.

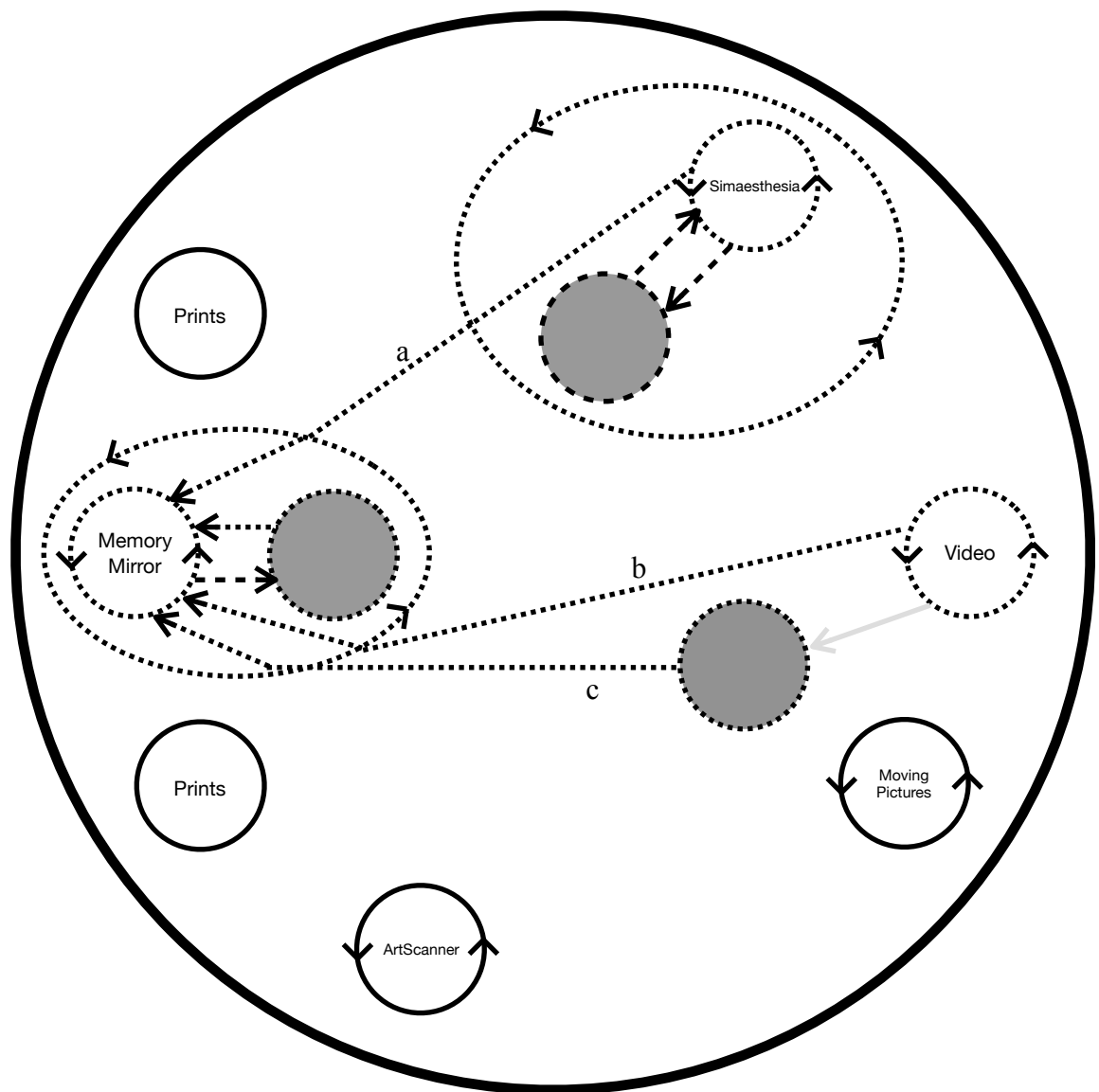**Figure 6.9 Interactions within *The Interact Gallery*.**

The important role of the *Memory Mirror* digital art system within The Interact Gallery is revealed through this analysis. The video artwork, previously seen as isolated, is seen as a source of matter for *Memory Mirror* – as is *Simaesthesia*. Intriguing, from a creative perspective, is the observation that the viewer of the video can be an

inadvertent participant in *Memory Mirror*. It is clear that there would be value in expanding the capabilities of the artworks in the exhibition such that they *all* interacted in *Memory Mirror* and each other in some way. Finally, with its potential for multiple interactions with humans and other artworks, *Memory Mirror* can be undoubtedly be described as a connected digital artwork.

6.5 An Analysis of Symbiotic

The *Symbiotic* exhibition (Section 5.5) was designed to explore the principles of digital art systems identified in Section 5.4. As with *The Interact Gallery*, the process of systems analysis begins with the identification of the exhibition's component digital art systems and their likely type. They are placed in the same locations they were in during the exhibition.

The two open systems – *The Whale* and Genetic Moo's *The Cockatoo Squid* – were located at opposite sides of the gallery and this is reflected in the layout of the system diagram. Genetic Moo's *It's Alive! Ants* was divided in to a red and blue part either side of the entrance. On the wall across from the entrance were the *Red Spinner* and *Blue Spinner* and Genetic Moo's *Starfish*. These are shown in Figure 6.10 with dashed boundaries since on initial inspection they do not exchange matter with other systems.
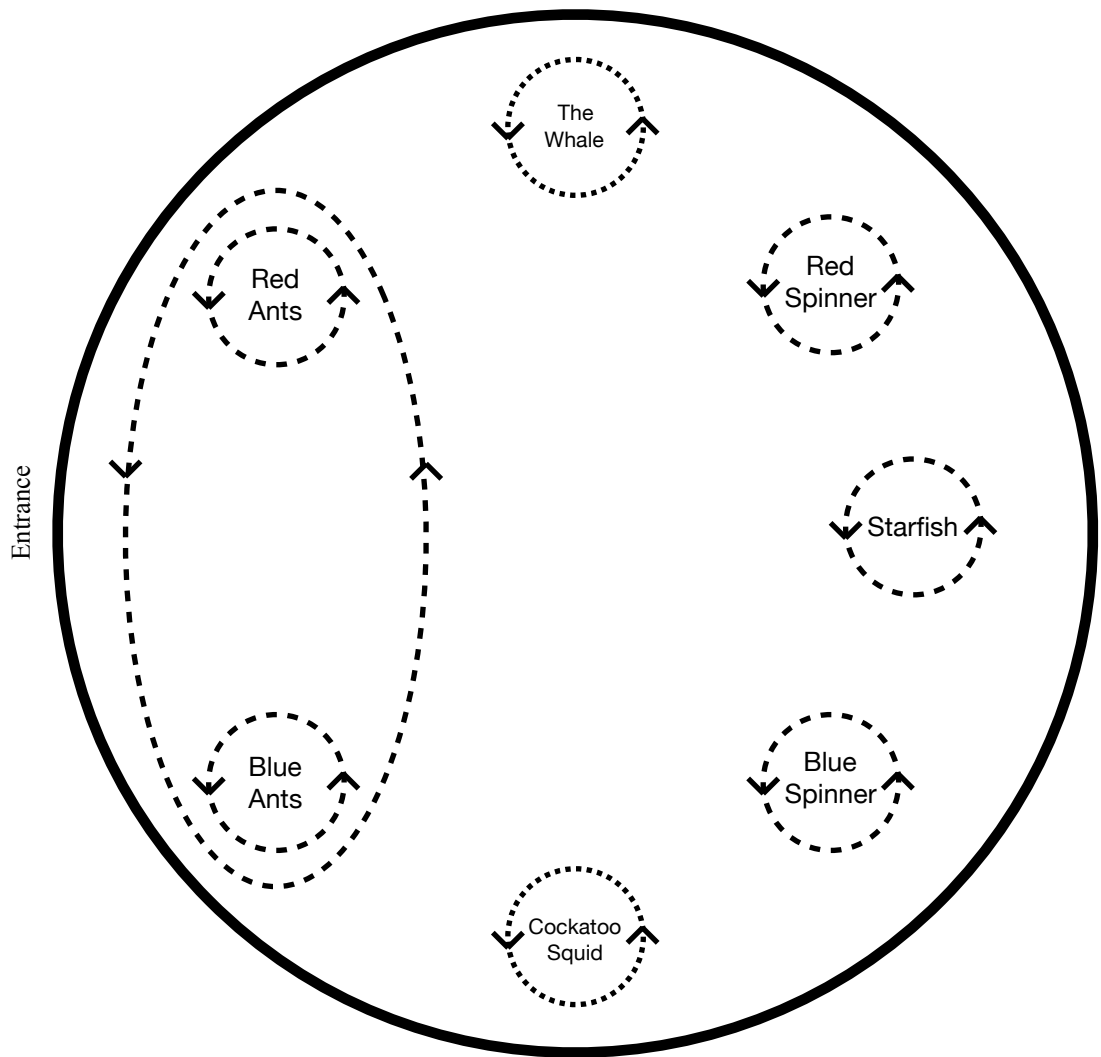
Figure 6.10 The digital art systems within *Symbiotic*.

The next stage of analysis looks at the the relationships between the artworks. There is an exchange of matter, in the form of images and sound, between *The Whale* and *The Cockatoo Squid*. When the *Red Spinner* and *Blue Spinner* are activated they generate light that triggers *It's Alive! Ants*. These are shown in Figure 6.11
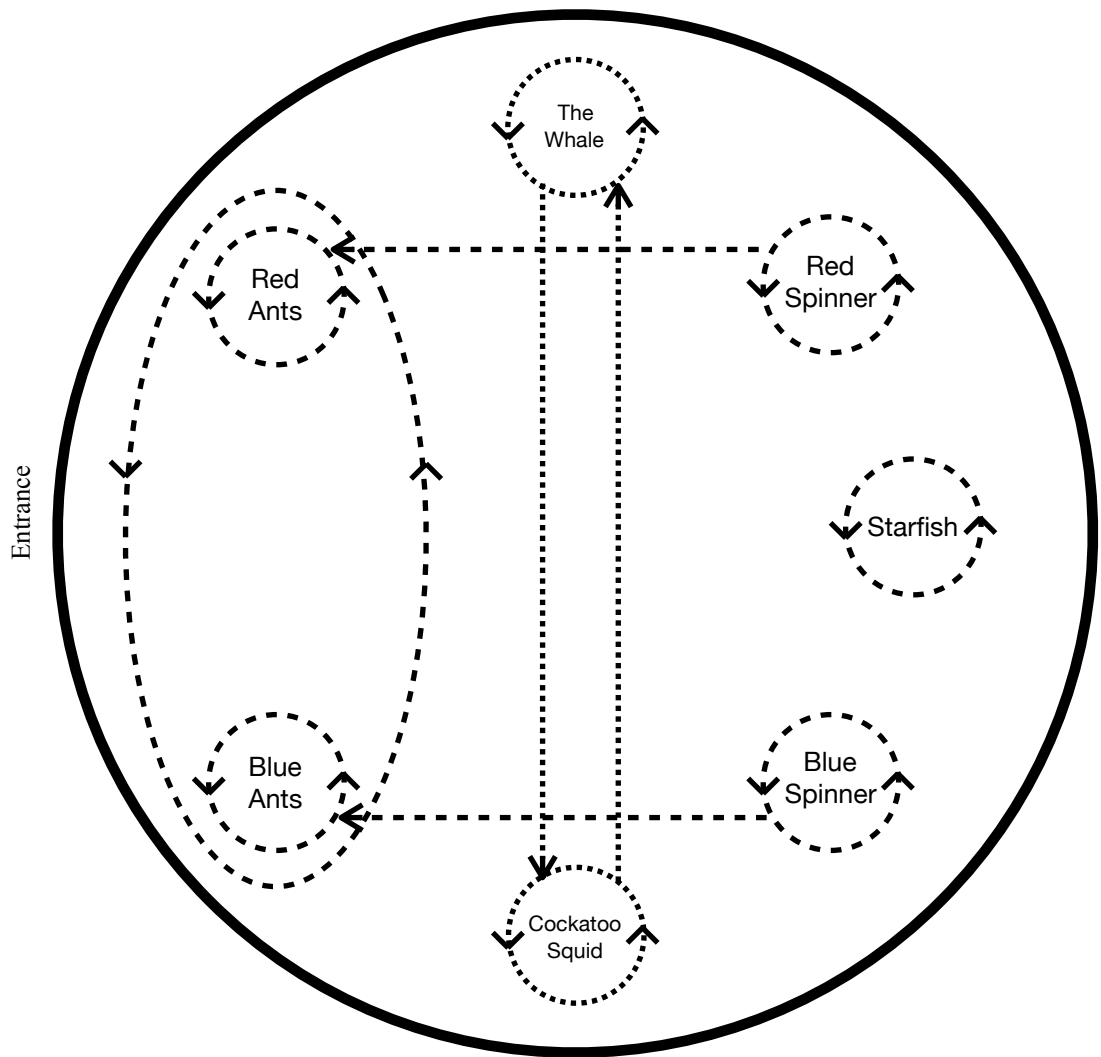
Figure 6.11 Inter-artwork communication in *Symbiotic*.

In Figure 6.12 some of the relationships between the participants and the artworks are explored. The top participant can be seen to be able to enter in to a feedback loop involving the exchange of energy (triggers) with *Red Spinner*. When this happens a trigger is also sent to *It's Alive! Ants* and activates the *Red Ants*. The participant can also trigger this artwork directly.

The lower participant appears to be in quite a simple relationship with *The Cockatoo Squid*, sending matter to it (images and sound) and receiving triggers in return. However, we know from Figure 6.10 that when they interact with it they are potentially also integrating with *The Whale*.
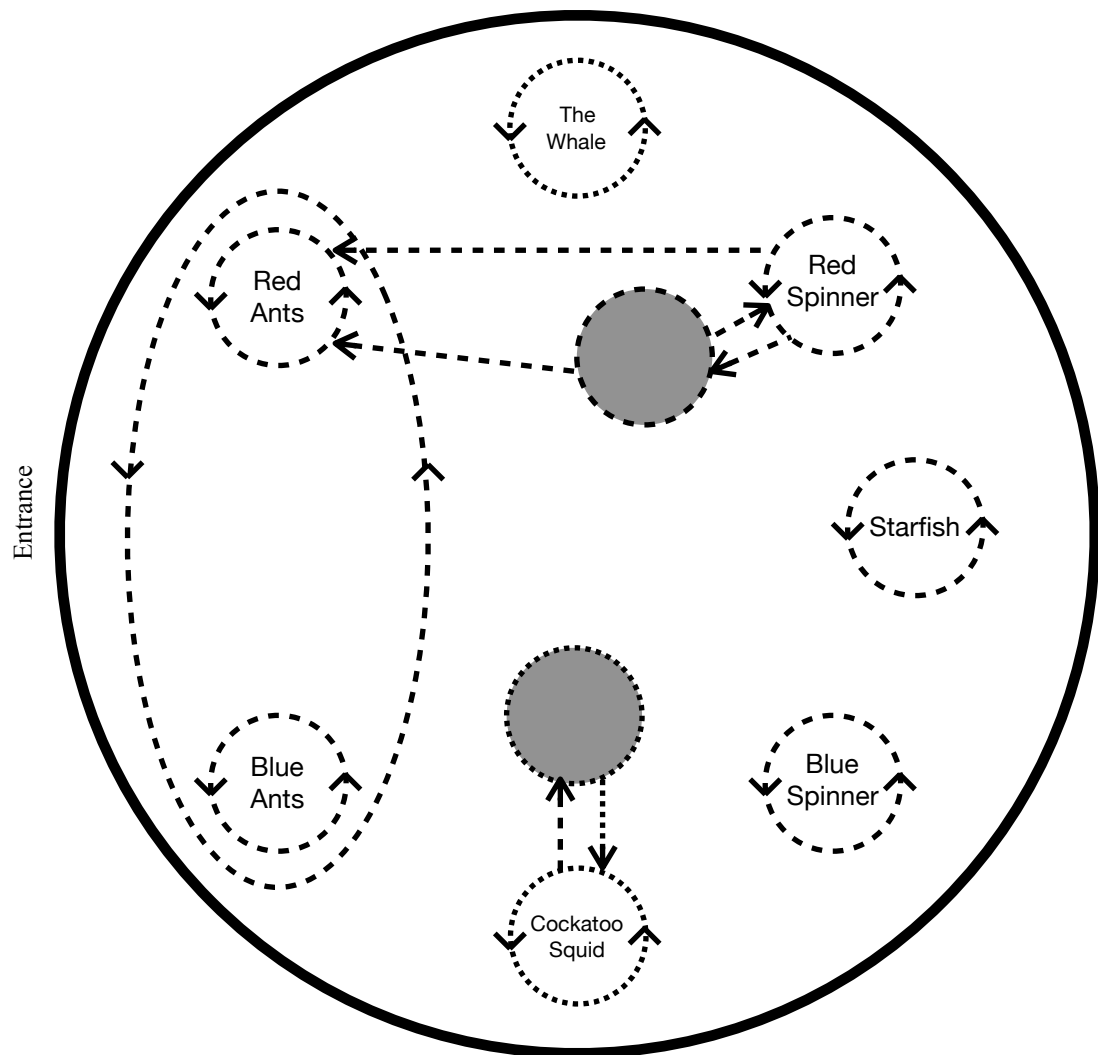
Figure 6.12 Participants in in *Symbiotic*.

The systems analysis of *Symbiotic* could continue, with other relationships between the artworks and human visitors being explored. However, the analysis has already revealed aspects of the nature of artworks that were not identified in Section 5.6. For example, since the *Red Spinner* and *Blue Spinner* generate sound, it is possible that they too feed matter in to the *Cockatoo Squid*. The ability of the participant to trigger changes directly in *It's Alive! Ants* or via the spinners is also creatively interesting since it introduces the idea of a person interacting with two digital artworks at the same time.

With the large number of connections between participants and artworks, the use of the *Framework for Connected Digital Artworks* makes it clear that *Symbiotic* matches the description of a digital art ecology.

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CHAPTER 7: A Cybernetic Ecology

A Cybernetic Ecology is the final Theory-Create-Exhibit-Reflect cycle presented in this research programme. The work began in soon after *Symbiotic* exhibition had finished in 2012 and resulted in a number of exhibitions as part of group exhibitions before being the subject of a solo exhibition in 2016. The title of the exhibition and research cycle "A Cybernetic Ecology" is taken from a line in the poem "All Watched Over by Machines of Loving Grace" by Richard Brautigan (Brautigan, 1967; see Appendix III.V) which served as an important inspiration during the early phases of the work.

7.1 Artistic Goals

The artistic goals of this cycle of creative work were to reappraise how I produced and presented my artworks in order to focus on the core concepts developed in the *Framework for Connected Digital Artworks*. I also wanted the artworks to have the potential to be distributed over multiple locations and make use of use of the internet in order to communicate.

7.2 Research Goals

The goal of the research was to undertake and appraise a full cycle of Theory-Create-Exhibit-Reflect in which the *Framework for Connected Digital Artworks* was the underlying theory and the results could be appraised in these terms.

7.3 Exploratory Work

The process of devising new ways of representing systems through digital artworks began with an exploration into how I could use web browser technologies to present grids of colours and images that could be interacted with by users on their desktop computers or mobile devices. This new creative direction emerged from the work I had done with the grids of symbols in *Moving Pictures* (Section 5.4.3) and the image swapping technology I had developed for *Dropsketch* (Section 5.4.4).

With the clear purpose made possible by the *Framework Connected Digital Artworks* in Chapter 6, I experimented by creating simple grids of colours that would start off on a randomised order and then be rearranged according to a pattern of organisation by following a process of organisation.

The pattern of organisation typically involved numbering each grid location and, for example, systematically reorganising the colours at each location according to how much red, blue or green they contained, or another colour rule. The process of organisation could be something as simple as a bubble sort algorithm that swapped the contents of the grid locations according the rule. An image of a colour grid displayed on a computer screen can be seen in Figure 7.1. In this image the colours are organised according to brightness, dark at the top and light at the bottom.
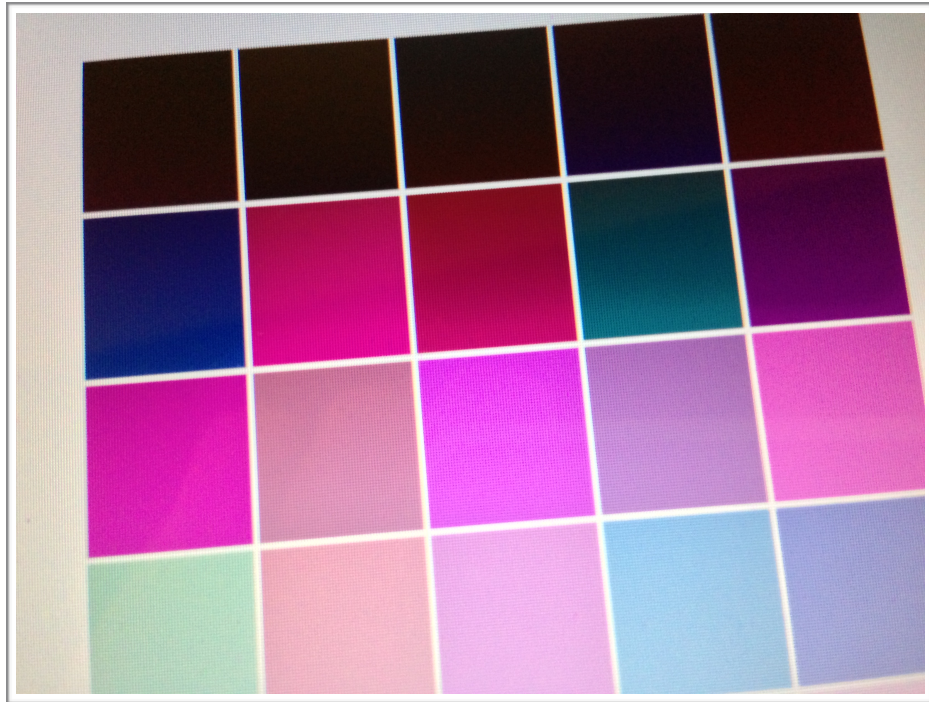
Figure 7.1 A self-organising colour grid (organised according to brightness).

The process or organisation was run at a slow enough rate for the viewer of the grid (in fact a participant) to see it taking place. They were also able to trigger their own changes in the grid organisation by touching squares. Hence, even when fully sorted the grid could be disrupted by the viewer triggering their own swaps within the grid.

These simple interactive digital art systems were effectively closed to new matter (in this case, colours) and they were open to energy (triggers from the participant). They were particularly engaging when presenting to users on mobile devices, having a somewhat game-like quality to them, with an interactive challenge taking place between the user (attempting to achieve their own colour arrangement) and the digital art system trying to self-organise according to its own set of rules.

7.3.1 ColourNet

ColourNet was created in collaboration with Ernest Edmonds for his exhibition *Light Logic* at the Site Gallery in Sheffield between 17th November 2012 and 2nd February 2013[20]. It connected one of my simple self-organising colour grids with one of Ernest Edmonds' *Shaping Form* interactive works via a simple web service. The colour grid was accessed via the user's mobile phone, or an iPad in the gallery, and the *Shaping Form* was projected on the upstairs gallery window (Figure 7.2).

Figure 7.2 *ColourNet* **in at the Site Gallery with** *Shaping Form* **is in the upper right window.**

The user of the colour grid was able to interact with it, disrupting the pattern of organisation and triggering the internal process. At the same time the colour selected by

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[20] Light Logic. http://www.sitegallery.org/ernest-edmonds-light-logic/

the user was sent to the *Shaping Form* to trigger a response from it. A colour from *Shaping Form* was then sent back to become part of the colour grid. In order to be compatible with *Shaping Form,* the colour grid was modified to use colours represented in Hue-Saturation-Lightness format (HSL) rather than Red-Green-Blue (RGB).

When used inside the gallery, or during the day, the colour grid was a stand-alone interactive work that encouraged the user to explore the self-organising nature of the work. When used outside of the gallery at night, it became a "remote control" in which the user could see the results of their colour selections appear on the *Shaping Form* image. The artwork was also shown in Paris at the CHI'13 conference (see Clark and Edmonds, 2013; included in Appendix V) exhibition and later that year at an exhibition in Sydney, Australia (Figure 7.3).
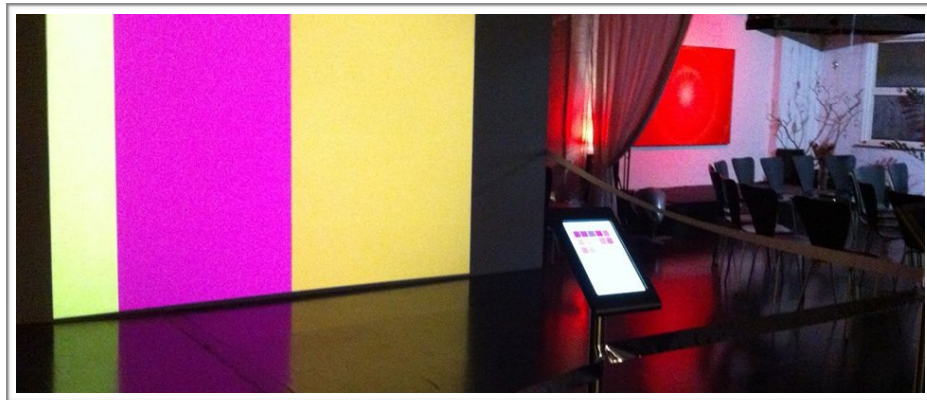

Figure 7.3 *ColourNet* in Sydney with *Shaping Form* on the big screen and a colour grid on the iPad.

7.3.2 System 1

The development of the colour grids offered insights into how it might be possible to create new artworks in which the *Framework for Connected Digital Artworks* is

considered from the beginning of the creative process. In particular, the concept of a pattern of organisation and a process of organisation were key to the creation of the these exploratory works.

The next stage in their development was to consider how the work could be extended to include better defined inputs and outputs and the exchange of matter and energy. *ColourNet* explored this, with the participants being able to trigger changes in the artworks and matter (in the form of colour values) being exchanged between the two main digital art systems (the colour grid and *Shaping Form*).

System 1 (other names have been used) develops these ideas even further and represents the first complete artwork that fully expresses the ideas contained within the *Framework for Connected Digital Artworks*.

The artwork is presented to the viewer as two five-by-five grids placed next to each other on a computer screen. Each grid begins with a set of 25 colours randomly selected from a colour palette of my creation. The grid positions are then numbered in a zigzag pattern from 1 to 25.

The selection of the colour palette used was a somewhat iterative and subjective process. It began with the full gamut of colours defined in the hue, saturation and lightness (HSL) colour space. The saturation and lightness values were then constrained until the colour selections were attractive to the artist. This constrained colour palette was then used in all of the artworks in this phase of work. The result of this approach is a clear visual connection between the artworks.

Grids and squares are used extensively in abstract and minimalist art. They were also a common form in early computer art. It was a conscious decision to place this new artwork in the broader context of these traditions. The grid also creates a clear boundary within which the squares are constrained and suggests the potential for a relationship between the adjacent parts.

While notionally a two-dimensional structure, the grids are actually one-dimensional forms. They were originally visualised as zigzagging snake-like shapes with an input (mouth) at one end and an output (tail) at the other. Conceptually, the snakes (grids) were connected to form a double ouroboros, a symbol I had long considered as a visual metaphor for two interacting systems (or the relationship between process and pattern) and had used a version of in artworks such as *Moving Pictures* at the *Interact Gallery* in 2011 (See section 5.4.3). While the figurative elements of the double ouroboros did not make it in to this final artwork, the structure remained. The figurative representation of the double ouroboros has remained an important inspiration during the research and it is included, with the statement "The one feeds the other", at the end of the concluding chapter of this thesis (Chapter 5).

When activated, the left-hand grid begins to sort its colours according to the lightness of the colours and the right-hand grid sorts them according to hue. When the first grid is fully sorted it releases a colour from a randomly selected position. When the second grid is ready it also releases a colour and they swap. Both grids then run the sorting process in order to place the new colour in the correct position according to their pattern of organisation. The process of organisation is a bubble sort algorithm, with each step in

the sorting process being visible to the viewer. An image of *System 1* can be seen in Figure 7.4, with a video of the work included on the attached USB stick.
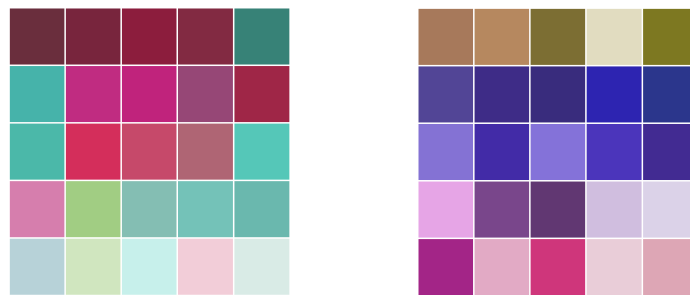
Figure 7.4 The left-hand grid is organised by lightness and the right-hand grid organised by hue.

An ongoing process follows with both grids endlessly swapping colours and reorganising themselves in response. The individual grids are open to new colours (from the other grid) even though the combined system is closed. In this artwork the principle of the exchange of material between the systems is demonstrated simply. Indeed the viewer, if they so wished, would be able to work out the pattern of organisation and process or organisation by following the colours as they moved around the grids.

This new work was first exhibited as a the *Automatic Art* exhibition curated by Ernest Edmonds at the GV Art Gallery in London from 3rd July until 10th September 2014[21].

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[21] Automatic Art. https://www.dora.dmu.ac.uk/xmlui/handle/2086/13017

The work, and variations of it, including prints of the fully-organised grids have since been exhibited elsewhere.

7.4 A Cybernetic Ecology at the LCB Depot in Leicester

A Cybernetic Ecology took place between the 6th and 23rd December 2016 at the LCB Depot LightBox gallery in Leicester and Phoenix Cafébar in Leicester. It was an exhibition of connected digital artworks primarily by myself, but also including collaborative pieces with Esther Rolinson, Ernest Edmonds and Genetic Moo.

7.4.1 Interim Presentation

Preparations for the Leicester exhibition took around a year, with an interim presentation of the new artworks taking place at the EVA London 2016 conference in London and HCI 2016 conference in Bournemouth in July 2016. This presentation involved artworks being placed in both locations and connected via the internet. A paper entitled *Connected Digital Artworks* was published in both conference proceedings and introduced the ideas contained within the artworks to both audiences (Clark, 2016; included in Appendix V).

In the London location (Figure 7.5) four artworks were shown. Top right, there was a screen-based piece (powered by a Raspberry Pi computer) that consisted of four self-organising colour grids placed in a two-by-two arrangement. The grids exchanged colours with each other, as well as other artworks in the network.

Top left and bottom right there were two LED-based grids (powered by Particle Photon micro-controllers). Despite using different technology to the screen-based piece they were still able to exchange colours with other artworks in the network. The LED grids also contained small light sensors and would alter the brightness of any colours they received in response to the light levels in their environment.

Bottom left, there was a print showing three overlaid colour grids. This was produced by running the three interacting colour grids live for a period of time and then capturing an image when the colour grids all reached a fully organised state.
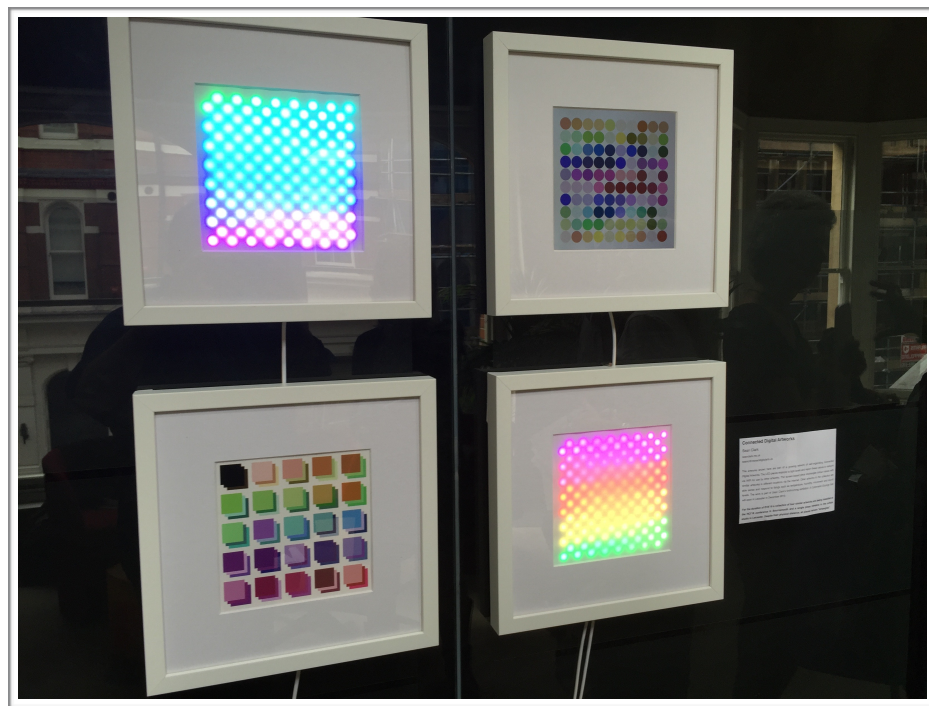
Figure 7.5 *Connected Digital Artworks* **at EVA London in July 2016.**

In Bournemouth, a similar arrangement of four pieces was presented (Figure 7.6). Top right was an LED grid, bottom left was a screen-based grid and top left and bottom right were prints of combinations of fully organised coloured grids.

Figure 7.6 *Connected Digital Artworks* **at HCI Bournemouth in July 2016.**

Importantly, all of the digital pieces in both locations (screen-based and LED-based) were connected together via the internet and could exchange colours. This interim presentation proved to be a valuable demonstration of the *A Cybernetic Ecology* concept. It also enabled a number of minor technical issues to be resolved prior to the full exhibition taking place.

7.4.1 Full Exhibition

The full *A Cybernetic Ecology* exhibition was centred around a large network of connected self-organising colour grids of the type presented above. This work was entitled *Transformations*. Digital screen-based, digital-LED based and print-based images were included. It was primarily located at the LCB Depot LightBox gallery in Leicester, with a connected exhibited in the Phoenix Cafébar, a short distance away.

In addition to the colour grids a collaborative piece with Ernest Edmonds called *Cities Tango 2* was included plus a new collaborative work with Esther Rolinson entitled *Signal* and an experimental work by G*enetic Moo* called *The World, the Flesh & the Devil*. All artworks had the potential to connect to the internet and exchange colour information using a colour swapping service.

7.4.1 Transformations

Transformations is a connected digital artwork composed of multiple interacting systems that can be co-located or distributed over distance. For this exhibition it was composed of six triptychs, five located at the LCD Depot Lightbox and one in the Phoenix Cafébar. Each triptych (Figure 7.7) is further composed of two printed fully-organised colour grids on the left and right and a central screen-based pair of overlaid colour grids (controlled by a small single board computer) that constantly reorganise themselves in response to colour exchanges with each other and the other digital art systems in the network. Both the printed and digital images are framed in the same way to help break the distinction between the analogue and digital.

The individual grids are not composed simply of squares. Other simple shapes are used (circles, triangles and lines) to give each triptych its own character (these are shown in Appendix III). However, the patterns of organisation used are similar to those used in previous works. These include forward and backward sorting of colours by hue, saturation and lightens. Likewise the bubble sort process of organisation is used to maintain the pattern of organisation in response to incoming and outgoing colours.

Figure 7.7 A *Transformations* triptych composed of two prints and a screen-based image.

Each triptych is constructed as a multi-layered system in its own right. The left and right prints are representations of the two systems contained within the central image, which themselves contain grids of 25 colours. At a higher level, the six triptychs are connected using a web service that enables them to exchange colours via the internet. This service, based around Internet of Things technology is described further in Section 7.6.

7.4.2 Cities Tango 2

Cities Tango 2 is a reworking of Ernest Edmonds' pioneering connected artwork *Cities Tango* (Edmonds and Franco, 2013). For this exhibition two nodes were installed at the LCB Depot Lightbox and an additional one at the Phoenix Cafébar. Each node consisted of a screen, small computer and a webcam. When movement is detected in a particular location the nodes swap webcam images and display them as the background to a self-organising colour grid the was connected to the *Transformations* network. When there is no movement a pre-captured image from the remote location was shown as the background, images of *Cities Tango 2* can be seen in Figure 7.8 and Figure 7.9.

Cities Tango 2 had previously been exhibited in Rio de Janeiro, Brasil as part of the *Primary Codes* exhibition in summer 2015 (Franco, 2018). It was also included in the ArtCHI 2016 exhibition as *Tango Apart: Moving Together* in San Jose, California in April 2016, with two nodes in San Jose and one in Leicester (Edmonds and Clark, 2016; included in Appendix V).

Figure 7.8 The *Cities Tango 2* node at the LCB Depot Lightbox.

Figure 7.8 A second view of the *Cities Tango 2* node at the LCB Depot Lightbox.

7.4.3 Signal

Signal was the result of my on-going collaboration with artist Esther Rolinson that had started with my technical involvement in her projects *Melt*, *Splinter* and *Thread* in 2014. Our work became more collaborative, leading to our award of the prestigious Lumen Prize for 3D/Sculpture in September 2016[22] for the artwork *Flown* (Rolinson and Clark, 2016; included in Appendix V).

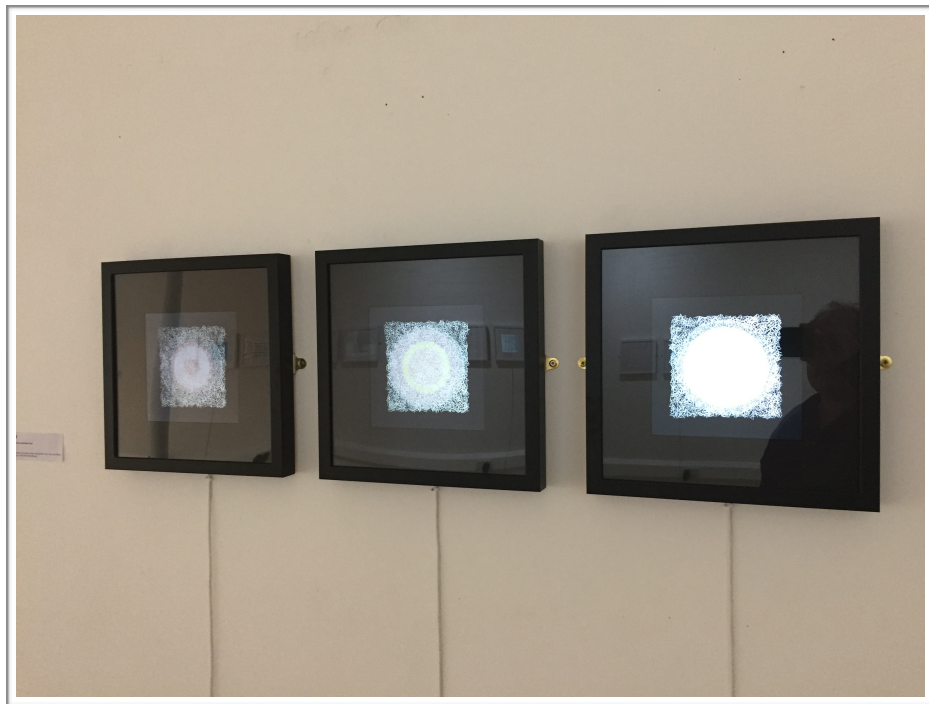**Figure 7.9 *Signal* by Sean Clark and Esther Rolinson.**

Signal took the form of another triptych in which three screens (powered by small computers) displayed an image of a drawing by Esther Rolinson that was overlaid with an evolving image of concentric circles programmed by myself (Figures 7.9 and 7.10).

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[22] Lumen Prize 2016. https://lumenprize.com/edition/edition-2016/ (retrieved 23rd August 2018).
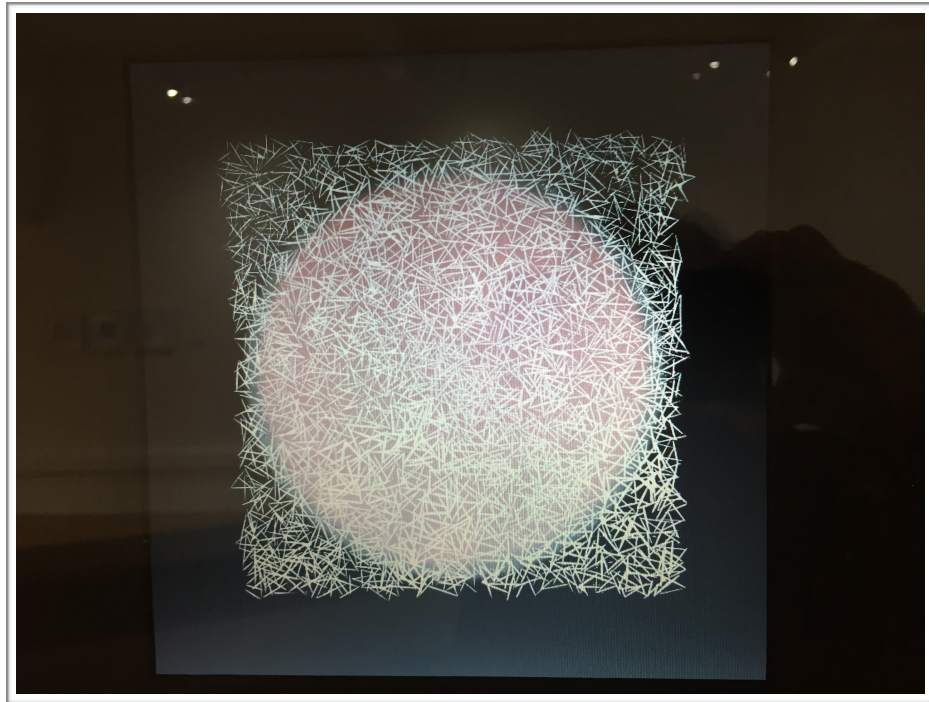
Figure 7.10 A closer view of *Signal* by Sean Clark and Esther Rolinson.

The concentric circle pattern was a consequence of a different process of organisation to the colour grids. Each screen began with eight circles, each circle with it's own random colour and rate of change. The circles grew out from the centre. When they hit the outer edge of the drawing they would then change direction, getting smaller and returning back to the centre, like ripples in a pond. When the centre was reached the system would swap a colour with another artwork in the *Signal* network and the circle would grow again with the new colour. This resulted in a breath-like quality to the triptych, with each part appearing to breath in and out as they exchanged colours between them.

Originally, it was envisaged that *Signal* would be part of the same colour-swapping network as *Transformations* and *Cities Tango 2*. However, this resulted in colour

combinations that did not aesthetically suit the piece, so for this exhibition *Signal* was configured to run in isolation, only swapping colours with its own kind.

In additional to the screen-based pieces, an LED-based, non-connected, version of *Signal* was also shown. The *Signal* artworks, and the processes involved in its creation, are described in more detail in the paper *Signal: A Systems-based Creative Collaboration* (Clark and Rolinson, 2017; included in Appendix V).

7.4.4 LED Grids

Two LED grids were installed in the exhibition at the LCB Depot LightBox. These were similar to the technology used in the interim presentation of the work described in Section 7.4.1. The grids were composed of LED panels controlled by a Particle Photon micro-controller (Figures 7.11 and 7.12). They were connected to the *Transformations* network and were able to swap colours with other artworks. A light sensor enabled the artwork to change the lightness of any received colour before sending it back in to the network. Unlike the previous use of LED grids, those used here only held a single colour at a time. The trigger to swap a colour was the detection of a certain amount of change in the light levels in the environment. The LED grids resulted in the colours being swapped becoming lighter during the day and darker at night.
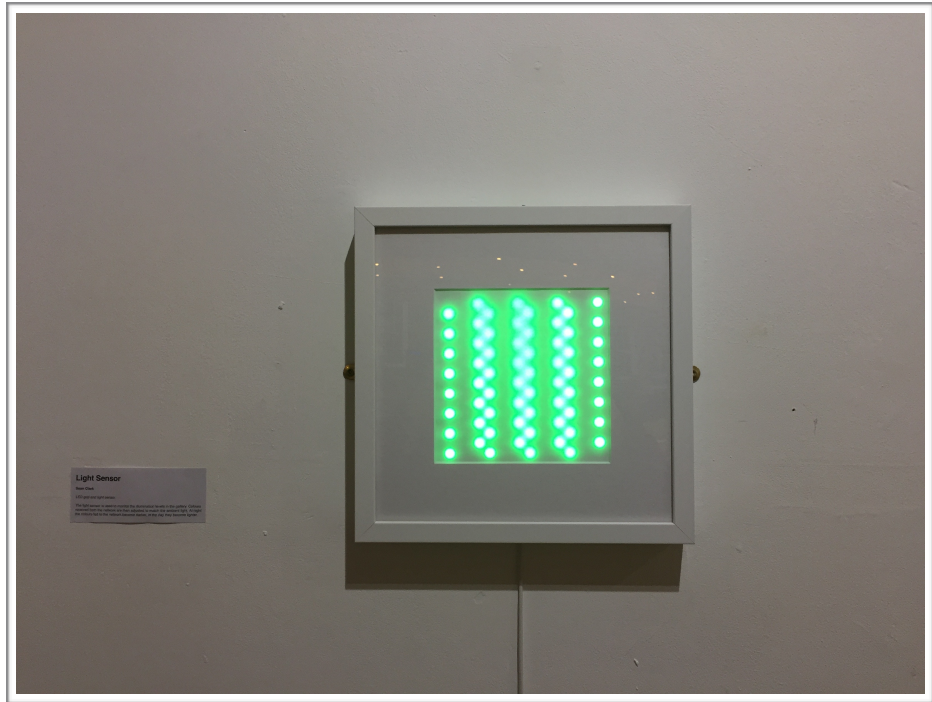
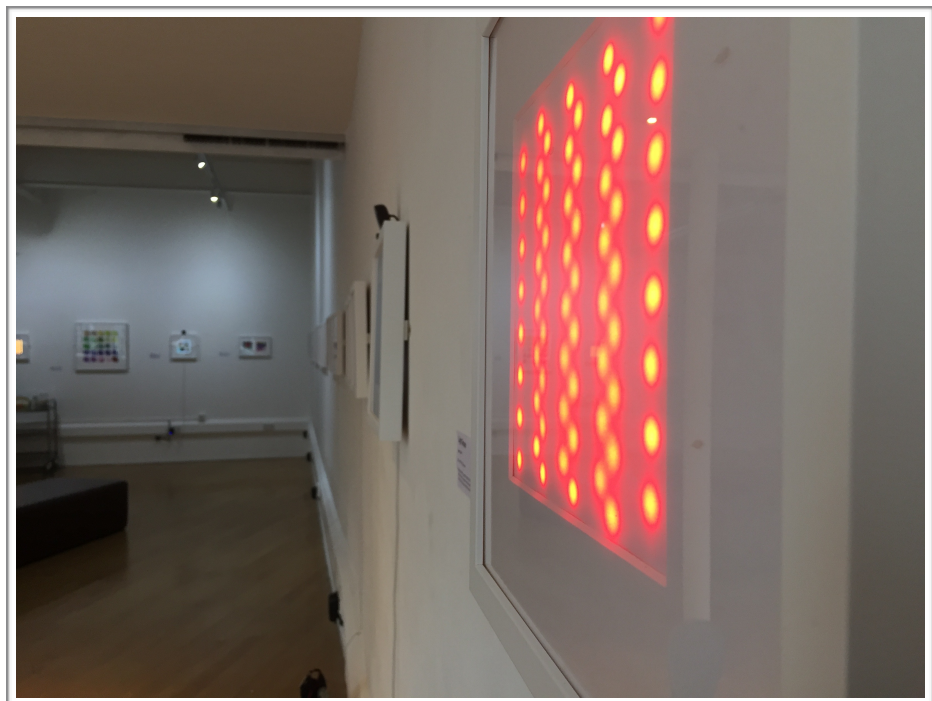**Figure 7.11 An LED grid installed at the LCB Depot LightBox.**

Figure 7.12 An alternative view of the LED grid installed at the LCB Depot LightBox.

7.4.5 The World, the Flesh & the Devil

The World, the Flesh & the Devil was an experimental interactive piece by Genetic Moo (Figure 7.13). It was our first attempt to connect a Genetic Moo artwork to the new colour-swapping system I had been developing.

The artwork was inspired by the scientist and futurist J.D. Bernal, who in his 1929 novel envisioned a hollowed out asteroid as a potential human spaceship, taking thousands of humans (mainly scientists) into a technological future away from the planet. In a space just outside of the main gallery Kinect sensors allowed the audience to populate a series of spheres whose launch sequences are triggered by other works in the exhibition and whose colours are taken from the *Transformations* artworks. The work was projected on a large video screen.
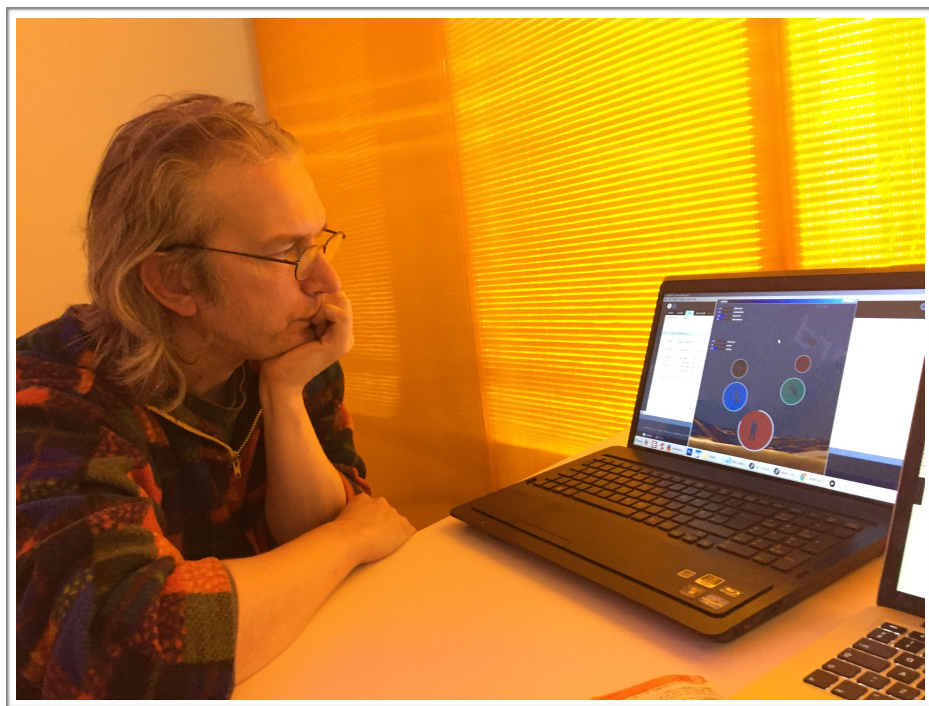
Figure 7.13 Tim Pickup from Genetic Moo testing *The World, the Flesh & the Devil.*

7.4.6 Prints

As well as the digital works, two prints were also exhibited. The first was a high-quality print of *System 1* described in Section 7.3.2, retitled *Double Grid (Figure 7.13),* and included because of its importance in establishing my new creative direction.

The second was *Triple Grid*, a new image produced specifically for the *A Cybernetic Ecology* exhibition and composed of three grids of 25 squares, with the same organisational rules, overlaid to emphasise how the the same pattern will appear different depending on the materials it is composed of. This image was used on the poster for the exhibition, shown in Figure 7.15.

Figure 7.14 A print of *System 1*, retitled *Double Grid*.

Figure 7.15 The *A Cybernetic Ecology* exhibition poster featuring *Triple Grid*.

7.4.7 Installation and Context

The exhibition was laid out in the LCB Depot LightBox in order to encourage visitors to first be drawn to a *Cities Tango 2* node and LED grid opposite the entrance to the gallery; they were then encouraged to follow a wall of the five *Transformations* triptych before encountering the prints, the second *Cities Tango 2* node, the second LED grid before finally encountering *Signal* on the wall that was not visible from the gallery entrance. Views of the exhibition are shown in Figures 7.16, 7.17 and 7.18 and in Appendix III.

Figure 7.16 The *A Cybernetic Ecology* exhibition.

Figure 7.17 *Transformations* **triptychs in the** *A Cybernetic Ecology* **exhibition.**

Figure 7.18 Wide view of the *A Cybernetic Ecology* **exhibition.**

The Phoenix Cafébar installation (Figure 7.19) was simpler, with a *Transformations* triptych accompanied by a *Cities Tango 2* node and an additional print. The digital pieces in this collection were connected to the same colour swapping service as those in the LCB Depot LightBox.

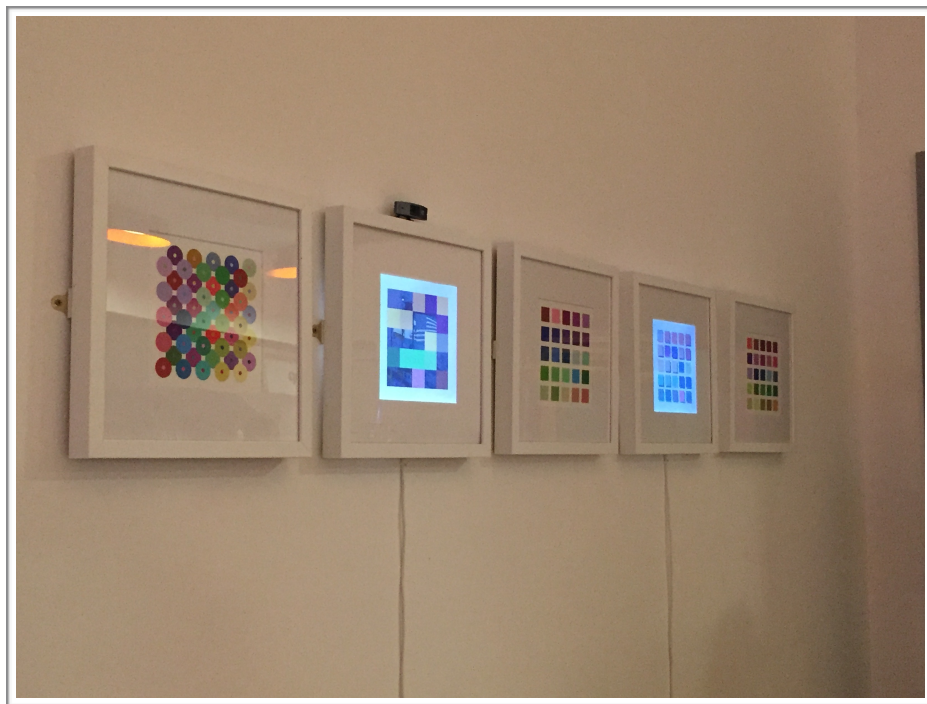**Figure 7.19 The *A Cybernetic Ecology* installation in the Phoenix Cafébar.**

An artist statement together with a list of artworks was displayed at both locations, a copy of which is included in Appendix III and on the accompanying USB stick. As well as background information about the exhibition, the statement also included the poem "All Watched Over By Machines of Loving Grace" by Richard Brautigan.

7.4.8 Live Performance

The exhibition opened with an evening of live music, spoken work and poetry from Leicester's Anerki Collective. The performers had been asked to reflect on the idea of 'connectedness' and encouraged to respond to the artworks around them. Pictures from the evening can be seen in Figures 7.20 and in Appendix III. I later published material from the performances in the *Interanerki Magazine* (a PDF copy is included on the accompanying USB stick).

Figure 7.20 Live performance in the *A Cybernetic Ecology* gallery space.

7.5 Analysis with the Framework for Connected Digital Artworks

The *A Cybernetic Ecology* exhibition was intentionally more complex than the exhibitions described earlier. This was particularly true in terms of the amount of inter-

artwork communication taking place. It also had a number of other important features not present in previous exhibitions. Perhaps most significantly was the presence of a digital environment. The *Transformations* colour swapping service and the *Cities Tango 2* webcam image swapping service both allowed matter to exist in a place that was not part of a specific digital art system – the shared digital environment. By using these services the artworks were able to communicate over distance via the internet.

An analysis of the exhibition using the *Framework for Connected Digital Artworks* can begin by representing these broad features, as shown in Figure 7.21.

Shared Digital Environment
(exchange of images and colours)

Phoenix

LCB
Depot
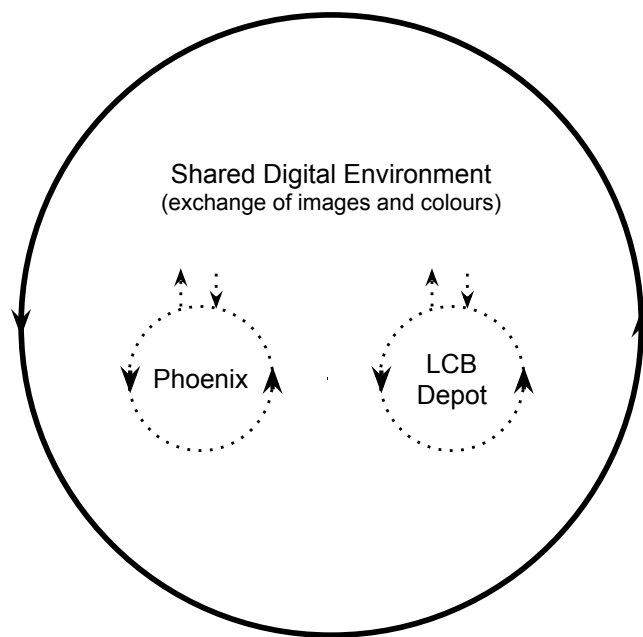
Figure 7.21 *A Cybernetic Ecology* **used two physical locations, Phoenix and LCB Depot.**

The two locations are shown as open systems able to exchange energy and matter with their environment (colours and webcam images). If we then focus on the simpler of the

locations, the Phoenix Cafébar, we can see the nature of these exchanges in more detail. This is shown below in Figure 7.22.
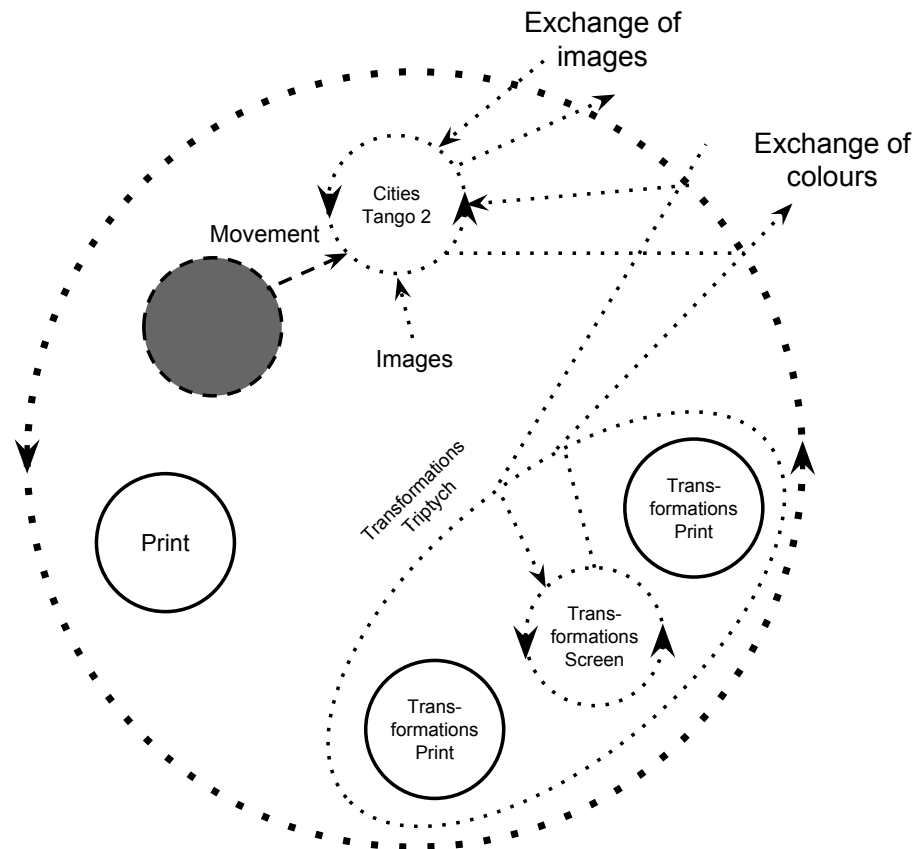
Figure 7.22 *A Cybernetic Ecology* **at the Phoenix Cafébar.**

A participant is able to trigger the *Cities Tango 2* node to grab an image. The image input is shown as coming from the local environment since the image is not specifically intended to be an image of the participant and it will not be shown to the participant in that location. Images then pass through the open system boundary of the location. The *Transformations* triptych consists of a framed screen with a computer and two framed

prints. Colours can pass in and out of the *Transformations* screen and so the boundary around the whole triptych is shown as open.

Cities Tango 2 can be further broken down in to its image swapping and colour swapping components. This is shown in Figure 7.23.

Exchange of
images

Exchange of
colours

Cities
Tango 2
Webcam

Movement

Images

Trans-
formations
Colours
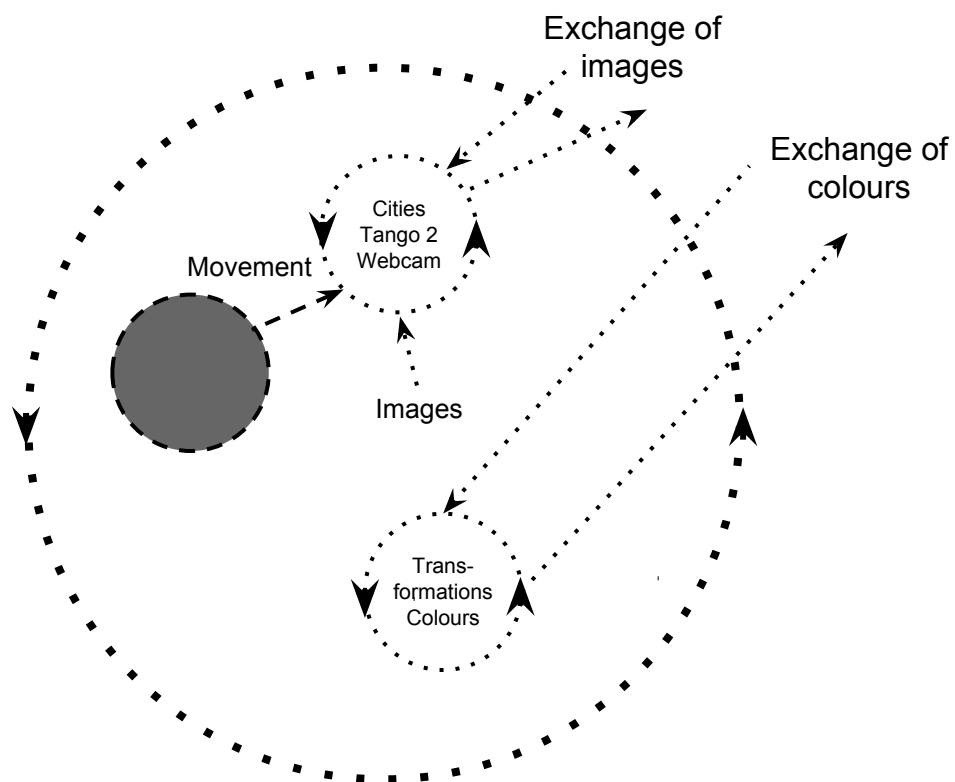
Figure 7.23 *Cities Tango 2* broken down in to its webcam and colour swapping components.

The analysis of the Phoenix location can be used as the basis for the LCB Depot Lightbox. However, as mentioned in the introduction to Chapter 6, any analysis using the Framework for Connected Digital Artworks will have an degree of subjectivity and it should be applied flexibly.

The analysis of the LCB Depot Lightbox part of the exhibition is illustrated in Figure 7.24. *Cities Tango 2* is shown in the same way as in Figures 7.22 and 7.23. A second *Cities Tango 2* node was also present in the LCB Depot location.

Figure 7.24 *A Cybernetic Ecolog***y at the LCB Depot LightBox**

In this diagram *Transformations* is shown as being within a single open system boundary. Inside this there are five triptychs of the same type as shown in Figure 7.19. The LED panels are shown as having an input for the light sensor together with an input and output for the colour swapping service. The *Signal* LED and *Signal* screen works

are both shown as isolated systems. Within the screen-based *Signal* there are three interacting systems with the observer outside of the isolated boundary, unable to influence the system. This are shown in Figure 7.25.
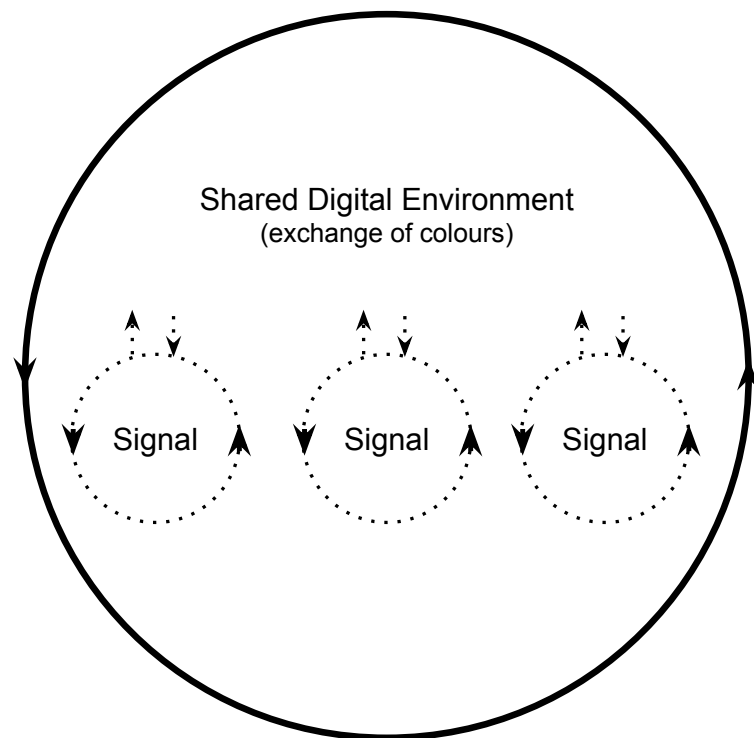
Figure 7.25 *Signal* is composed of three interacting parts that exchange colours via their environment.

The *Framework for Connected Digital Artworks* reveals the complex *interconnected* nature of *A Cybernetic Ecology*. Multiple artworks make use of the colour swapping service, which is an integral part of the artwork's environment. Unlike the artworks presented in the earlier chapters, the *Transformations* artwork does not have a human participant. However, it is still a highly connected artwork that is able to respond to its

environment *via* the LED panels that lighten or darken the colours being swapped in accordance to the light sensor.

7.6 The Internet of Art Things

In order to realise *A Cybernetic* Ecology it was necessary to develop a technical infrastructure capable of supporting inter-artwork communication. Different technologies were used to build the various artworks – some artworks used micro controllers, some used single-board computers and others used desktop computers – so the challenge was to produce something that was platform agnostic whilst also being efficient and scalable. The technology also needed to be compatible with the ideas contained within the *Framework For Connected Digital Artworks*.

The developing field of the "Internet of Things" provided rich source of potential technologies and, in particular, a protocol called MQTT was found to be highly suited for artwork-to-artwork communication. MQTT (Message Queuing Telemetry Transport) is an ISO standard (ISO/IEC 20922:2016[23]) for publish-and-subscribe messaging. It is a very lightweight protocol that can be implemented on low-powered computing devices and transported over TCP/IP networks.

Clients, in this case artworks, can publish messages to a server, known as a message broker. Messages can be as simple as a sensor reading, or as complex as a media file, such as an image or sound. Clients can also subscribe to messages via the broker. The

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[23] ISO/IEC 20922:2016. https://www.iso.org/standard/69466.html

job of the message broker is to route messages as fast as possible and to manage the connections with the clients.

The messaging broker used for *A Cybernetic Ecology* was the open source Mosquitto[24] system. This was found to be fast and reliable and well-supported across the IoT community. With the Mosquitto MQTT server handling the communications an environment server was also created to manage the storage of multimedia material that was not presently part of a digital art system. This server was created using the node.js system[25] and also handled the more complex routing of messages. The structure of the technical environment for *A Cybernetic Ecology* can be seen in Figure 7.26. The arrows show the flow of MQTT messages.
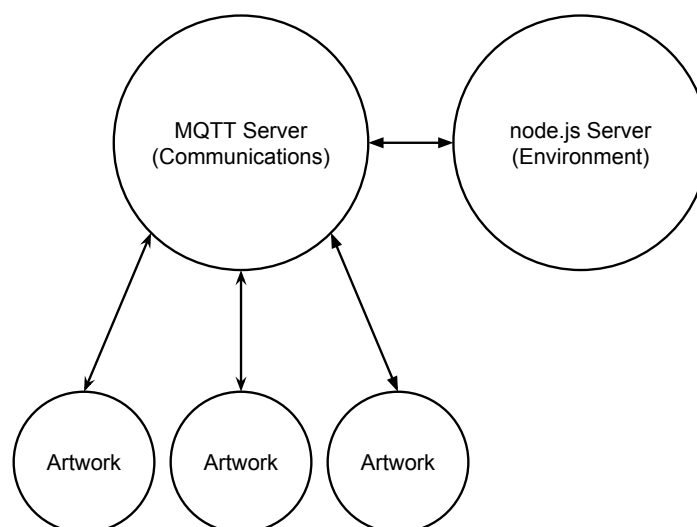

Figure 7.26 The flow of MQTT message in the *A Cybernetic Ecology* technical environment.

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[24] Mosquitto. https://mosquitto.org/

[25] node.js. http://nodejs.org

MQTT messages can be broken in to two key parts the message topic and the message content. In order to allow the artworks to communicate, a standard format for both parts was developed for *A Cybernetic Ecology.*

The message topic, which in MQTT is hierarchical with each part in the hierarchy being separated by a "/", is divided in *The Internet of Art Things* in to four parts: 1) the art *ecosystem* it is from; 2) the type of art *system* it is from; 3) the *component* of that system it is from; and 4) the type of message it is.

Fo example, a message published from a *Transformations* artwork would have the topic:

```
cybecol/transformations/<id>/colourhsl
```

Where "cybecol" is the name of the ecosystem, or overall collections of artworks, "transformations" is the specific type of artwork, <id> is a unique identifier for the digital art system and "colourhsl" indicates that a hue-saturation-lightness value is to be expected. In this example message content would then contain three numbers, separated by commas.

All *Transformations* digital art systems are then able to subscribe to this type of message, with a wildcard being used for the component part of the topic:

```
cybecol/transformations/+/colourhsl
```

The "+" symbol is the wildcard, hence this example subscribes to all *Transformations* colourhsl message. The Mosquitto MQTT server then ensures that all message are appropriately routed.

This example is actually slightly simplistic since what would actually happen is that all messages from all *Transformations* artworks, including those from the sender itself, are received by all *Transformations* artworks simultaneously. The routing is therefore too general and results in everything being connected to everything else and no logic to the communication. This may be desirable, but in the case of *Transformations* is it not.

In reality, the node.js environment server subscribes to these messages and then uses its internal logic is used to direct the messages to the most appropriate *Transformations* artwork. The environment stores the <id> of the sender and then sends back a message when a colour from an appropriate source is available. Hence the artwork would actually subscribe to messages in the form:

```
cybecol/env/<id>/colourhsl
```

Where "env" indicates that the message has come from the environment server and <id> is the artwork's unique identifier. This prevents the artwork subscribing to its own outgoing messages. A version of the Signal artwork with an information panel showing recently exchanged MQTT messages is shown in Figure 7.27.

This simple MQTT message hierarchy has proven to be very flexible and, combined with routing logic in the node.js server, enables all of the inter-artwork communication to take place within *A Cybernetic Ecology*. The exchange of webcam images is supported through the addition of a "webcam" message type. Before sending, the webcam image is converted into a text format and split into multiple packets that are

sent via the MQTT server to the targeted recipients. When they arrive the packets are

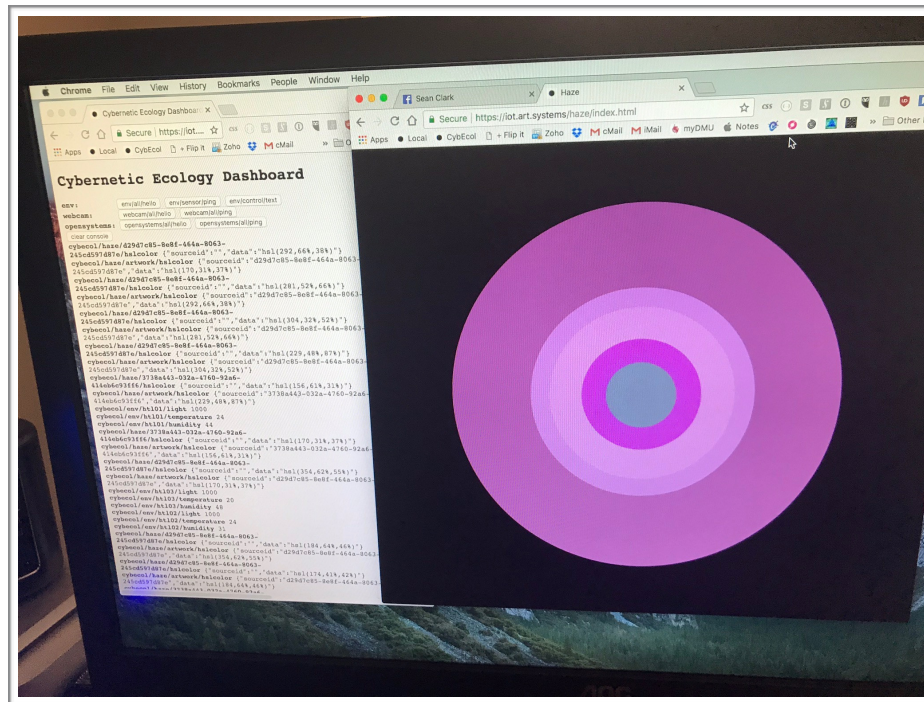then reassembled and converted back to an image format.

Figure 7.27 Signal, on the right, with an MQTT message console, on the left.

As part of *A Cybernetic Ecology*, software clients were written in Javascript for web

browser artworks (such as those using the Chrome web browser, or Chrome OS), in

Wiring for micro-controller artworks (such as those using the Arduino) and in Python

for single-board computer artworks (such as those using the Raspberry Pi). The

technology has been named *The Internet of Art Things* and is being made available for

use by other digital artists (see Appendix IV).

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CHAPTER 8: Results

In the introduction to this thesis it was stated that the primary goal of the research programme was **to develop a framework that would provide a set of tools to enable the connections between a collection of digital artworks and their audience members to be described and represented visually**. The corresponding *Framework for Connected Digital Artworks* has been presented in detail in Chapter 6 and a cycle of artwork development making use of it presented in Chapter 7. The results of this research cycle are described below.

The *A Cybernetic Ecology* artworks presented in Chapter 7 used the framework in both its conception and contextualisation. Aesthetically, these artworks are significantly different from the creative work described in Chapter 5. However, the *Framework for Connected Digital Artworks'* terminology and visual notation makes it possible for the commonalities from a systems perspective to be described.

The digital art system [Framework Point 1.1] is seen in terms of an environment [1.5] with systems defined by boundaries [1.6]. These systems are then analysed in terms of their open, closed and isolated state [2.3] and the nature of their communications, via inputs and outputs [1.7] involving the exchange of matter and/or energy [2.1 and 2.2]. The framework's conceptualisation of the digital art system then sees them as containing a pattern of organisation [3.1] and a process of organisation [3.2].

These principles are concisely illustrated in the artwork *System 1* (Section 7.3.2) where the two colour grids are configured to exchange colours and reorganise themselves in

response to the exchange. The pattern of organisation of the artwork, colours arranged according to their hue, saturation and lightness levels, is a result of the process of organisation, a colour sorting mechanism.

System 1 also illustrates the multi-level potential of systems-based digital artworks. The piece can be seen as two interacting artworks (the left and right grids) that are individually *open* but part of a *closed* network. Both parts are on the same screen that is presented as a whole when exhibited. However, in the artwork *Signal* (Section 7.4.3) each part runs on a separate screen and the whole is the result of the three being placed next to each other in the gallery. Since the parts of *Signal* communicate via the internet they could easily placed in different locations, resulting in parts that may not be seen as wholes by an observer who only visits one of the locations.

The analysis of artworks using the *Framework for Connected Digital Artworks* can also be applied to the *components* of the digital art system. *System 1* and *Signal* are both made of parts (collections of colours organised according to their patterns) and it would be quite possible to see these parts as being artworks in their own right that could be distributed across multiple locations. The value of doing this with these particular pieces is not agued for, but the possibility remains.

The *A Cybernetic Ecology* exhibition as a *whole* takes the concepts highlighted above even further. Multiple digital artworks, in multiple locations, involving multiple artists, communicate via the colour swapping service. The central piece, my artwork *Transformations* (Section 7.4.1), is an ambitious extension of *System 1* containing six triptychs, each composed of one digital and two print works. Again, the grouping of

parts and wholes is at one level implied by the grouping of the triptychs on the gallery wall, but a larger multi-location whole is also present and the triptychs could be broken in to parts, which themselves are made of parts.

The communication between the digital parts of *Transformations* is made possible by an internet service. Initially conceived with the sole purpose of enabling colour swapping between my digital art systems, during the development of the artworks it became a generic platform for inter-artwork communication that I call the *Internet of Art Things*. The *Internet of Art Things* infrastructure makes use of standard Internet of Things services and technology to allow the exchange of images and other media as well as colour values between digital artworks powered computers, web browsers and micro-controllers.

The title of the final exhibition, *A Cybernetic Ecology*, was taken from a line from the poem *All Watched Over by Machines of Loving Grace* by Richard Brautigan. Within the *Framework for Connected Digital Artworks*, the term used for collections of connected digital artworks [Framework Point 4.1] that exhibit a high degree of connectedness [4.2] is a digital art ecology [4.3]. The closeness of these two terms is such that the generic term cybernetic ecology should be seen as a synonym for digital art ecology, with *A Cybernetic Ecology* being an example of such a work.

The different roles of the human components of *A Cybernetic Ecology* are also made clear by applying the framework to the digital art systems contained within the exhibition. The artist [1.2], or in fact *artists*, are myself and the other contributors, whose role was to define the properties of the digital art system. In all cases, the artists

did not remain actively involved in the development of the exhibition once it had been installed so were not included in the visual notation shown in Section 7.5

The human visitors to this exhibition were, intentionally, largely viewers [1.4], since they could not directly influence most of the artworks. The exception to this was *Cities Tango 2*, where the people were participants [1.3], able to trigger changes in that particular artwork. This is in contrast to the *Symbiotic* exhibition (Section 5.6) where, again intentionally, all of the humans entering he exhibition were participants and the viewer role was only possible by observing the operation of the artworks from outside of the gallery space.

The use of the *Framework for Connected Digital Artworks* in the development of *A Cybernetic Ecology*, as well as the retrospective analysis of the foundation works in Chapter 4 and *The Interact Gallery* and *Symbiotic* exhibitions (Chapter 5) demonstrates how a systems-led view with a defined set of terms can be used to understand the nature of digital art systems. This systems view was grounded in the early work of Cornock and Edmonds, but extends their insights to include a more detailed understanding of the operation of the art system (in terms of pattern and process) and the nature of the connections between the art systems (as an exchange matter and energy).

Using the theory of autopoiesis by Maturana and Varela (1987) to aid the conceptualisation of the operation of the digital art system enabled the distinction between pattern and process of organisation to be made. In *System 1* and *Transformations*, both a pattern and process can be clearly identified. This is an

important contribution to the analysis of digital artworks from a systems perspective, the implications of which are discussed further in Chapter 9.

The distinction between the exchange of matter and the exchange of energy, using terms borrowed from thermodynamics, has proven to be a valuable part of the systems approach to understanding digital artworks. *Cities Tango 2* takes images from its environment and exchanges them across the network of nodes. This matter contributes to the material contained *within* the artwork. Likewise, the colour swapping artworks in *A Cybernetic Ecology* are regarded as swapping *matter* in the form of colour values. The *LED Panels*, however, do not take material from their environment. They use a sensor to *trigger* a change in the matter they contain. In this case the change is an alteration of the light value of their in response to the environment. Again, this is an important contribution to the conceptualisation of communication between digital artworks and is discussed further in Chapter 9.

The identification of parts and wholes using the *Framework for Connected Digital Artworks* is intended to be fluid and involve the person using it. This is undoubtedly the case in my analysis of artworks, as presented in Chapters 6 and 7. The analyses represent my view of the key features of the artworks at the time. As a systems thinker, though, I am aware that it may be useful to change my perspective and look for parts and wholes elsewhere.

The visual notation described in Chapter 6 (Section 6.2) is a valuable tool for uncovering the relationships between the parts and wholes in a digital art system. Its application is first shown in Section 6.3 with reference to generic artworks and those

described in the foundation work. It was then applied to *The Interact Gallery* (Section 6.4) and *Symbiotic* (Section 6.5) before being used in *A Cybernetic Ecology* (Chapter 7). This has resulted in a set of case studies in how the visual notation, and the framework in general, can use applied to the analysis of digital artwork.

Across multiple cycles of research, a large body of new artworks have been produced which are documented throughout this thesis and in the appendices. The important *Memory Mirror* artwork (Section 5.4.1) can be seen as having evolved from the foundation works *vLooper* (Section 4.3) and *Autopoiesis* (Section 4.4) before becoming *One Living Thing* (in *The Interact Gallery*) and *The Whale* (in *Symbiotic,* Section 5.6.1). Many of the ideas within *ArtScanner* (Section 4.2) were present within the app-based artwork *Dropsketch* (5.4.2). All of these artworks involved the incorporation of multimedia materials generated by participants. In *The Interact Gallery* exhibition, *Moving Pictures* (5.4.3) the viewer to simply *triggered* changes within the artwork, something that was also done within *Red Spinner / Blue Spinner* (5.6.2) in *Symbiotic*. As highlighted earlier, despite these differences, insights in to the nature of all of these artworks can be gained by applying the *Framework for Connected Digital Artworks*. Potential new artworks resulting from these insights are discussed in Chapter 9.

The value of the *Internet of Art Things* infrastructure produced for *A Cybernetic Ecology* is demonstrated not only by the *Transformations* artwork but also in how it is used in the collaborative pieces *Cities Tango 2* (with Ernest Edmonds) and *Signal* (with Esther Rolinson) and by Genetic Moo's *The World, the Flesh & the Devil.* In these cases very different digital artworks are connected to each other via the internet and the use of

the *Internet of Art Things* colour swapping service. This suggests a very interesting potential in the definition of standard methods of communication to enable digital artists to create connected digital artworks that communicate over distance. This is also discussed further in Chapter 9.

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CHAPTER 9: Concluding Discussion

Cornock and Edmonds' paper *The Creative Process Where the Artist is Amplified or Superseded by the Computer,* first circulated in 1970, was an important reference point throughout the research programme. It demonstrates how a systems-theoretical view of technological art could remain useful over time, even if when the technology used by the artists to create the work changes significantly. This in itself is a very systems-like observation, with the *whole*, the art concepts being explored, being able to persist even if the *parts*, the technology used, change.

In a field of art practice where the medium is constantly changing, a method of contextualising an artwork that is not dependent solely on the current properties of the medium should be seen has having a particular utility. Indeed, I would go as far to suggest it is essential and that *The Framework for Connected Digital Artworks* contributes to this in a significant way. It certainly adds support to the idea that a systems approach can be applied to this problem and it provides a base on which further research can be built, just as it itself builds on earlier research.

The framework is therefore valuable at both a conceptual and constructional level. As well as enabling the artist to actively engage with the interactive nature of an artwork and understand its internal and external processes and relationships, it also provides an environment in which future artworks can be imagined. Understanding that an artwork comprises of parts and wholes held in relationship to each other and organised by

processes to form patterns opens a wide range of creative possibilities snd a conceptual platform for future work.

In my own work, I now look at the materials available to me – computers, networks, software, sensors and so on – in terms of their ability to enable the construction of connected systems. This applies to newly developed materials as well as existing ones. This is significant in that it separates me from the 'newer is better' mentality that is often associated with artists who work with digital technology. In no other medium is the newness of the materials used so often allowed to dominate over the ideas and processes contained within the artwork. This is something that I would expect other artists applying *The Framework for Connected Digital Artworks* to their work would begin to adhere to – *the system, its parts and its connections are more important than the parts themselves.*

I have not argued that the presence of systemic properties within the digital art system should be seen as part of the process of *aesthetic interpretation* of the artwork. This is something, though, that does interest me as an artist. The idea of a "systems aesthetic" has be proposed before (Burnham, 1968) and "systems art" is a well-defined art form in its own right (Shanken, 2015). These, however, were not part of the central focus of this thesis and aesthetics have not been explored as part of the research programme.

My future artwork will engage in the idea of a systems aesthetic, or rather a "connected aesthetic" in a much stronger way. Such an aesthetic will be focussed around representations and expressions of *connectedness* as a key property of the artwork. This will undoubtedly have a significant impact on my practice and will strengthen the

concept of the connected digital artwork further. The colour swapping mechanism used in *A Cybernetic Ecology* is an interesting candidate for something out of which artworks containing a connected aesthetic will emerge. However, more research is needed to ascertain how audience members might be able to appreciate this quality in an artwork. Some audience data relating to this was collected during *A Cybernetic Ecology*, but a further cycle of Theory-Create-Exhibit-Reflect will be needed to analyse this and create artworks that will focus audience members' attention on the aesthetics of connectedness.

An important aspect of the *The Framework for Connected Digital Artworks* is in how the open, closed and isolated nature of digital art systems and their components is defined by their ability to exchange matter and energy. Consistency with the terminology of thermodynamics is maintained throughout the thesis, with *multimedia material* being analogous to matter and *triggers* being analogous to energy. The analogies are important ones, since when combined with the concepts of *pattern of organisation* and *process of organisation* they form the basis of a rich language for describing digital art systems.

In the physical world, where thermodynamics operates, both energy and matter are subject to laws of *conservation*, where neither can be created or destroyed. Both can pass through the boundary of a system (depending on the system type) but cannot be in more than one location at a time or spontaneously disappear. This is something that is not explicitly enforced in the operation of my digital art systems, but it could be.

Conservation of energy and matter could be implemented through technology, particularly if the artworks were communicating through the *Internet of Art Things*

infrastructure. In a set of artworks connected in this way, any materials entering a digital art system from the environment would be recycled around the cybernetic ecology until they returned to the environment. It would be possible for these materials to be decomposed (for example, colours could be broken up in to their red, green and blue components) and recombined (three musical notes might form a chord that is then passed around as a single entity). The "energy source" for such processes would be the interactive triggers provided by the human participants.

While this may appear to be stretching the thermodynamics metaphor, a principle implemented within the *Transformations* artwork is that once digital components start no new colours are created and when the artwork is operating by itself matter (the colours) is conserved. A version of the artwork where the process of organisation only took place when the energy of human participation was present was considered during the research cycle and will be investigated in future iterations of the artwork.

The work of Maturana and Varela was important in expanding the conception of the digital art system by identifying a relationship between *pattern* and *process*. Their concept of autopoiesis was also a valuable motivating principle in the creation of many of the artworks. This interest predates the start of the research programme, as apparent in its use as the title for one of the foundation works.

Despite progress being made in my understanding the systemic nature of digital artworks, questions around the possibility of an autopoietic digital artwork remain. An autopoietic digital artwork would contain a network of processes or organisation that produce a pattern of organisation in turn enables the internal processes. The artwork

would be able to maintain its internal pattern and boundary in response to inputs and outputs and would probably conserve both energy and pattern. These concepts all sound consistent with the terminology used in this thesis to describe the operation of digital art systems. However, I am still unsure as to if the term "autopoietic" could genuinely be applied to to a digital artwork even if it appeared to contain these properties.

The term "autopoiesis" was originally introduced by Maturana and Varela to describe the operation of biological organisms and their chemical and metabolic processes. The concept has been extended to include descriptions of cognitive and social processes, but my intuition is to say that ultimately it is something that can only be part of living systems and networks of living systems. As such, a digital artwork, or any machine that operates at least partly in the digital domain, may be able to *simulate* an autopoietic system, but this does not mean it *is* an autopoietic system.

This places the discussion of artificial autopoiesis in a similar domain to that of artificial consciousness and artificial intelligence. Again, at what point does the simulation become equivalent to the thing being simulated? This uncertainty only serves to maintain my interest in the concept of autopoiesis and it will remain as an important source of inspiration in the creation of my future artworks.

Another area of this thesis that would be a strong basis for further research is the *Internet of Art Things* infrastructure. The MQTT messaging protocol used may appear simple, but it is highly flexible. The standardised topic hierarchy allows messages to be passed around collections of art systems, as well as their components, and communication logic to represented as rules in a node.js process.

In a presentation at the EVA London conference in July 2018 (see Appendix IV; included on the attached USB stick) I presented the *Internet of Art Things* as having the potential to become an open infrastructure for inter-artwork communication. Users of *Internet of Art Things* platform would be able to register names of their digital art systems with a central service, together with a definition of the artwork's input and output capabilities. Artworks by multiple artists could then be grouped in to cybernetic ecologies that would be distributed around the world, connected by the internet and IoAT messaging. This idea was progressed further though my involvement in the the Mozilla Open Leaders programme, an invitation-only training course designed to assist in the development of open technologies projects. "artThings" now has a shared code repository on GitHub and is actively recruiting project participants [26].

One final aspect of the *Framework for Connected Digital Artworks* that warrants further exploration is its expansion to integrate more human roles and biological systems. A hypothetical *Framework for Connected Artworks* would consider all participating systems in the connected artwork, both the digital and human (and even plants and animals in keeping with Richard Brautigan's poem), in the same way. Such an artwork might include participative or performative human-to-human elements, combined with interacting digital elements. The artwork would be described purely in terms of the function of the systems it contains. The artwork could then be realised equally through the organisation of its parts by digital or human systems. A prototype artwork of this type based on *System 1* was produced just prior to the completion of this thesis. In *System Game 1* the pattern and processes are codified in a set of written rules and the

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[26] artThings. https://github.com/seancuttlefish/artthings

coloured squares are reorganised by a human player without the use of a computer at all. The production of a framework to describe such artworks would require more research and, most certainly, a new starting contextualisation.

This discussion demonstrates that the research programme presented in this thesis has not only resulted in the development of the *Framework for Connected Digital Artworks*, a body of new digital artworks and a new inter-artwork communication infrastructure, but it has also stimulated the formation of many new ideas for the development of future artworks and research.

As an artist I have found the practice-based research process challenging, but ultimately rewarding. All artists are researchers, even if they are not aware of the fact. We experiment, theorise and create and in doing so we become more accomplished at what we do. What artists are not necessarily good at, though, is formalising, externalising and sharing our personal research processes. However, it is only in this formalising, externalising and sharing where new knowledge can be found. *From Connected Digital Art to Cybernetic Ecologies* is my contribution to this process of knowledge generation through art practice. I hope that the tools and examples it contains will be a source of inspiration to others, especially other artists, looking to follow a similar path.

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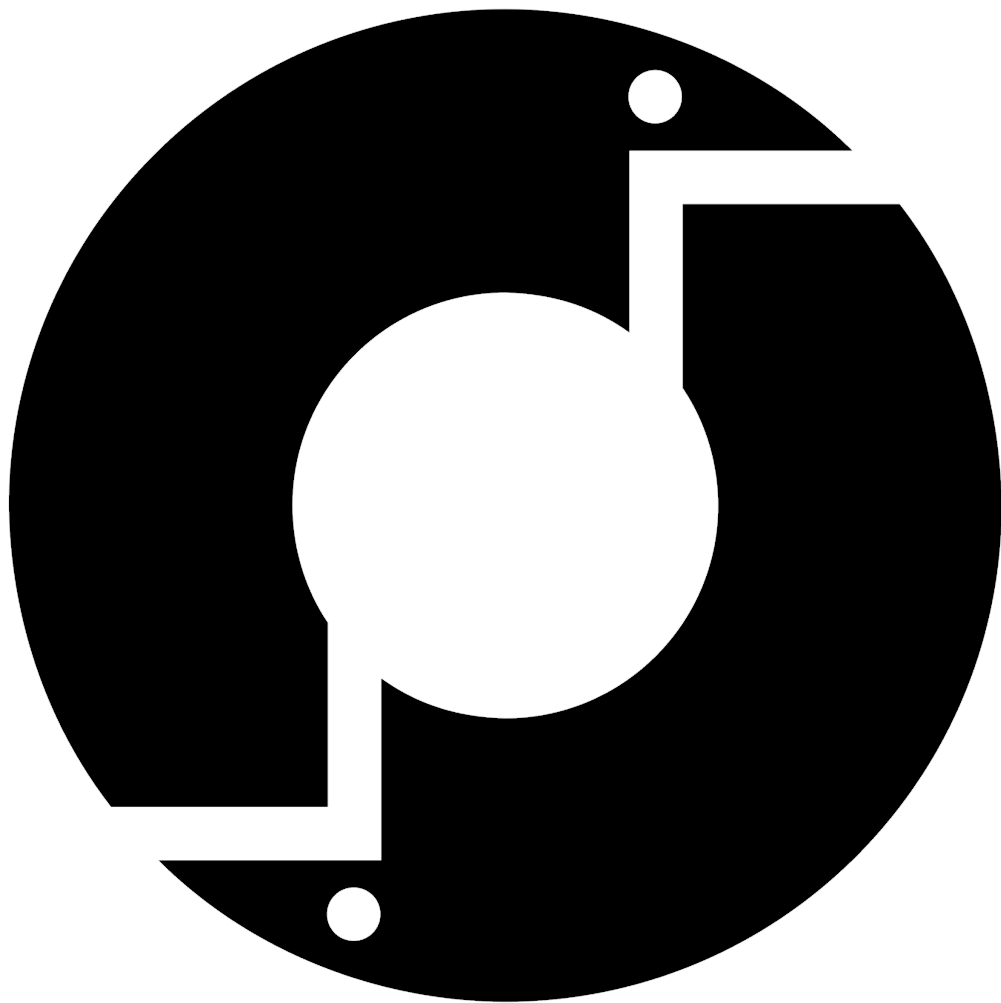
"The one feeds the other"

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APPENDICES

All of the photographs in the appendices are included on the USB stick attached to the inside back cover in the **Photographs** folder. The videos, in QuickTime mp4 format are included in the **Videos** folder. General PDF documents are in the **Documents** folder and papers are in the **Published Papers** folder. A copy of **The Interact Gallery** website is also included that can be viewed by opening the index.html file in a web browser.

A copy of this thesis in PDF format is also included in the **Thesis** folder.

The contents of the USB stick can also be downloaded from:

http://www.seanclark.me.uk/phd/

I: Foundation Work

- *I See You* photographs

- *I See You* video (included on USB stick)

- *ArtScanner* photographs

- *vLooper* photographs

- *vLooper* video (included on USB stick)

- *Autopoiesis* photographs

- *Autopoiesis* video (included on USB stick)

I See You (2008)
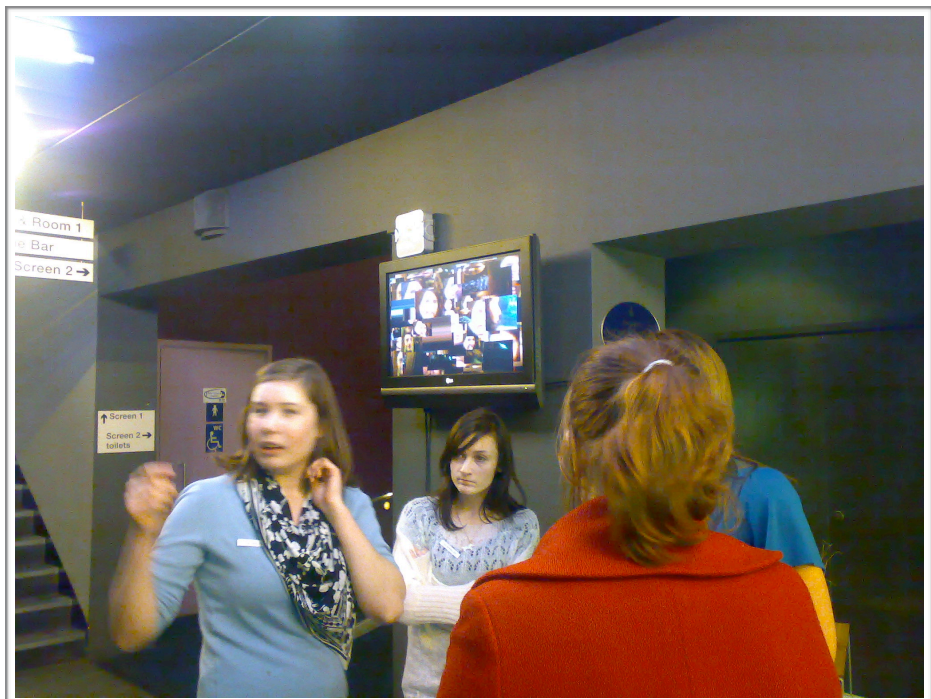
I See You (2008)

ArtScanner (2008)

ArtScanner (2008)

vLooper **(2008)**

vLooper **(2013)**

Autopoiesis (2008)
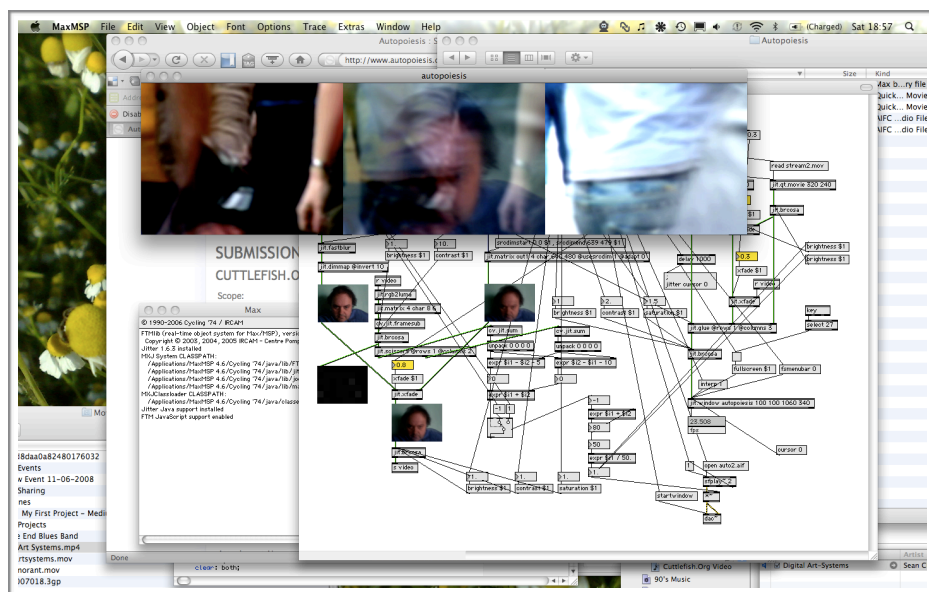
Autopoiesis (2008)

II: The Interact Gallery and Symbiotic

- *The Interact Gallery* photographs.

- *The Interact Gallery* walkthrough video (included on attached USB stick). Recorded by John Coster.

- *Interact Live* video (included on attached USB stick).

- *The Interact Gallery* website (included on attached USB stick).

- *Memory Mirror aka One Living Thing* photographs.

- *Memory Mirror* video (included on attached USB stick).

- *Summer Sundae* video (included on attached USB stick).

- *Dropsketch* photographs.

- *Reflections on Growth and Form* images.

- *Symbiotic* photographs.

- *Symbiotic* walkthrough video (included on attached USB stick).

The Interact Gallery (2011)

The Interact Gallery (2011)

The Interact Gallery **(2011)**
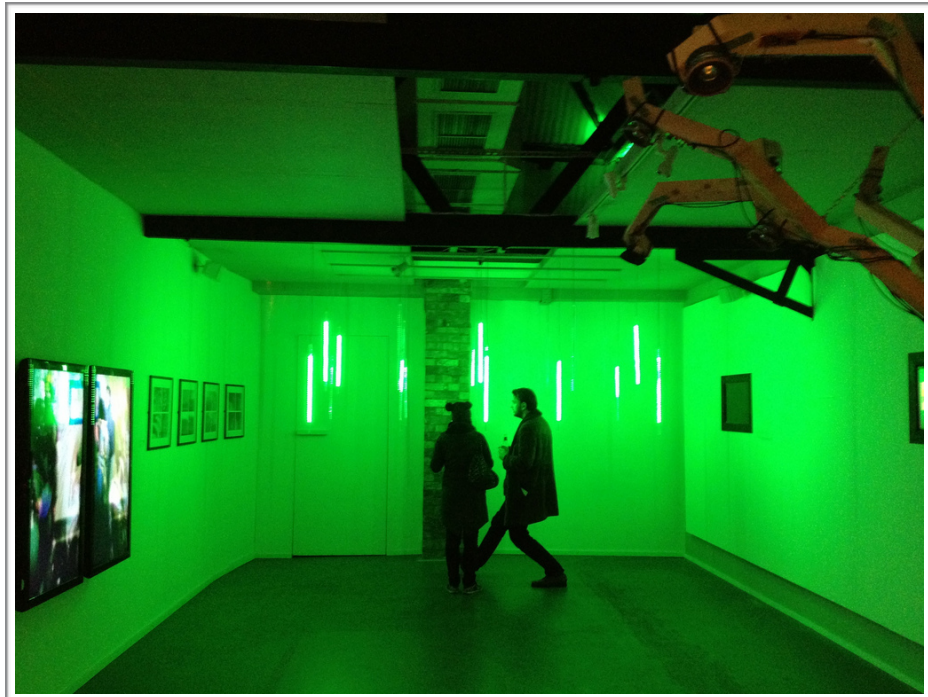
The Interact Gallery **(2011)**

Memory Mirror **(2011)**
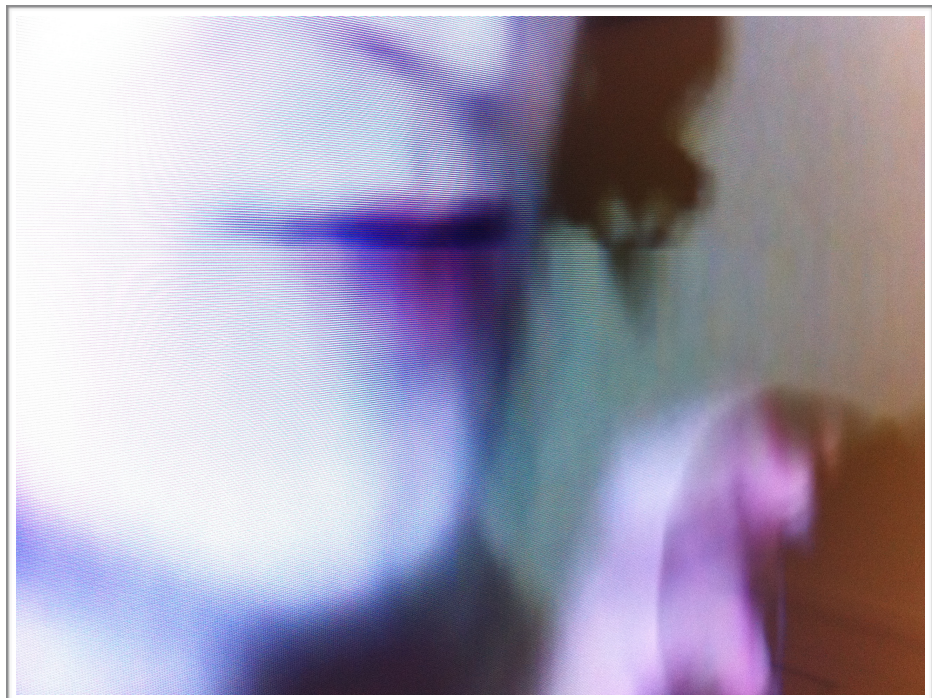
Memory Mirror **(2011)**
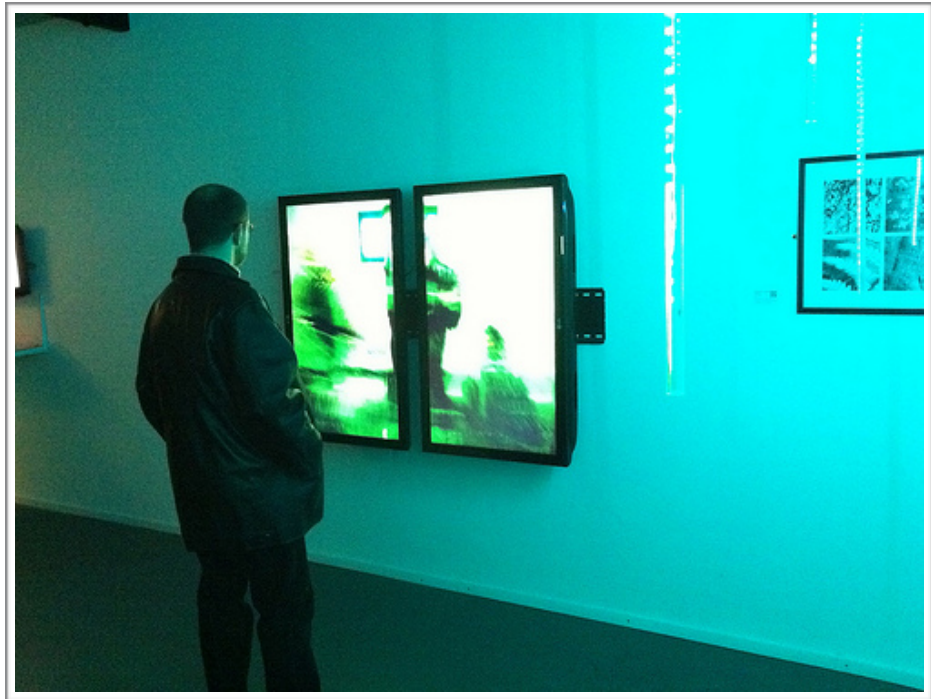
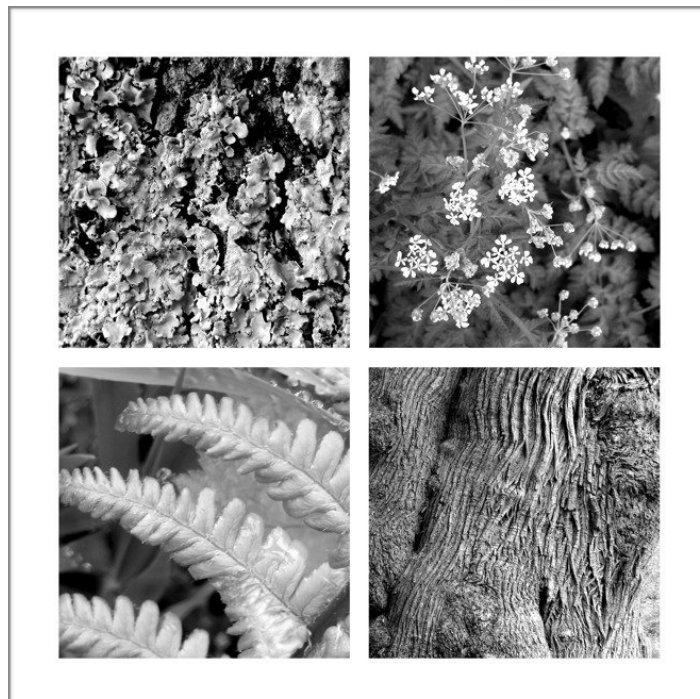***One Living Thing*** (2011)
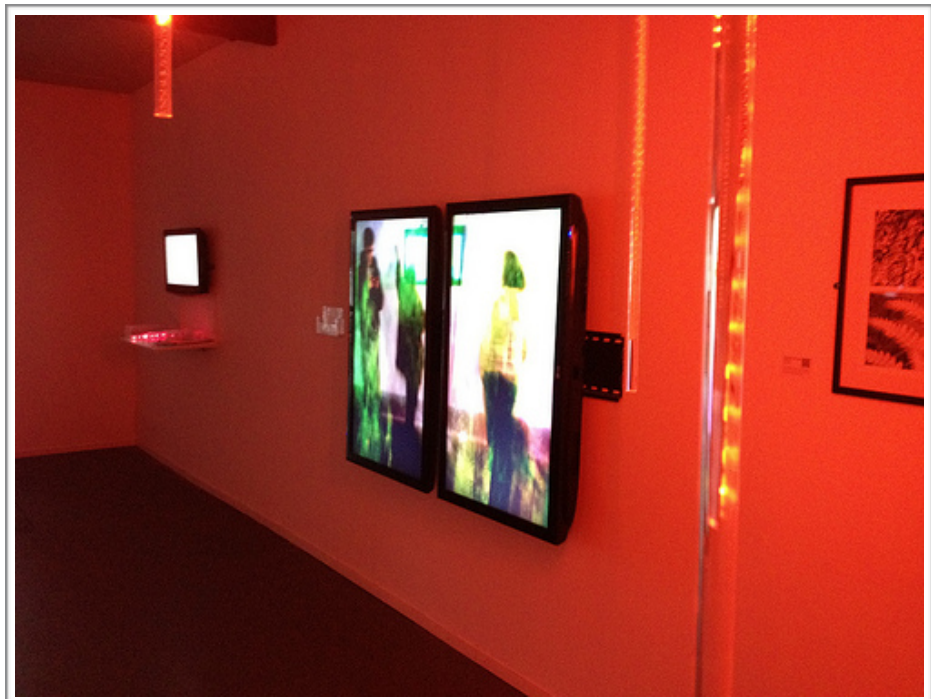
One Living Thing (2011)
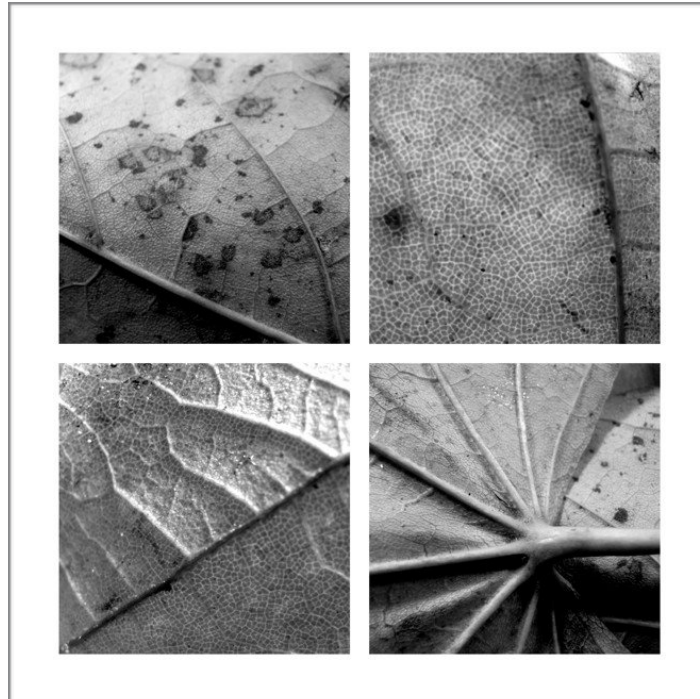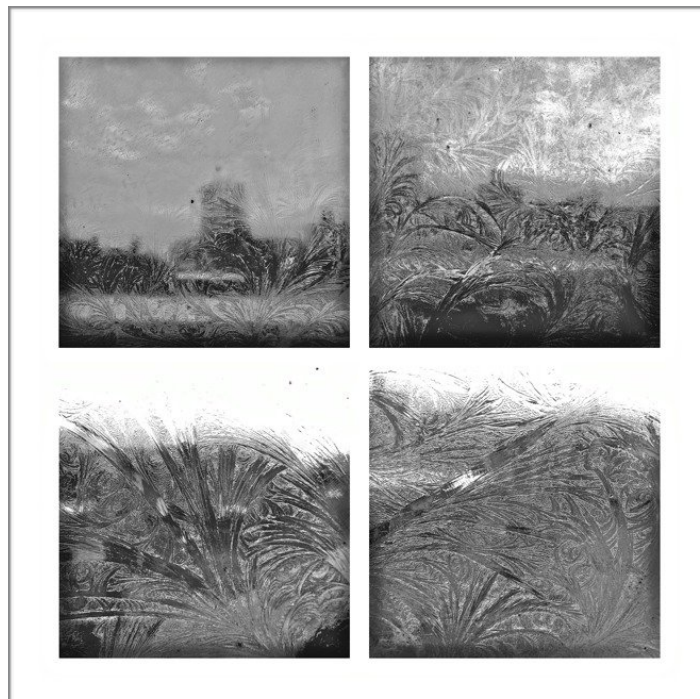
Dropsketch (2011)

Dropsketch (2011)

Reflections on Growth and Form (2011)

Reflections on Growth and Form (2011)

Reflections on Growth and Form (2011)

Reflections on Growth and Form (2011)
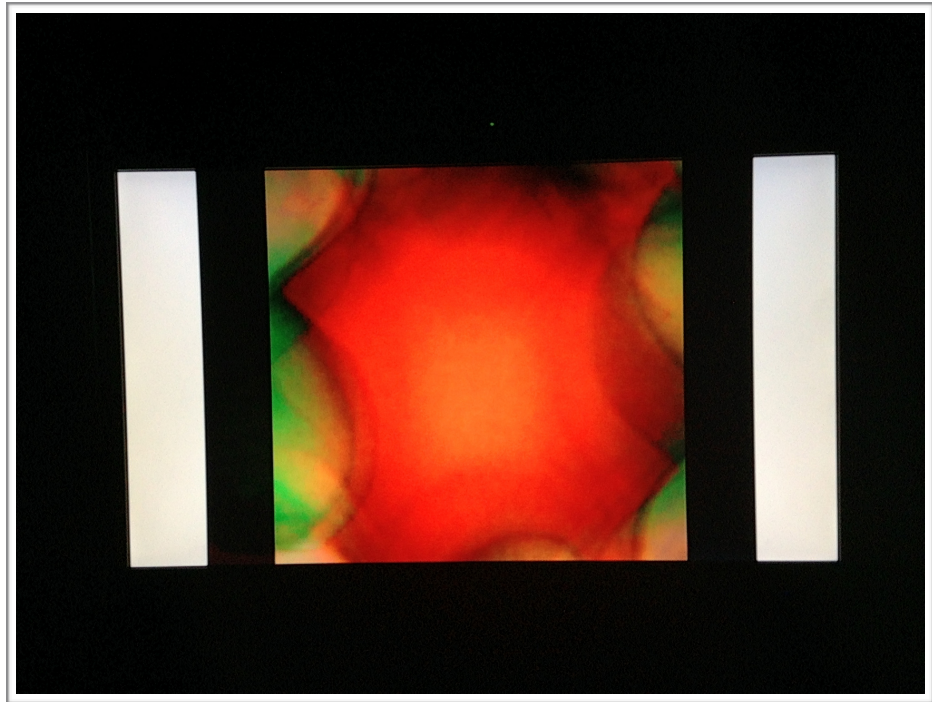
***Symbiotic* exhibition (2012)**
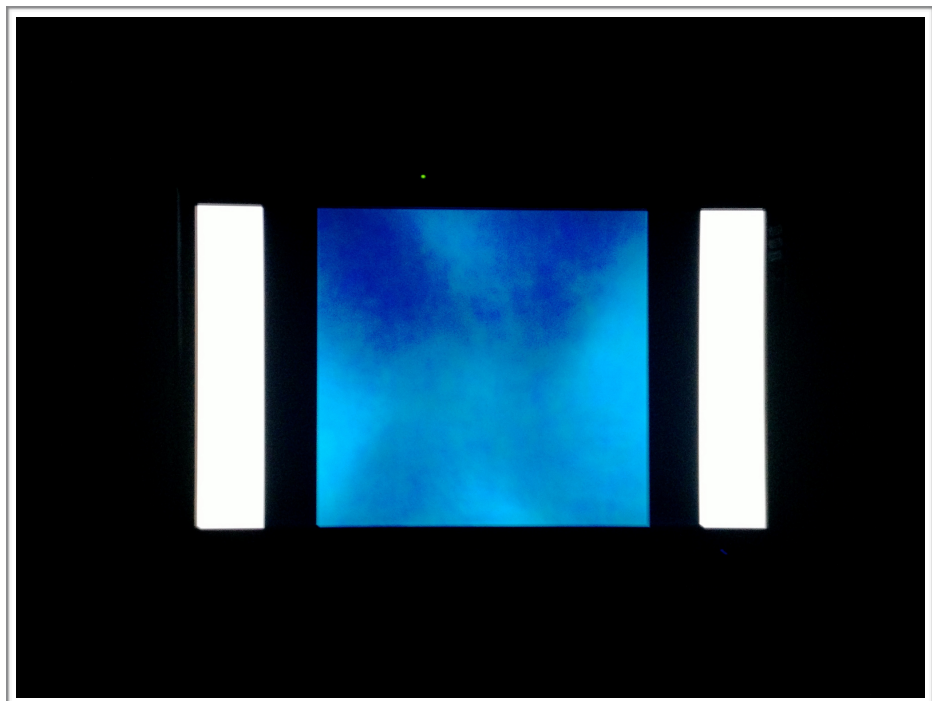

***Symbiotic* exhibition (2012)**

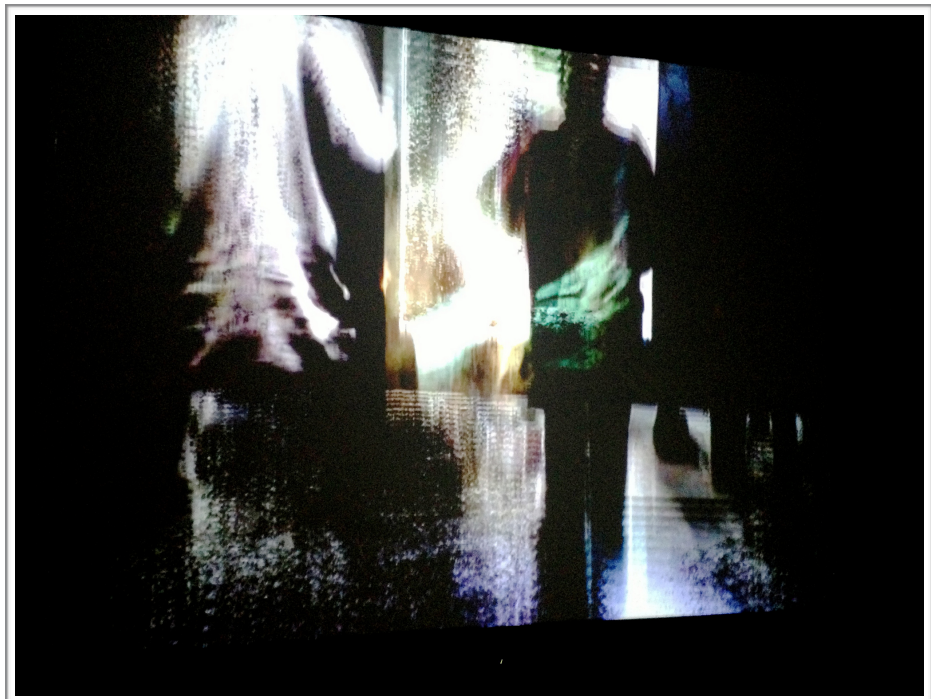***Symbiotic* exhibition (2012)**

***Symbiotic* exhibition (2012)**

Red Spinner (2012)
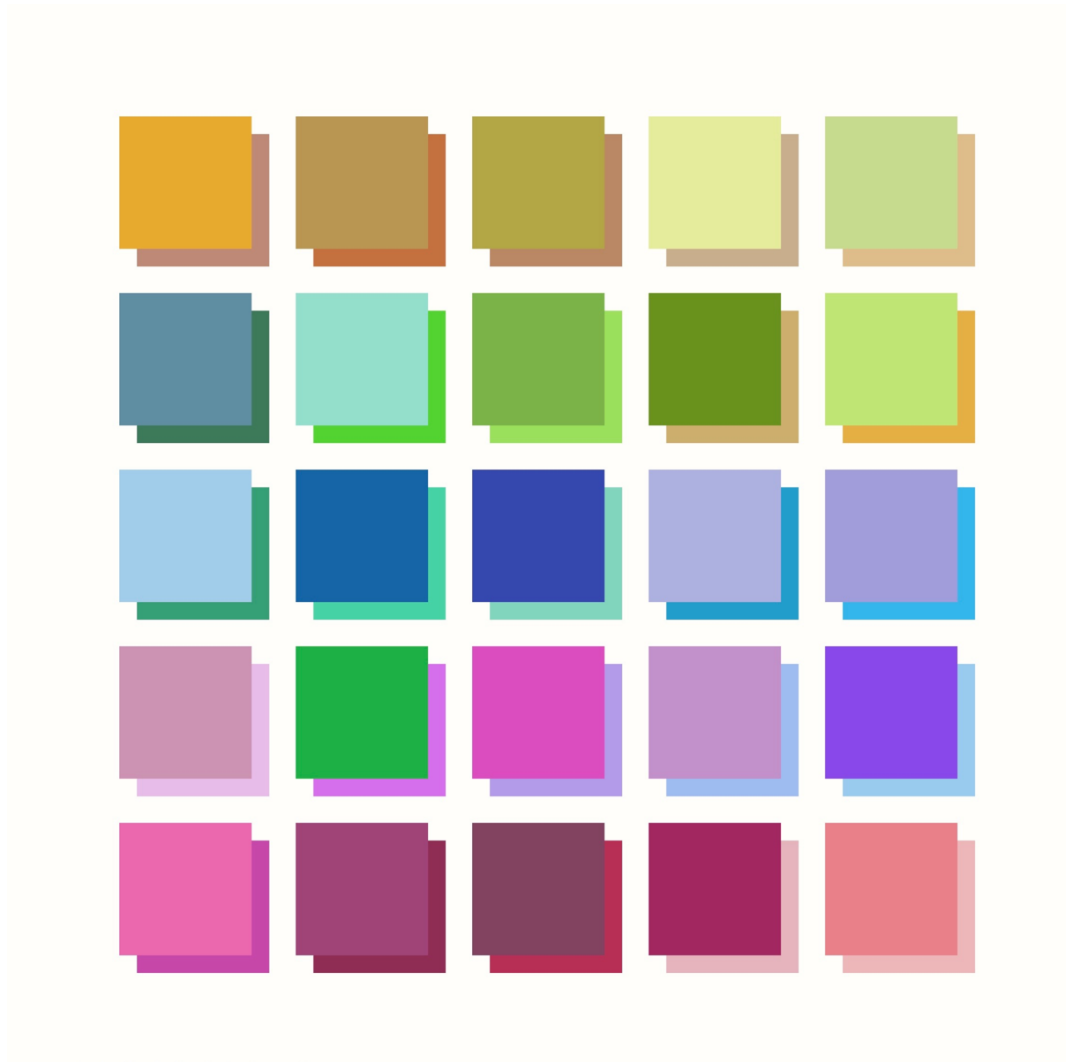

Blue Spinner (2012)

The Whale **(2012)**

The Whale **(2012)**
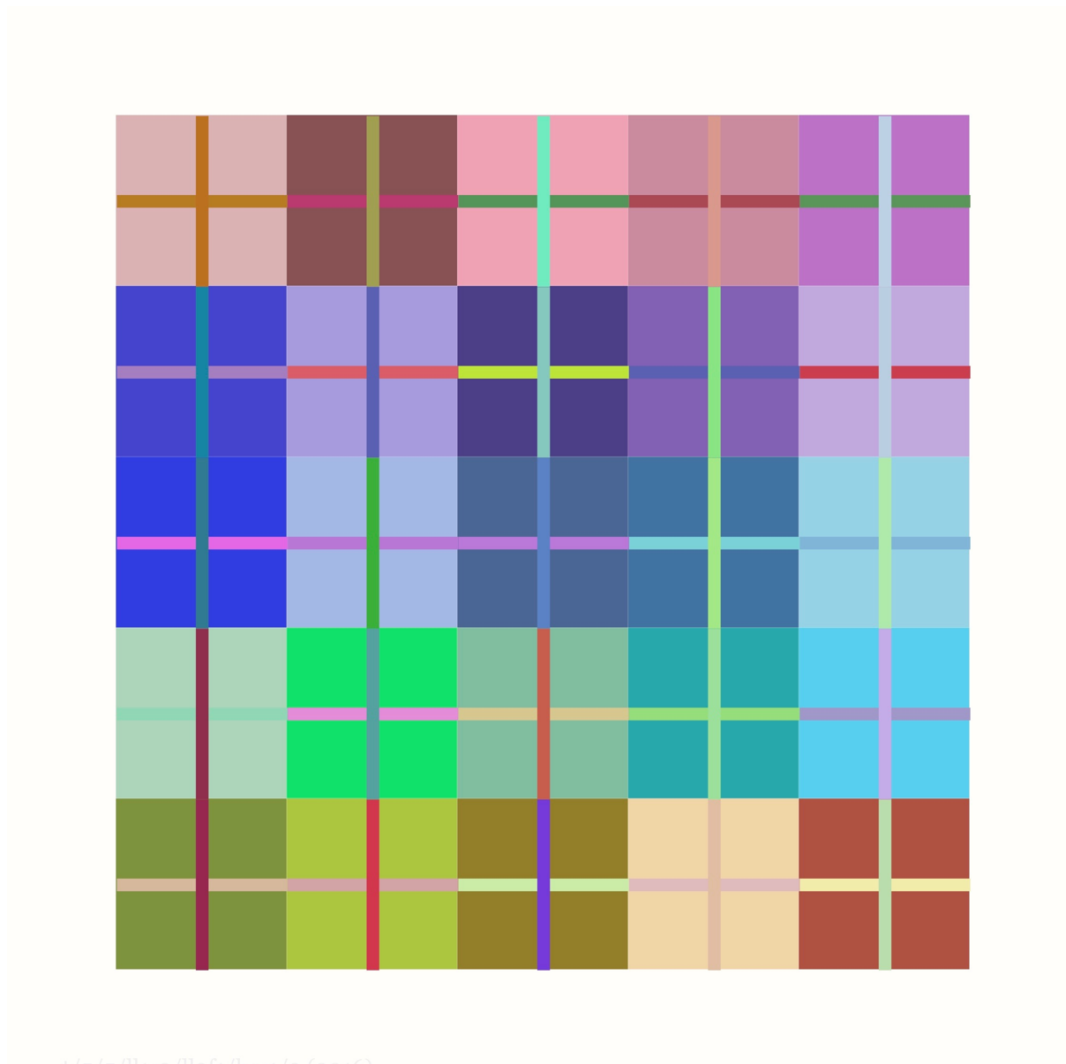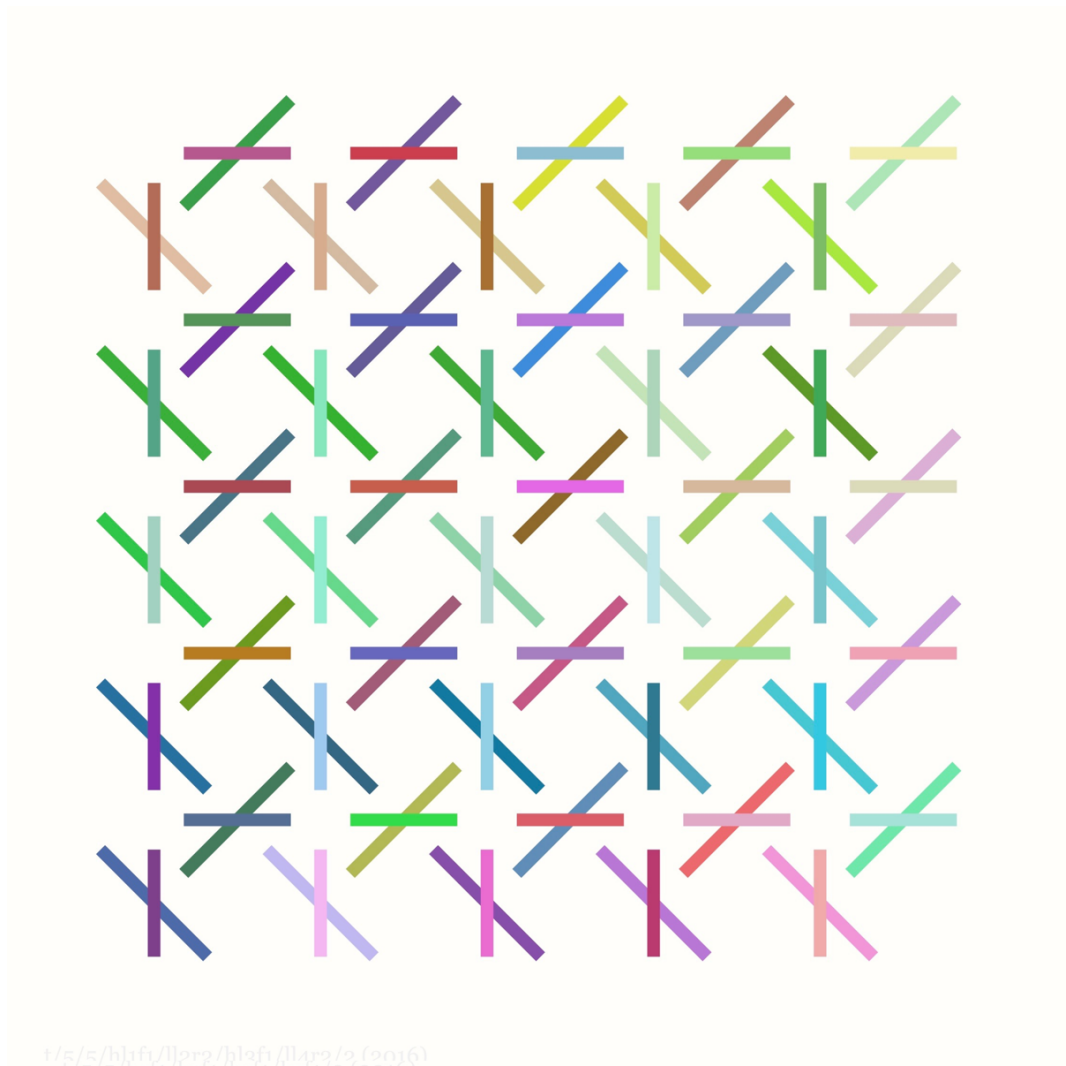
III: A Cybernetic Ecology

- Transformations 1 - 6.

- *A Cybernetic Ecology* exhibition photographs.

- *A Cybernetic Ecology* live event photographs.

- A Cybernetic Ecology artist statement and context.

Transformations 1 (2016).

Transformations 2 (2016).

Transformations 3 (2016).
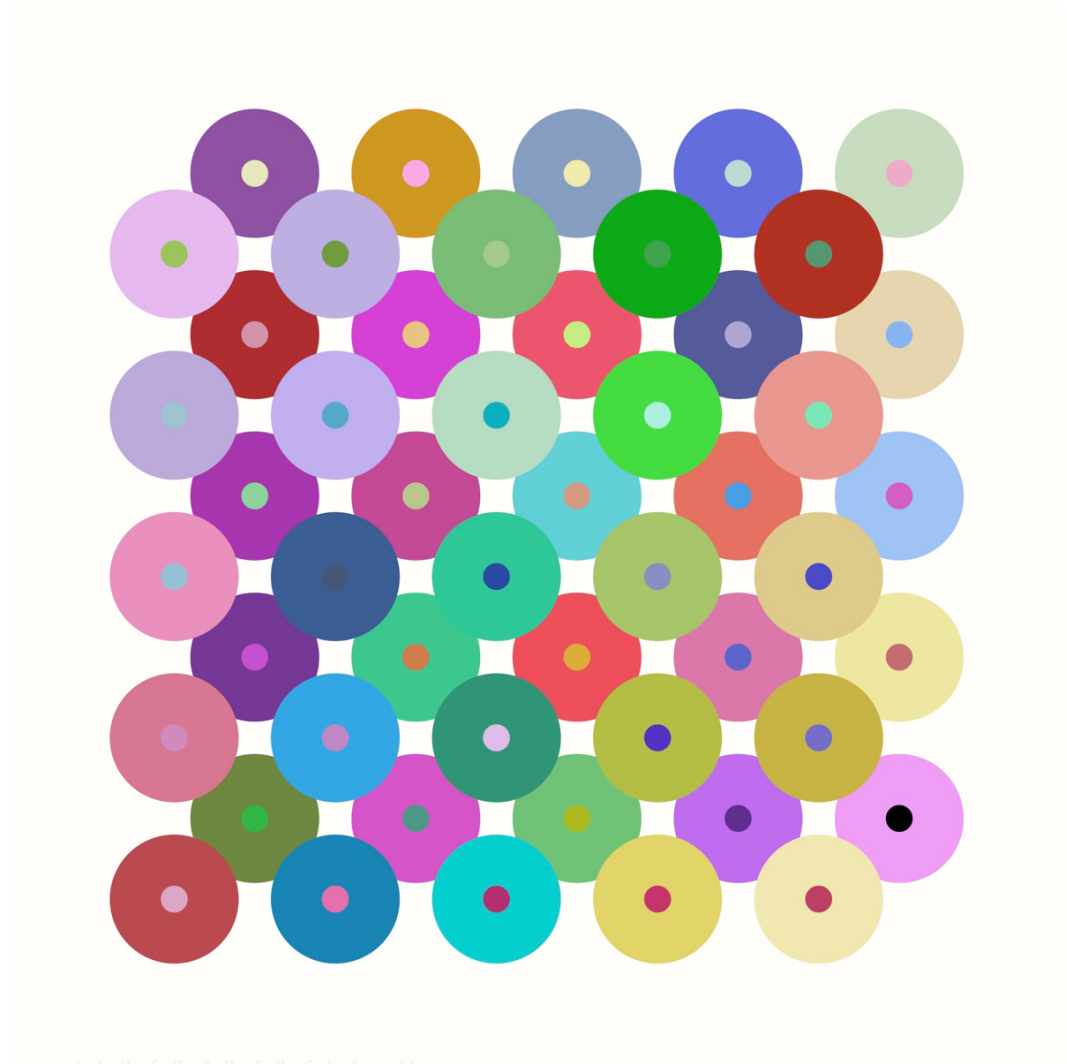
Transformations 4 (2016).

Transformations 5 (2016).

Transformations 6 (2016).
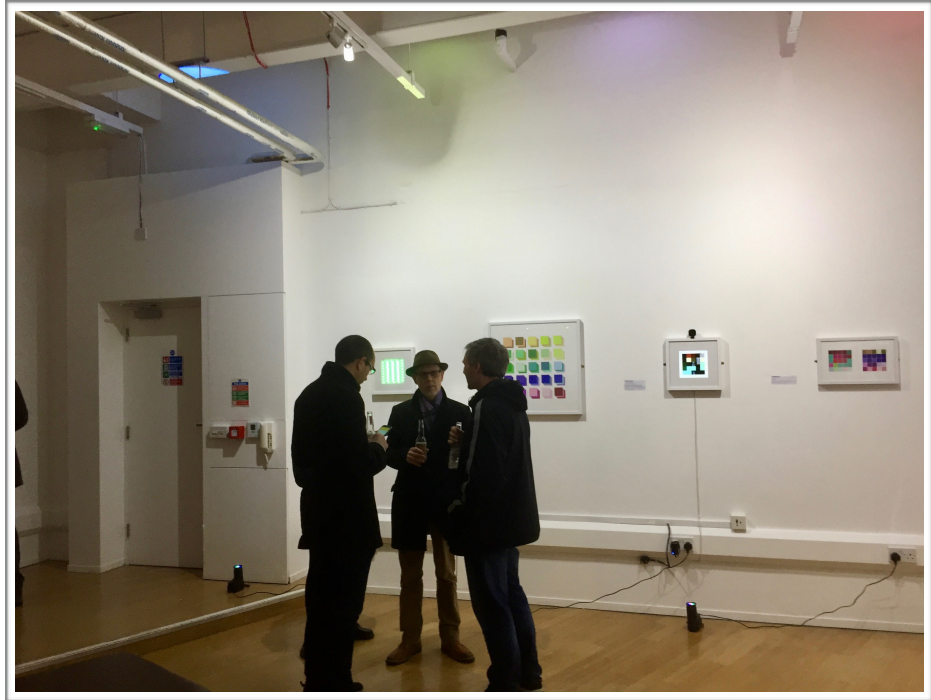
A Cybernetic Ecology exhibition (2016).

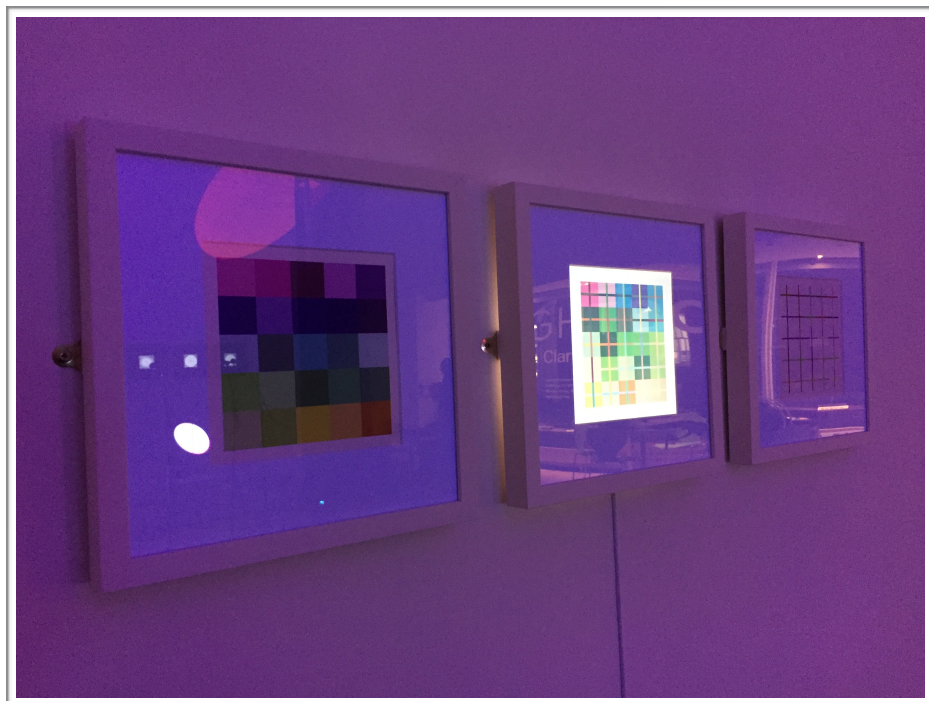

A Cybernetic Ecology exhibition (2016).

A Cybernetic Ecology exhibition (2016).

A Cybernetic Ecology exhibition (2016).

A Cybernetic Ecology live event (2016).

A Cybernetic Ecology live event (2016).

A Cybernetic Ecology live event (2016).

A Cybernetic Ecology live event (2016).

A Cybernetic Ecology

Exhibition by Sean Clark

Introduction

This Arts Council England supported exhibition began as a question: "How can I use my interest in systems to create digital artworks?" Despite having a long interest in 'systems theory' I spent much of my time first trying to make sense of what I actually meant by a 'system'. The textbook definition is 'a set of things working together as parts of a mechanism or an interconnecting network'. This is fine, but how do you distill it in to something that you can use as the basis of an artwork?

After a number of attempts at creating systems-like artworks (some worked better than others) I settled on a concept that, to me, captured the essence of the systems world view – *connectedness*. While may be cliché to say "everything is connected", it's factually true. Nothing exists in isolation and everything is made of parts whose *connectedness* makes the 'thing' what it is. What's more I felt that, connectedness is a concept familiar enough to people to form the basis of an artwork or other creative project.

The work on display here is all connected, be it through the patterns they contain or through a live process. The screen-based pieces in particular demonstrate my approach to exploring connectedness in a very real and dynamic way.

Each of the *Transformations* screens contains two or more grids of colours that are ordered according to rules such as "increasing hue (colour wheel) values" or "decreasing brightness". The grids are overlaid and make use of coloured shapes, such as squares, circles or triangles. Each grid activity monitors its 'state of organisation' and when fully organised (according to its rule) it swaps a colour with one of the other artworks. These artworks then work to incorporate the new colour by finding the correct position for it in the grid. Hence the artworks are constantly maintaining their pattern (or system) in response to their *connectedness* to the other artworks. The prints either side of the screens can be used to help you decode the rules (if you so wish).

As well as the core *Transformations* artwork, other artworks (produced in collaboration with Ernest Edmonds, Esther Rolinson and Genetic Moo) also form part of the colour swapping system. Creating an ever-changing network of self-organising artworks.

While I was working on the processes and technology that became the underlying enabler for this exhibition I remembered a poem by Richard Brautigan that seemed to capture even more of what I was trying to achieve through this exploration of connectedness. "All Watched Over by Machines of Loving Grace" became my muse as I developed the work and a line from the poem "A Cybernetic Ecology" became the exhibition title.

Sean Clark
December 2016
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All Watched Over by Machines of Loving Grace

By Richard Brautigan

I like to think (and
the sooner the better!)
of a cybernetic meadow
where mammals and computers
live together in mutually
programming harmony
like pure water
touching clear sky.

I like to think
(right now, please!)
of a cybernetic forest
filled with pines and electronics
where deer stroll peacefully
past computers
as if they were flowers
with spinning blossoms.

I like to think
(it has to be!)
of a cybernetic ecology
where we are free of our labors
and joined back to nature,
returned to our mammal
brothers and sisters,
and all watched over
by machines of loving grace.

Artworks

Transformations
Sean Clark
Six triptychs. Each comprising of an LCD screen and two digital prints

Each LCD screen contains two or more self-organising systems that swap colours via the Internet. A smaller version of this work was first exhibited at the EVA and HCI exhibitions in London and Bournemouth in June 2016.

One triptych is located at Phoenix.

Light Sensor
Sean Clark
LED grid and light sensor

The light sensor is used to monitor the illumination levels in the gallery. Colours received from the *Transformations* network are then adjusted to match the ambient light. At night the colours fed to the network become darker, in the day they become lighter.

Cities Tango II
Ernest Edmonds and Sean Clark
Three distributed screen-based artworks

Each artwork consists of three interactive systems. The first is a Transformations grid, the second exchanges background images from the installed location and the third exchanges webcam images.

The pieces shown here contain images from an installation that connected Leicester with San Jose, CA.

One artwork is located at Phoenix.

Signal – 1
Esther Rolinson in collaboration with Sean Clark
Hand cut preservation board and programmed LEDs

'Signal' is a series of works started in drawing and linoprint cutting that are now being developed into programmed, connected light works.

Signal – 2, 3, 4
Esther Rolinson in collaboration with Sean Clark
Animated linocut drawing

These screen works are derived from a series of hand coloured linocuts. They are working sketches towards the making of three-dimensional pieces.

Square Grid
Sean Clark
24" x 24" d*igital print on photo rag paper. Limited edition of 10. £350, including frame*

This *Transformations* print contains three grids of colours each ordered by saturation. It was produced as a limited edition of 10 to commemorate the *A Cybernetic Ecology* exhibition.

Double Grid
Sean Clark
16" x 12" d*igital print on photo rag paper. Limited edition of 10. £250, including frame*

This was the first piece in the *Transformations* series to be exhibited in both digital and print form. It was shown under the name *System 1* as part of *Automatic Art: Human and Machine Processes That Make Art* at GV Art Gallery, London, 3rd July to 10th September 2014. It consists of two grids of colours, one ordered by hue and the other by lightness.

The World, the Flesh & the Devil: A Kinect Sketch
Genetic Moo
*Kinect, Mac mini, Processing Software*

The World, the Flesh & the Devil is the latest interactive piece by Genetic Moo. Inspired by the writings of the scientist and futurist J.D. Bernal, who in his 1929 novel envisioned a hollowed out asteroid as a potential human spaceship, taking thousands of humans (mainly scientists) into a technological future away from the planet. In the gallery Kinect sensors allow the audience to populate a series of spheres whose launch sequences are triggered by other works in the space and whose colours are taken from the *Transformations* artworks.

IV: The Internet of Art Things aka ArtThings

- *ArtThings* position paper.

- *ArtThings* promotional flyer.

- *ArtThings* presentation (included on attached USB stick).

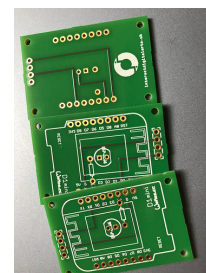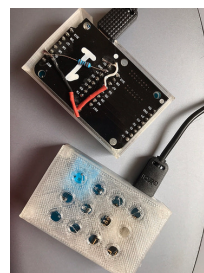# The Internet of Art Things aka ArtThings

Sean Clark
seanc@cuttlefish.com
http://www.seanclark.me.uk
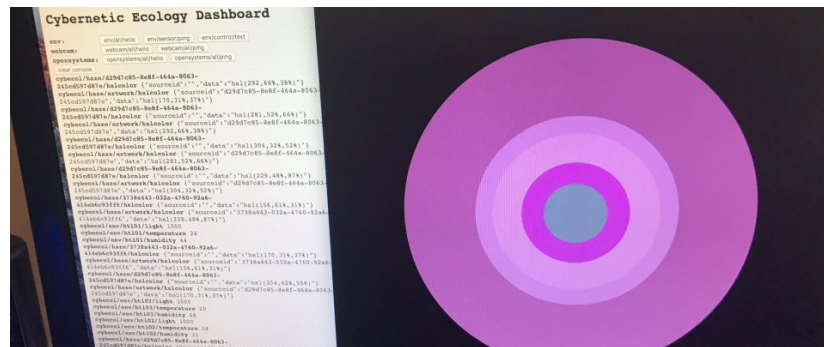
The Internet of Art Things represents a coming together of a number of elements of my creative practice. Firstly, there is my long-standing interest in "connectedness" in the natural and human-made worlds. Next, my algorithmically generated "art systems". And finally there is my practical interest in "digital making" and the belief that digital art can be a handmade practice, just as much as other art forms, such as painting or sculpture.

At the heart of my new **Internet of Art Things** infrastructure is an MQTT message broker that passes messages between things, artworks and software processes. Messages are exchanged via "publish and subscribe" and can be directed at groups of systems right down to individual components of an artwork. I use a systems model for the message hierarchy, where "ecosystems" are comprised of "systems" which are in turn comprised of "components". Because a publish-and-subscribe approach is used, connected things can come and go without breaking connections or causing the server to hang waiting for messages to get through.

Connected to the MQTT broker is a node.js server that takes incoming messages from sensors and artworks and turns them in to outgoing messages that other artworks can subscribe to. This allows complex message passing and generative logic to be implemented so that connected artworks do not simply have to subscribe to fixed messages from connected sensors.

This demonstration will present the **Internet of Art Things** platform and show a number of connected devices constructed by myself, including connected LEDs, environment sensors, digital artworks and connected cameras.
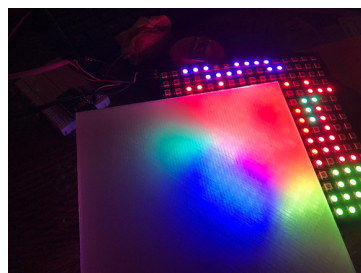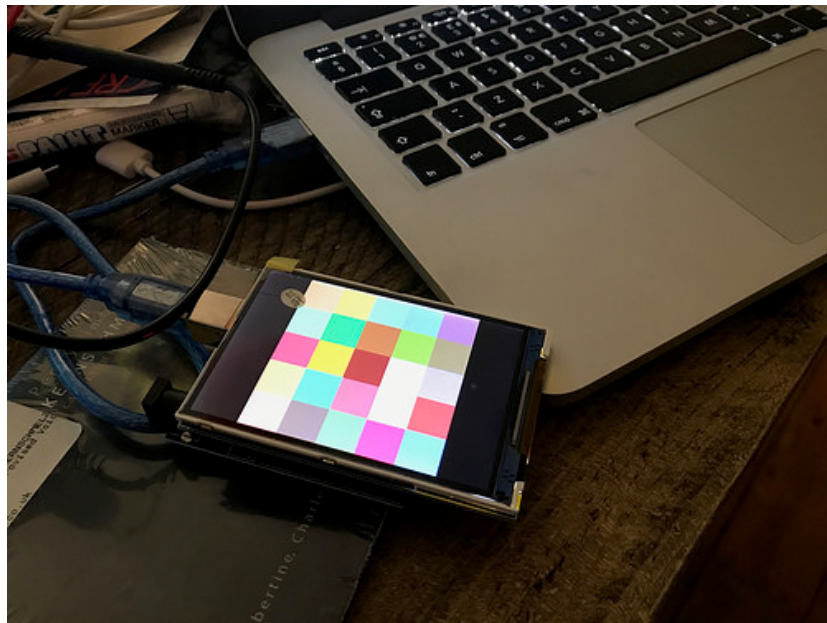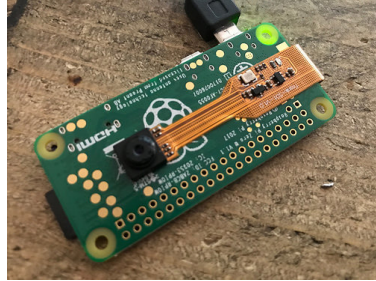
The Internet of Art Things

Sean Clark

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interactdigitalarts.uk/the-internet-of-art-things

The Internet of Art Things is an open infrastructure for connecting interactive digital artworks that makes use of standard Internet of Things technology. It is built around the widely-used MQTT machine-to-machine messaging protocol (that is both lightweight and fast) and suitable for use on a wide variety of computer platforms.

A flexible hierarchical topic structure enables artworks to subscribe directly to each other, or to groups of other artworks, be they located in a single art gallery or located around the world and connected by the global internet. Messages containing colour and sound information, sensor values and images can be exchanged. The platform is fully extendable, allowing additional message types to be added if needed.

The technology was initially developed in 2016 developed by the author to enable his screen-based and light-based digital artworks to communicate with each other without needing to be aware of the other artworks' underlying technology. It has since been successfully integrated into web browser artworks, into multiple micro-controller artworks and into digital artworks powered by desktop computers.

It has been used as the underlying technology for a number of gallery exhibitions, including "A Cybernetic Ecology" in Leicester in 2016 and "Resonance: Patterns That Connect" in 2017, and future exhibition are being planned. The concept and protocols developed are now being shared in order to encourage the development of a community of artists interested in experimenting with **The Internet of Art Things** within their own work.

V: Published Papers

The following papers were published during the research programme and are referenced in the main body of the thesis. Copies are included in the appendix and are included in the **Published Papers** folder on the attached USB stick.

Clark, Sean (2011) **Revisiting Interactive Art Systems**, EVA London 2011, 6 - 8 July 2011, London, UK.

Clark, Sean and Edmonds, Ernest (2013) **ColourNet: A System of Interactive and Interacting Digital Artworks**. CHI'13 Extended Abstracts on Human Factors in Computing Systems, April 27 - May 2, 2013. Paris, France.

Clark, Sean (2013) **Dropsketch Installation**. C&C'13 Proceedings of Creativity and Cognition, June 17 - 20 2013. Sydney, NSW, Australia.

Edmonds, Ernest and Clark, Sean (2016) **Tango Apart: Moving Together**. CHI'16 Extended Abstracts, May 7 - 12, San Jose, CA, USA.

Rolinson, Esther and Clark, Sean (2016) **'Flown' - Sculptural Light Installation**. CHI'16 Extended Abstracts, May 7 - 12, 2016. San Jose, CA, USA.

Clark, Sean (2016) **Connected Digital Artworks.** HCI'16 Proceedings of British HCI Conference Fusion, 11 - 15 July, 2016. Bournemouth, UK.

Clark, Sean and Rolinson, Esther (2017) **Signal: A Systems-based Creative Collaboration**, EVA London 2017, 11 - 13 July 2017. London, UK.

Revisiting Interactive Art Systems

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1. INTRODUCTION

In their pioneering paper "The Creative Process Where the Artist is Amplified or Superseded by the Computer" (1973) Cornock and Edmonds describe a model for the classification of artworks according to their systemic behaviour. In this presentation I revisit this model, discuss its subsequent development (Edmonds, Turner & Candy, 2004) and present an extension to it that incorporates my own research into the use of the theory of *autopoiesis* (Maturana & Varela, 1987) as basis for an expanded description of the 'interactive art system'.

2. ART SYSTEMS & AUTOPOIESIS

Cornock and Edmonds identified the 'art system' as consisting of the *artist*, the *participant and participants*, the *artwork*, the *environment* in which these elements are placed, and the dynamic *processes* or *interactions* that result. This is a classic system-oriented model and will be familiar to anyone who has studied systems theory in any discipline.

Maturana and Varela identify similar elements and relationships within their autopoietic model of *biological* systems and it was to this model I looked when considering how Cornock and Edmond's might be developed further.

The essence of Maturana and Varela's work is a description of how self-maintaining systems interact. Their work describes how such systems are able to maintain their structural organisation over time and co-evolve in response to each other and their environment. Despite being initially concerned with living systems, the concepts they introduce can be applied to systems generally and, I will argue, are particularly suited to describing interactive artworks.

By considering the relationship between the participant and the artwork in their terms I will demonstrate that it is possible to gain additional insight into the interactive process and the nature of interactivity. Similarly, by comparing the systemic properties of the artwork to those of an autopoietic system (such as the participant) I will show that the range of systemic properties that can be considered in the interactive art systems model can be expanded.

3. ACTIVE MIRRORS & MOVING PICTURES

As an artist, the goal of my research into interactive art systems has been to support my creative practice. I will illustrate my presentation with a demonstration of current Active Mirror, Memory Place and Moving Pictures art systems.

The Active Mirror engages the participant, or participants, in a fast-moving feedback loop of interaction. Memory Place adds a memory to the system and rewards stillness rather than movement. Moving Pictures self-construct over time in response to changes in their environment.

All three art systems will be part of a major exhibition of new work by Sean Clark to be held in Leicester in August 2011. The evaluation of these artworks will form the next stage in the author's study in to the nature of interactive art systems.

4. REFERENCES

Cornock, S. and Edmonds, E. (1973) The Creative Process Where the Artist is Amplified or Superseded by the Computer, *Leonardo*, Vol. 6, 11-16. Pergamon Press.

Edmonds, E., Turner, G., Candy, L. (2004) Approaches to interactive Art Systems, *Proceedings of the 2nd International Conference on Computer Graphics and Interactive Techniques in Australasia and South East Asia*, June 15-18, 2004, Singapore.

Maturana, M. R. and F. J. Varela F. J. (1987) *The Tree of Knowledge.* Boston, MA. Shambhala Publications.

ColourNet: A System Of Interactive and Interacting Digital Artworks

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Abstract

ColourNet is a digital art system composed of a set interactive and interacting artworks. Although the artworks are able to work independently, they can also operate together to provide enhanced possibilities for human interaction and creative participation. We

describe the *ColourNet* digital art system and will demonstrate how people can interact with a smartphone artwork and a screen-based work that each interact with one another.

Author Keywords
Digital arts; Interaction; Color

ACM Classification Keywords
H.5.m. Creative interactive interface architectures

General Terms
Design; Human factors

Introduction
Ernest Edmonds' *ColourNet* system includes the possibility of separate, possibly mobile, artworks by others to be included within the distributed system. The version to be demonstrated at CHI consists of two digital artworks – the core Shaping Form component and the Transformations by Sean Clark. Both components are able to interact with multiple users simultaneously and can work independently. However, they are also able to interact with each other by exchanging color information via the Internet.

The Shaping Form ColourNet Core

Shaping Form is an established series of artworks by Ernest Edmonds [1,2]. The version used in *ColourNet* takes the form of a generative system that produces an image composed of changing blocks of color. The color values and proportions of these components change over time in accordance with a generative algorithm.

The image can be displayed on an LCD screen or projected as shown in Figure 1. A video camera monitors the space in front of the image, gathering information about audience (user) behavior. A given level of movement triggers a 'fast response' sequence that gives users feedback: they have been 'seen' by the artwork. The changes accumulate and alter the longer-term evolution of the colors and their proportions displayed by the artwork. *Shaping Form* learns and evolves in response to its experiences [3].

Figure 1: A projected Shaping Form.

Transformations

Transformations is an artwork by Sean Clark that consists of a web page designed for use on a smartphone. The page displays 25 colored squares in a 5 by 5 grid. When the user touches one of the squares grid changes in response. The configuration of this new grid is dependent upon its previous state and the position of the square touched.

More than one instance of *Transformations* can be active at the same time. If just one person is using it then the nature of the grid transformations, resulting from their interactions, are quite simple to identify. If, however, multiple people interact with it simultaneously then the transformations appear to be more complex.

Figure 2: a) A Transformations starting configuration; and b) the same grid after a series of user interactions.

When operating as an independent artwork, the color pallet of the *Transformations* grid does not change. From a starting state such as in Figure 2a, user interactions result in a change in the position of the colored squares, such as in Figure 2b.

The artwork is typically accessed on a smartphone, with users in different locations having no direct

communication with each other. However, it can also be presented in a gallery environment on a projected screen. In this configuration multiple users are able to interact with the artwork on their personal mobile devices while collectively viewing the projected image.

ColourNet: Interactions Between Shaping Form and Transformations

Both the *Shaping Form* core and *Transformations* were conceived as art systems in which interactions between the artwork and its users are essential to the development of the piece. In Figure 3, the *Shaping Form* component is represented as System A, with the artwork able to interact with users via its video camera and screen. System B represents *Transformations*, with interactions taking place between the artwork and the users via the touch screen on the smartphone.

ColourNet, represented as System C, introduces the possibility of interactions between *Shaping Form* and *Transformations* (shown by the dashed line in Figure 3). In *Shaping Form*, whenever it updates its image, the new 'highlight color' is passed to *Transformations*. This is then used to set the color of the central square in the color grid. In *Transformations* whenever a square is touched the color value is passed to *Shaping Form* and triggers a 'fast response', with the incoming color used as the background color for the process.

The result of introducing interaction between the *Shaping Form* and *Transformations* is that they now operate as sub-systems of a new art system, *ColourNet*. The sub-systems can still be interpreted as individual art systems, but the relationship between the two now becomes a vital part of the dynamic of the piece.
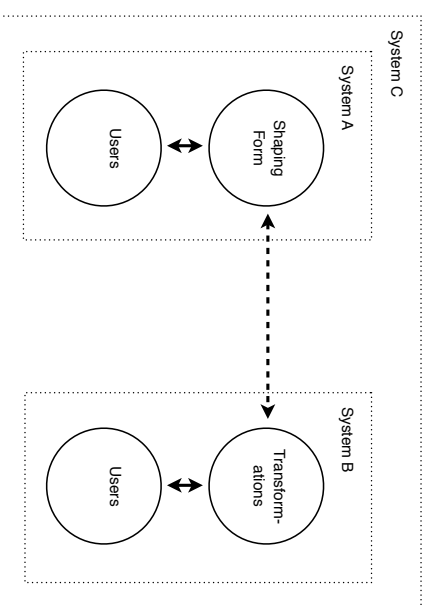

Figure 3: The *Shaping Form* and *Transformations* systems.

The role of the users within the combined system also changes. In Figure 4 the users are now divided in to three groups. G1 contains those who are only interacting with the *Shaping Form* sub-system, G2 are those who are only interacting with the *Transformations* sub-system, and G3 are those who are directly interacting with both.

For the users in group G1, their experience of *Shaping Form* is different when the artwork forms part of *ColourNet*. In particular, the pace of the piece changes, with additional, 'fast response' states being triggered – the source of which cannot be determined without awareness of the full *ColourNet* art system. For those in the G2 group, the squares in the *Transformations* grid begin to change color – with the colors, again, coming from an unknown source.
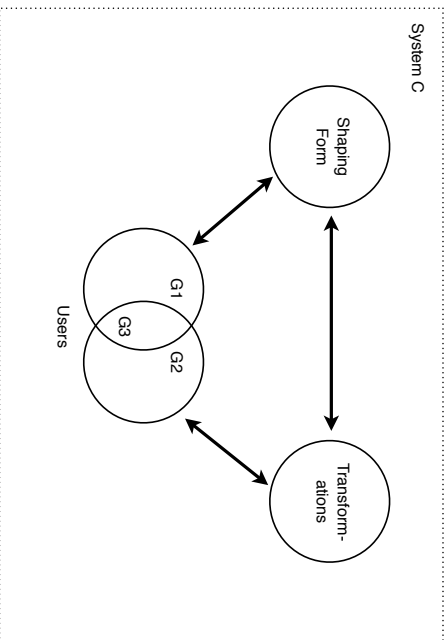
Figure 4: User groups within the *ColourNet* system.

Only the users in the overlapping G3 group are exposed the full nature of the *ColourNet* art system. By interacting with *Shaping Form* and *Transformations* simultaneously, the users will first see that they are able to trigger instant color changes in *Shaping Form*, and then discover that the resulting 'highlight color' is returned to the centre of the Transformations color grid.

The Exhibition of ColourNet

ColourNet was first installed as part of Ernest Edmond's Light Logic exhibition at Site Gallery in Sheffield, UK, between 17th November 2012 and 2nd February 2013 [4]. *Shaping Form* was displayed in an upper window of the gallery (see Figure 5) for viewing at night, with a copy of the screen shown on an iPad in the main gallery for viewing during the day. Scanning a QR code located inside the gallery accessed the *Transformations* web page.

Figure 5, ColourNet at the Light Logic exhibition

References

[1] Edmonds, E. A. Shaping Forms Series (ongoing). In Jennings, P. (editor) *Speculative data and Creative Imaginary*. National Academy of Sciences, Washington, D. C. (2007), 18-19.

[2] Edmonds, E. A. *Shaping Form*. Creativity and Cognition Press, UTS, Sydney, Australia (2007).

[3] Edmonds, E. A. Reflections on the Nature of Interaction. *CoDesign 3* 3 (2007) 139-143.

[4] Sillars, L. (editor) *Ernest Edmonds: Light Logic*. Site Gallery, Sheffield, UK (2012)

Dropsketch Installation

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Abstract

Dropsketch is a Smartphone drawing system that enables users to anonymously create and share simple black and white sketches of their surroundings. The free app, available for iPhone and Android devices, contains an easy-to-use sketching tool and the facility to 'drop' completed sketches on a shared map. It makes use of the Smartphone's built in positioning system to identify the location of the sketch. The app is used to drive the *Dropsketch* installation that allows participants to interactively explore the ever-growing database of incoming sketches.

Author Keywords

Digital arts; Interaction.; Sketching

ACM Classification Keywords

H.5.m. Creative interactive interface architectures

Introduction

Dropsketch [1] was developed for the iPhone in 2011 and was first shown publicly as part of the *Digital Art Systems* exhibition at the Interact Gallery in Leicester, UK [2]. The Smartphone app can be downloaded for free and provides the user with a simple black and white sketchpad. Users are encouraged to make quick sketches of their environment, or anything else that comes to mind, and anonymously 'drop' them on to a shared world map. This can then be seen by other users within the *Dropsketch* app as well as by visitors to the *Dropsketch* website (see Figure 1).

During the *Digital Art Systems* exhibition, a screen was installed in the gallery that automatically displayed all incoming *Dropsketch* sketches. The exhibition was well publicised in the city of Leicester and featured in the local press [3]. Somewhat surprisingly, a large number of users from *other* parts of the world were also attracted to the system, with contributions arriving from around Europe and the UK, North and South America and Saudi Arabia. During the two-month exhibition, *Dropsketch* accumulated over 1,000 user-contributed sketches of numerous subjects.

Figure 1: A map of *Dropsketch* contributions.

The Dropsketch Installation

Dropsketch can operate simply as an app without any physical presence. However, when presented as an installation artwork, the app becomes a part of a larger *art system*. Drawings made by users on their mobile devices provide a source of material that is used by the installation to construct itself. The installation will only grow if new drawings are gathered by the *Dropsketch* app and fed to it; otherwise it becomes static and moribund. For Creativity and Cognition 2013 I have created a new interactive installation that runs on an Internet-connected computer using the Chrome web browser.

The *Dropsketch* app will be promoted to conference delegates prior to and during the conference, as well as through any other local marketing channels that might be available. Incoming sketches will appear on a world map as soon as they are 'dropped' by the participants.

Figure 2: The *Dropsketch* app for iPhone.

Unlike the previous installation, the screen is much more interactive, enabling users to explore the map, zooming in to see sketches that may have been dropped in the conference building, or zooming out to see sketches from around the world. People are also able to flag drawings they particularly like to draw attention to them. Instructions will be placed near the installation encouraging people to add their own images via their Smartphones and to tell other people about the app in order to help the installation grow.

This is the first exhibition to make use of the new cross-platform *Dropsketch* app (for Android as well as iPhone). Screen grabs from the current iPhone version are shown in Figure 2. For this iteration of the work extra emphasis has been placed on the fluidity of the interactive experience for both the app and installation users.

Technology

The iPhone and Android *Dropsketch* apps are free to download from the relevant app stores. In order to share the sketches, the user's device must be connected to the Internet, either via Wi-Fi or 3G (which may incur charges to the user. This is made clear in the app). The installation uses a Mac or PC computer with the Chrome web browser. The ideal physical space is one in which people are able to stop and interact with the installation. Copies of the installation can be put on multiple computers, in multiple locations.

It should be noted that the incoming sketches are not filtered or censored, although inappropriate images can be removed if necessary.

Context

I have had a long-standing interest in the computer support of sketching. In fact, I contributed a paper to the first Creativity and Cognition conference in 1993 relating to the topic [4]. The *Dropsketch* drawing tool is connected to this early work in that it offers simple unencumbered pencil-like tools in preference to object-based drawing tools.

I see mark making as the fundamental creative act; the first thing we learn in 'art' classes at school and something most of us continue to do every day. The *Dropsketch* installation attempts to aggregate these simple sketches and 'doodles' in such a way that the whole becomes greater than the sum of the parts.

What might initially appear to be trivial and throwaway begins to take on new meaning when seen as part of a collection. Patterns and themes appear in the incoming stream of sketches – faces, words, animals, buildings and cartoons. Some marks remain mysterious, such as the example in Figure 4. Might it be a map of where the contributor lives or works? As word of the installation spreads, and more people around the world use it, the universality of the desire to make a mark becomes even more apparent. It's also, quite simply, fun to use.
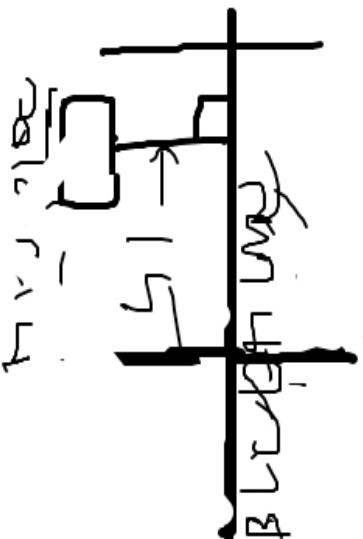

Figure 4: An anonymous contribution from Thailand

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Connected Digital Artworks

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This paper describes an art installation that illustrates the concept of the Connected Digital Artwork. The installation is being run simultaneously at the HCI Interactions Gallery and EVA London. The concept of a 'Cybernetic Ecology' is introduced and its relationship to the Internet of Things is discussed.

Networked, Connected, Systems

1. INTRODUCTION

This installation presents a selection of LED and screen-based connected digital artworks produced by the author as part of his forthcoming solo exhibition "A Cybernetic Ecology".

The artworks individually and collectively explore the concepts of "flow" and "connectedness" and present a contemporary realisation of the notion of a systems aesthetic (Burnham, 1968).

The installation in the HCI Interactions Gallery in Bournmouth s being run simultaneously with a similar installation at EVA'16 in London, with the artworks connected via the Internet.

2. THE OPERATION OF THE ARTWORKS

Each artwork is able to accept inputs from, and push outputs to, the other artworks in the network. In the pieces exhibited here, inputs and outputs take the form of numerical values that are exchanged via an Internet web service. As such the network is closed to human interaction. However, open configurations are possible where human participants form part of the network. In artworks such as "A Colloquy of Glass Jars" (Clark, 2015), communication between the artworks is through sound and light, enabling humans to participate. In the collaborative piece "Cities Tango 2" the inputs and outputs also included images, the exchange of which was triggered by the movement of viewers near the artworks (Edmonds and Clark, 2015).

When an artwork accepts a new input value it reorganises itself in order to maintain a rule-driven pattern of organisation. Having achieved a fully organised state, any values that are no longer required by the artwork are output via the web service and become available for use as the inputs to other artworks.

The process of the artwork reorganising itself is presented to the viewer as a dynamic grid of colours based on the values that make up the structure of the artwork. The rules used to reorder the grid, referred to as its organising principle, involve algorithms that order the colours according to their hue, saturation and lightness levels.

3. A CYBERNETIC ECOLOGY

The constant exchange and reuse of materials within the network of artworks is intended to be analogous to an "eco-system" where inputs taken from the environment are processed by an organism in order to maintain its internal structure. Material that is no longer needed by the organism is then released back in to the environment and forms the inputs to other organisms.

A network of connected digital artworks is referred to by the author as 'A Cybernetic Ecology'. The term captures two key influences behind the work, that is cybernetic theory and ecological thinking. It is also a line from the Richard Brautigan poem "All Watched Over by Machines of Loving Grace". This poem imagines a future world of harmonious co-existence between living and technological systems (Brautigan, 1967).

4. CONNECTED DIGITAL ARTWORKS AND THE INTERNET OF THINGS

The exploration of the "connected digital artwork" - a digital artwork that is intrinsically connected to its viewers and other artworks - has lead the author to consider a number of other propositions.

Firstly, should connectedness be seen not simply as one aspect of digital art but instead its key affordance? The author would argue that this is indeed the case and that "digital art" is on an inevitable journey to becoming "connected art".

Secondly, might viewing a network of connected digital artworks from a systems perspective be something that has value when considering the "Internet of Things"? As ever larger sense and control networks are developed, the author suggests that a "Systems Theory of the Internet of Things" might become increasingly valuable.

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Tango Apart: Moving Together

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Abstract

Tango Apart: Moving Together is an interactive digital art system that has two or more communicating parts in different locations. Although each part is able to work independently, they also operate together, connecting the different locations and providing an aesthetic communication channel and creative participation. In particular, the work will connect CHI2016's Interactivity with its Art Exhibition. Through the addition of mobile phone components, CHI participants will be able to join and experience the work throughout the conference, out and about in San Jose and back home afterwards.

Author Keywords

Interactive art; Communication; Distributed

ACM Classification Keywords

H.5.m. Creative interactive interface architectures

General Terms

Design; Human factors

Introduction

The primary aim of this proposal is to install an artwork that is shown both in CHI2016 Interactivity and the Art Exhibition. It is an artwork that connects the two events together and provides a communication channel between them. Whilst it is not a simple direct video-link it does include the transmission of images between the two locations. As the exhibition lasts much longer than the conference a third element is included so that the coherence of the work is maintained throughout the Art Exhibition. This third element will be in Leicester, England.

The key issue that this artwork addresses is the aesthetics of distributed connected interaction. It explores the creation of new aesthetic experiences in and around connected spaces: Interactivity and the Art Exhibition on the one hand, San Jose and Leicester on the other.

Tango Apart: Moving Together is an artwork that is in many parts (with a minimum of two elements, or 'nodes') that are distributed. That is to say each node is in a physically distinct location, perhaps different rooms in the same building or, equally, different cities or continents. It is a development from *Cities Tango 2*, first shown in 2015. In both works, each node interacts with active participants, and people who pass by, in their locations and also interacts with the other nodes across the Internet. The colours and the images seen are influenced by, and show, the partner nodes, forming a *virtual tango* between, in the case of *Cities Tango 2*, Leicester and Rio de Janeiro. *Tango Apart: Moving Together* also connects San Jose with Leicester but, more significantly, it connects CHI2016's Interactivity with the Art Exhibition, providing a virtual connection between the two related components of CHI. Interactivity will communicate with the Art Exhibition.

An additional element of the work is the availability of unlimited extra nodes on smart phones in which preferred colours can be selected by touch that then influence the colours at all the other nodes, from Leicester to San Jose.

Historical Context

Tango Apart: Moving Together is an extension of *Cities Tango 2*, which was itself a development of *Communications Game* by Edmonds, first shown in 1971, and his recent *Cities Tango* Internet version [2]. Both *Tango Apart: Moving Together* and *Cities Tango 2* incorporate recent work by Sean Clark with this historical development.

Communications Game

Communications Game, originally a proposal for the Computer '70s trade exhibition, was based on the idea that the core of the artwork would be people interacting with one another through a network. Being 1970, the network idea was not, of-course, based on any concept of the Internet.

The proposal provided stations for a maximum of 15 participants and for a minimum of two participants. The stations are arranged such that a participant can only see one, two, three or four stimulus-providing units within his station and a station is part of the group activity only when it is occupied by a participant. Each unit can be acted upon by the participant in response to a given stimulus. No instructions are given to participants on the manner in which the system of units operates.

The first realization of the *Communications Game* was shown in the Invention of Problems II Exhibition at the City of Leicester Polytechnic (now De Montfort University) in 1971. Only three networks of units are used and each unit is equipped with an input switch for turning on lights in units of the same network and a single light for output. For each participant, the lights provide the stimuli and the switches are the means for the participant to respond.

Cities Tango

The artwork, *Cities Tango: between Belfast and Sydney* [3] is an example of the recent works, based on the core concepts of *Communications Game*, that use the Internet to implement distributed interactive art. In this case, the two cities, Belfast and Sydney, interact with one another across continents and time zones. In particular, the colors, stripes and timings used are driven by

movements at the remote location, so that in the European day Belfast may see 'night' colors, for example, and Sydney may see 'day' ones. On the other hand, the display, from time to time, of real time images from the remote location is influenced by the local audience.

Immediate responses to movement are seen by the 'audience' in their own location. The live connection is sensed through the real time images. It created a small stir, for example, when people in the Sydney gallery recognized Ernest Edmonds appearing on their display. He was, of-course, in Belfast.

Cities Tango 2

Cities Tango 2 is a collaborative artwork made by Ernest Edmonds and Sean Clark. It was first shown in the *Primary Codes* exhibition at Oi Futuro Flamengo, Rio de Jeneiro and at both De Montfort University and Phoenix Arts in Leicester, UK [5].

In this work, the *Cities Tango* concept was again used, but the colour stripes of the earlier work were replaced by the Transformations colour patterns by Sean Clark. This had the significant consequence that a mobile phone artwork was added to the network of nodes, making the possible number of interacting elements unbounded.

Transformations

Transformations is an artwork by Sean Clark that consists of a web page designed for use on a smartphone. The page displays 25 colored squares in a 5 by 5 grid. When the user touches one of the squares grid changes in response. The configuration of this new grid is dependent upon its previous state and the position of the square touched.
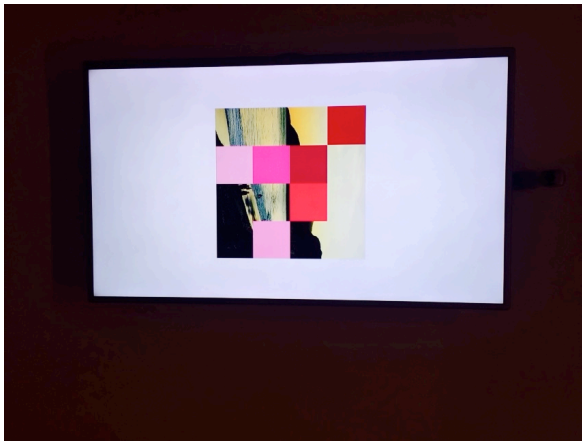

Figure 1: Cities Tango 2 in the Primary Codes exhibition.

More than one view of the *Transformations* grid can be active at the same time. If just one person is using it then the nature of the grid transformations, resulting from their interactions, are quite simple to identify. If, however, multiple people interact with it simultaneously then the transformations appear to be more complex.

When operating as an independent artwork, the color pallet of the *Transformations* grid does not change. From a starting state such as in Figure 2a, user interactions result in a change in the position of the colored squares, such as in Figure 2b.

Physical Realization

Tango Apart: Moving Together has, at its core, two or more nodes each of which consists of a standard screen hung in portrait orientation, a web cam and a computer, such as a MacMini, connected to the

ColourNet

An important pre-cursor to this work, from another stream of development, was Edmonds and Clark's *ColourNet* systems artwork that was first shown at the Site Gallery, Sheffield UK, in 2012 [4] and also included in the CHI2013 Interactivity [1]. *ColourNet* takes the distributed interacting nodes idea used in all of the works from *Communications Game* to *Cities Tango* and extends it to include the possibility of different nodes being independent interacting artworks, initially exemplified by a fixed location work interacting with multiple smartphone/tablet based artworks. *ColourNet* thus influenced *Cities Tango 2* and the current work, *Tango Apart: Moving Together.*

Figure 2: a) A Transformations starting configuration; and b) the same grid after a series of user interactions.

The artwork is typically accessed on a smartphone, with users in different locations having no direct communication with each other.

internet. The software is based on web technology, so the hardware demands are very basic and general. One such node is placed in each location [Interactivity, Art Exhibition, Leicester UK]. All of the nodes communicate with a server that controls the complete system and passes information between the nodes.

In addition, the public is invited to scan a Tag to enable them to add instances of the work's nodes on their smartphones or tablets. In this way, extra moving locations are added to the network of communicating elements.

Acknowledgements

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'Flown' - Sculptural Light Installation

Abstract

'Flown' is a sculptural installation by artist Esther
Rolinson. It is a hand-folded animated acrylic structure
that has been constructed through the process of
drawing, model making and research into materials and
technology. This is a proposal to exhibit a developed
version of 'Flown' using generative programming and
the addition of an interaction design made in
collaboration with Sean Clark.

'Flown' was commissioned for the Illuminating York
Light Festival and made with the assistance of a team
of creative technologists and programmers including
Sean Clark, Graeme Stuart and Luke Woodbury.
'Flown' has been detailed as a scalable kit of parts that
can be reconfigured to its location. In this showing it
will be scaled down to fit into a group exhibition
appearing as a cascading form or geometric haze
molding around the gallery architecture.

Author Keywords

Art, art technology, collaboration, light sculptures,
drawing

ACM Classification Keywords

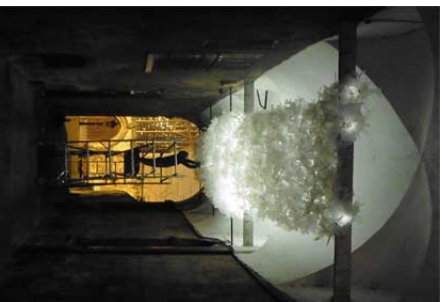H.5.m. Information interfaces and presentation (e.g.,
HCI): Miscellaneous.

Figure 1: 'Flown' being installed in York Oct 2015

Figure 2: 'Flown' York Oct 2016

Introduction

"My intention is to make objects and architectures that invite reflection on each persons' relationship to the places they inhabit and remember. I want to make the familiar patterns of movement that I experience in the everyday visible, such as the motion of water or the simple act of breathing".

'Flown' is a large abstract light sculpture constructed from a multitude of small interlocking geometric shapes. It appears as an illuminated mist animated with delicate patterns of movement and is based on the notion of an ephemeral cloud-like structure that has drifted to ground. It is as if we are viewing it at a molecular level, watching light refracting through its cells.

At full scale **'Flown'** is constructed from over 800 hand-folded pieces of polypropylene, animated with LED's. It was commissioned for York's annual light festival, 'Illuminating York' and was viewed by over 50,000 festival visitors in October 2015. This video showing an extract of the work:

https://vimeo.com/145522112

In this version of **'Flown'** we will use a practiced construction method to make a smaller structure that has the quality of a frozen waterfall or a cluster of ice particles. From this established format we will expand the works animation language with a sensitive interaction design.

Background

'Flown' was made over six-months through an intuitive drawing and model making process. It is essentially a drawing rendered in three dimensions and based

directly on pencil drawings of interlinking, rhythmic forms. During its construction Esther employed the same instinctive drawing-like approach to working with the acrylic, using the folds and supporting rods to create marks. The piece has a minimal support system of ropes specified by project sponsors GDH Livigun Engineers. The geometric forms are back-lit with LEDs and attached onto the ropes using wooden rods.

In its first showing **'Flown'** was programmed with software written in 'Processing' by Graeme Stuart. This created sequences of soft wave-like movements interspersed with staccato phases evocative of bursts of lightning. These behaviors were developed over a two-year period in partnership with Dave Everitt and Sean Clark in relation to the three works **'Melt', 'Splinter'** and **'Thread'.** The programming was steered by poetic descriptions and drawings of organic patterns such as waves, trickles and rushes. The behaviors can be altered in terms of speed, scale, intensity and color and applied to any three-dimensional array of lights to create continuous motions through a structure. An aim in developing them was to sensitively animate light to express the drawing language used to design the physical forms.

Evolution

The next step for **'Flown'** is to experiment with the complexity of its animation. An ambition is to create subtle nuances that influence the viewer's sensory experience with organic movement patterns that are complex but familiar. The programming approach will adhere to the work's original aesthetic whilst introducing intricacies in the movement design that have been planned but not yet practiced. The process will be incremental. In the first instance researching
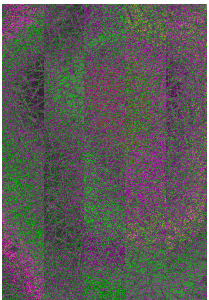
Figure 4 'Flown' York - Detail
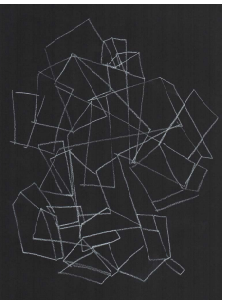

Figure 4: 'Flown' Detail of drawing

Figure 5: 'Flown' Pastel Drawing

Figure 6: Esther Rolinson and Sean Clark working on 'Splinter'

generative movement patterns based on the flow of ink in water as seen in the video link below, then progressing on to create a meaningful interplay between generative patterns and changes in temperature, light and moisture. https://vimeo.com/131406907

The temperature, light and humidity sensors will be installed both in and around the artwork. The subtle differences in the readings from the sensors will then be used to trigger generative changes in the lighting states of the artwork.

Exhibition Set-up This version of '**Flown**' could be between 2 and 4 meters square. It can be arranged and sized in numerous ways and could be located on a wall, cascading from the ceiling downwards or spanning the corner of a room. The location and configuration can be negotiated depending on the layout of the exhibition. The piece will be composed of smaller scale versions of the acrylic forms. As it is light -weight it requires minimal fixing and can be held in place with batons drilled into the wall.

Collaborative Dialogue The development of '**Flown**' is part of an ongoing collaborative dialogue between Esther Rolinson and Sean Clark that has arisen over the past three years working on '**Melt**', '**Splinter**', '**Thread**' and the first version of '**Flown**'. Both share an interest in connectedness and systems and explore these ideas through their diverse art practices; Esther through the process of drawing and making and Sean through the use of technology as a vehicle to create and understand connected systems and objects.

The development of '**Flown**' as a responsive piece is informative for new work emerging from both artists. Sean Clark has an on-going interest in applying a systems-theoretic approach to the development of digital artworks. This piece can be seen in such terms, with the artwork's inputs (sensors) and outputs (lights) intimately connecting it to the gallery environment and providing opportunities for the creation of feedback loops and the emergence of complexity

Esther Rolinson's works are concerned with creating sensory connections between viewer and form. She uses structures and animation to make installations that resonate with the felt experience. This phase of development for '**Flown**' raises questions and ideas around: the identity of works as singular pieces, the sequencing of movement, and what environmental information is pertinent to each work.

The use of environment sensors - temperature, light and moisture - will allow the artwork to respond subtly to the exhibition environment. Human beings are highly tuned to these environmental properties and are able affect them by simply being in a space. Viewers may also discover that specifically interacting with the sensors - by affecting light levels with their hands or blowing on the sensors - causes responses from the artwork. Our intention, however, would be to allow viewers to discover and explore these possibilities themselves.
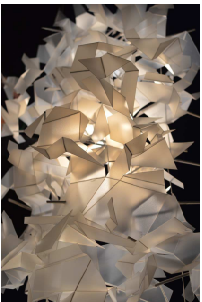
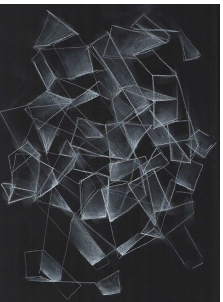Figure 7: 'Flown' Prototype - a small scale version of the work
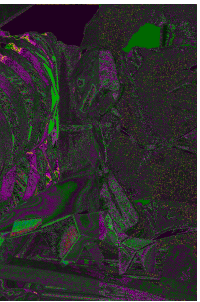

Figure 8 'Flown' Pastel Drawing

Figure 9: Esther Rolinson cutting

Figure 10: 'Flown' Prototype - a small scale version of the work in daylight

Esther Rolinson – Biography

Esther Rolinson is based in South East England. She completed her Visual and Performing Arts degree at Brighton University in 1993 and since that time has worked solely as a visual artist working with drawing, gallery installations, three dimensional design, digital imaging and light. Recent exhibitions in 2014-15 include:

- Computer Drawing – DP Henry and Beyond, LCB Gallery, Leicester
- 'Still Holding', Drawings, Towner Gallery, Eastbourne
- 'Melt, Splinter and Thread', Cube Gallery, Phoenix Arts Centre, Leicester.
- 'Underwing' Drawings, Wall Gallery, Musgrove Park Hospital, Taunton.
- 'Melt, Splinter and Thread' - Work in Progress, Digital Media Print Gallery, Hastings.

Esther makes independent and site-specific surfaces and structures, focusing on the idea of sensitizing environments. She digitally animates found and self generated images that are often developed as sculptural works. These are exhibited as temporary and permanent works such as 'Drift', a light work embedded into the seating wall, Brighton (2008), and 'Supple Solid', a large scale projection commissioned by the British Council, Berlin (2002).

Esther's work explores the architectural applications of three-dimensional structures, animated light designs and digital technologies. Her work sits at the borders between art, architecture and computer technology. Her major permanent works include: 'Stream', a lightwork, Hastings (2002), 'Air Wave', an articulated acrylic surface, Bracknell (2004), 'Trace Elements', a

large scale LED installation, Coventry (2006), and 'Align', a lightwork, Lewes (2006).

Esther's drawing practice is the basis for many works such as the sand blasted granite floor 'Flow' commissioned for Musgrove Park Hospital, Taunton 2014. Her drawings are also exhibited and sold in their own right. Esther's work can be seen at: http://www.estherrolinson.co.uk.

Sean Clark – Biography

Sean Clark is a digital artist, a web and mobile developer and a Visiting Research Fellow at the Institute of Creative Technologies at De Montfort University. In his commercial work he is interested in social networking, mobile multimedia, collaborative computing and location-aware information systems. In his arts work he is inspired by systems theory, the nature of interactivity and creative explorations of flow and connectedness.

His artworks include individual and collaborative pieces that explore the interconnected nature of the world around us through the use of computer hardware and software. These have been exhibited nationally and internationally, including recently in Leicester, 2011, 2012, 2013, 2014; Cardiff, 2013, 2014; Sheffield, 2012 ; Paris, 2013; Sydney, 2013, 2014; London, 2014; Rio de Janeiro, 2015; Beijing, 2015). He is increasingly making use of so-called 'Internet of Things' technology in is creative practice. Examples of this can be seen at: http://seanclark.me.uk and http://interactdigitalarts.uk .

Signal: A Systems-based Creative Collaboration

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1. INTRODUCTION

This paper describes "*Signal*" a new connected digital artwork created by Esther Rolinson and Sean Clark. In common with much of their collaborative work, including the award-winning artwork "Flown" (Rolinson & Clark 2016), *Signal* began as a hand-made drawing by Esther Rolinson, before being developed in to a light piece and then an Internet-connected digital artwork with the involvement of Sean Clark. This paper describes the systemic nature of both collaborative process and the artwork itself.

2. SIGNAL

The incarnation of *Signal* described here (and exhibited at the conference) takes the form of three framed screens, each containing a small internet-connected PC. Each screen displays an image composed of the original sketch plus an animated set of coloured concentric circles moving at different speeds.

Figure 1: *The three screens forming Signal*

Circles grow out from the centre of each screen, reach the edge of the drawing and then return to the back centre, where they are swapped with a colour from another screen. The process continues with a constant recycling of colours as they pass between screens.
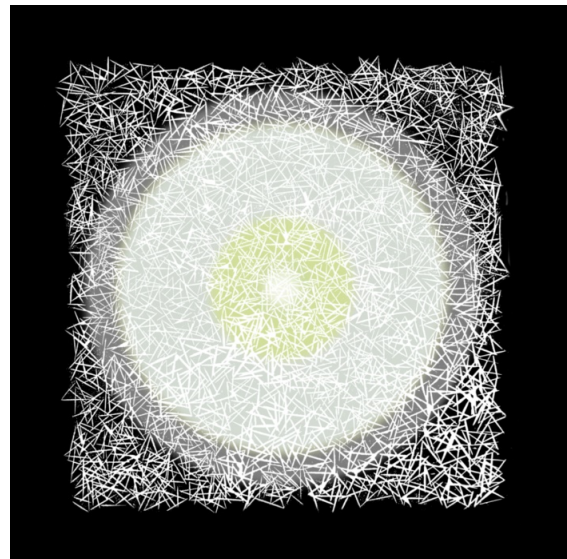

Figure 2: *Concentric circles of colour in Signal*

2. OPEN AND CLOSED SYSTEMS

Signal can be seen as a single closed system made up of three individual open systems. The colours contained within each screen are continuously being exchanged with the other screens, and hence are unlikely to be the same form one minute to the next. However, the pool of colours used across the whole system remains the same. This is intended to be analogous to an ecosystem in nature where individual organisms maintain their living structures through an intimate exchange of materials with other organisms. It is

also a realisation of the Connected Digital Artwork concept previously presented at the EVA London conference by Sean Clark (2016).

When first exhibited, *Signal* formed part of the larger *A Cybernetic Ecology* exhibition (Clark 2017) where the three screens were also able to exchange colours with other artworks in the exhibition in a way similar to that developed for *ColourNet* (Clark & Edmonds 2013).

The colours accepted by *Signal* when operating as part of this wider network had to fall within the palette of colours that the artists felt were appropriate for the artwork to maintain its aesthetic integrity. Again, similar to a living organism, the system was only open to the material necessary to maintain it's structural form.

3. A SYSTEMS-BASED COLLABORATION

A systems-based approach was been used throughout the construction of *Signal*, as well as in its contextualisation.

The hand-made drawing that forms the centre of the piece was produced by Esther Rolinson using a rule-based technique as part of a meditative drawing process.
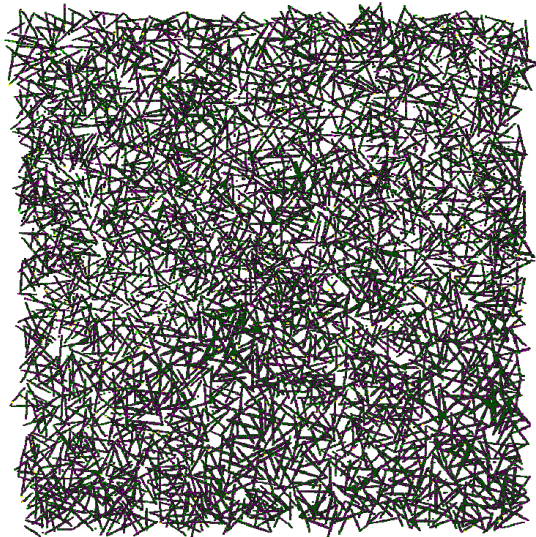

Figure 3: The original hand-made drawing for Signal

The use of rules of construction is then applied to the development of the animated elements and then to the connected behaviours.

At each level, it would be possible for a committed viewer to make sense of the rules used to construct the work. However, the multiple layers used add to the complexity of the piece and it is not expected by the artists that viewer need understand the full systemic nature of the artwork to appreciate it.

4. NEXT STEPS

As the collaboration develops, opportunities for closer connections between the Esther Rolinson's drawing systems and Sean Clark's digital systems are being explored.

This is presently focussed around the use of drawing capture to generate patterns and rhythms that can be used in the creation of the rules for the digital animations.

Similarly, we are looking to find ways to use the patterns produced by the digital aspects of the work to inform the sketching process.

We hope that the result of this collaboration will be the development of a hybrid analogue/digital arts practice. Something that combines the sketching process and digital technology in a way produces new artworks that explore territory beyond that of either existing medium.

5. REFERENCES

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