Mechatronic art: beyond craft-fetishism

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In Sabrina Raaf's *Grower* (2006), a robot detects levels of Carbon Dioxide in a gallery and draws grass on the walls. In my public art installation, *(re)collector* (2007), surveillance cameras are set up throughout a city, programmed to recognize and record anything resembling a scene from the movie *Blow Up*. In Philippe Rahm's project *Interior Weather* (2008), light, humidity and temperature readings from one room are used to compose stories in another room. I want to provide some historical and theoretical context for this kind of work: work that intelligently responds to, and more importantly, generates knowledge from its environment. I would like to distinguish works such as these as examples of 'mechatronic art': systems-based works that involve customized mechanical and electronic devices to physically interface real world data with computer software. I want to argue that mechatronic art involves a specific set of vocabularies that separates it from other forms of digital art, in the same fashion that we might distinguish painting from sculpture, or video from sound.

In Jack Burnham's seminal essay 'Systems Esthetics', published in *Artforum* in 1968, he refers to the emergence of 'unobjects', specifically citing works such as Hans Haacke's *Condensation Cube* (1963) and Otto Piene's *Light Ballets* (1958-62): dynamic, evolving systems in symbiotic dialogue with nature. These new works, directly integrating with their sites and capable of adapting to environmental changes, were more than simply autonomous objects: artwork and nature became inseparable from one another. Nature was not the only system with which such works engaged: Les Levine's *Electric Shock* (1968) and Haacke's *Photo Electric Viewer-Programmed Coordinate System* (1968) looked to directly use audience interactions over time as their subject matter, repositioning gallery visitors from passive observers to active participants, in centre-stage. Burnham saw these works as evidence of a new paradigm in art, one in which art transitioned from being object-based to being systems-based: 'Here, change emanates, not from things, but from the way things are done.'[1]

Properties such as adaptation, symbiosis and interactivity are increasingly common in the vocabulary of digital art today, as is the idea that art is an autonomous system in dialogue with an environment rather than an object autonomous from it. These two, perhaps contradictory, uses of the term 'autonomous' are symptomatic of the transition that Burnham envisioned. This paper examines the notion of ‘mechatronic’ art, arguing that Burnham’s observations referred to a new paradigm for art that is only now capable of being fully realized. Interestingly, Burnham’s theories emerged out of sculptural concerns, which are often anathema to many people’s understanding of digital art: Burnham was not referring to screen-based, graphically oriented work, he was talking about physical experiences, embodied and situated in the real world.

In mechatronic art this is explored to the fullest extent, via a dynamic synergy of art, computing and engineering. Artists working within this paradigm often develop custom-built hardware and electronics to control hybrid telematic environments, constructing components that are designed with built-in logical goals. Traditionally in digital art, these kind of algorithmic systems have been implemented using just software, but increasingly artists are working with combinations of hardware and software, essentially allowing each to learn from the other. The knowledge economy involved in building such projects requires artists to work within laboratory environments, sometimes developing new tools and technical solutions that make genuine contributions to allied scientific fields. This multidisciplinary approach has made mechatronic technologies – such as microcontrollers, sensors and actuators – highly accessible, as well as allowing the field to expand quickly from both a conceptual and a technical point of view. Artists operating within this paradigm are finding opportunities to make work that operates and responds to the real world, rather than work that is bound by conventional art structures and materials. As Burnham commented:

> Craft-fetishism remains the basis of modern formalism. Instead the significant artist strives to reduce the technical and psychical distance between his artistic output and the productive means of his society. Gradually this strategy

[1] Jack Burnham, 'Systems Esthetics', *Great Western Saltworks,* New York: George Braziller, 1974:16.

> transforms artistic and technological decision-making into a single activity.

A key feature of mechatronic art therefore is to bring artists closer in their modes of production to that of the real world. This is a necessary strategy in order for artists to create a seamlessness between their ideas about society and the work that they produce within it. In a systems-oriented society, traditional art-making processes arguably reinforce a sense of alienation from modes of production. For example, Burnham compared Picasso with Duchamp, identifying Cubism as bound up within the internal semantics of a finite art object that operated in isolation from the world, and attributed Duchamp's more enduring legacy to the fact that the relationship between the artist and his materials was identical to his audience's. Nevertheless, in both of these cases, the artists used traditional framing devices to isolate their work from their audience and maintain the work's 'autonomy': both were static, closed objects. Burnham was proposing more than simply a shift in the kinds of materials used by artists; he was suggesting that art should fully integrate itself within public spaces. Not in the sense of composing novel public decorations, or complementary site-specific sculpture, but rather as a means to directly intervene in reality:

> In evaluating systems, the artist is a perspectivist considering goals, boundaries, structure, input, output, and related activity inside and outside the system. Where the object almost always has a fixed shape and boundaries, the consistency of a system may be altered in time and space, its behaviour determined both by external conditions and its mechanisms of control.[2]

So whereas object-based art was seen in terms of form and distinction from what was around it, systems art was more concerned with behaviour, integration with the world around it, and how it could tap into larger-scale socio-political organizational systems. Burnham was therefore suggesting that Duchamp did not go far enough: instead of removing the work from reality, creating a duality between art and everyday, the art could reside within reality, without the protection of a frame. In other words, by taking a systems approach, the discontinuity between art and reality could be removed. In simultaneously manipulating the materials of modern society, and occupying its sites of public engagement, artists were opening up their practices to encompass interactivity, site-specificity and change over time, as well as establishing bi-directional dialogues between artwork and environment. Here we contemplate a

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[2] Burnham, *Great Western Saltworks* 1974:17

radical shift in the idea of the autonomy of art: the work asserts its independence not by its object-based separation from reality, but rather by its systemic role within it.

The mechatronic art that we see today builds upon the critical and theoretical foundations laid by Burnham and his 'unobjects'. It is not concerned with formally cohering to the size, shape or scale of conventional art objects, preferring to use the formal characteristics of actual, real-world systems as its visual reference points: industrial robots, surveillance systems, security networks, etc. It is behaviourally that mechatronic artworks distinguish themselves from these everyday devices, via the incorporation of algorithmically controlled agency, and where we find the next stage of development for Burnham's systems aesthetics. In a mechatronic system the work is engaged in a material exchange with its environment. Here I am not considering a simple environmental exchange, such as in Haacke's *Condensation Cube*, but rather a transformative interchange of material poetry; a synchronous embodiment of a single idea within two or more separate entities, human or otherwise. The First Law of Thermodynamics states that Energy is never created or destroyed, but simply transformed. An artwork that can be considered a mechatronic system breaks this law by gaining more than it receives, becoming more than the sum of its parts as a function of its knowledge-based, embedded, transactional structure. A mechatronic system, embedded within spaces we cannot physically occupy, and capable of perceiving data that is outside of our sensory capacity, has the potential to show us something new about ourselves that we cannot find out any other way. Here we can again consider a very different form of autonomy to that provided by the frame; rather than art and reality being separated on the outside – visually – here, the separation occurs on the inside, behaviourally and systematically.

Artists' use of techniques such as interactivity, site-specificity, systems theory, sensing and control methods, and algorithmic processes can be seen as attempts to establish a generative relationship between artwork, site and audience, something that I would consider central to mechatronic art. The notion of a generative art system is best understood in terms of the balance between top-down and bottom-up strategies in the work. In a painting, for example, we do not expect to see a facsimile of reality: what results is a transformation of an idea through the manipulation of a surface. The decision concerning what is represented on this surface remains with the artist – analogous to a top-down approach. On the other hand, in a work that can be said to operate as an 'open system' – i.e. a work that feeds back with its site/audience – what is represented is determined both by the artist and the real time relationship of work to its environment. In this regard, the artist delegates some aspects of the aesthetic responsibility to the work itself: it operates autonomously, with the artist not knowing for certain what will happen. Some knowledge is provided by the artist, but other knowledge is acquired from the work's relationship to its site/audience and as a result may be unpredictable. By this I do not mean that it is random or chaotic, but rather what occurs is carefully composed within an algorithmic framework designed to generate new information. This constitutes an important balance between top-down and bottom-up strategies in mechatronic art: how will the work respond to its environment – what transformation will occur, and what will it mean? This is a decision that traditionally resided with the artist alone, and which now becomes a powerful means of developing unique strategies to cope with the large-scale systems we find ourselves immersed within. We can reflect on the vast array of experiments with materials, site, time and space that characterize mechatronic art as evidence of artists' desires to synthesize knowledge gained from diverse creative fields such as dance, music and literature, in order to construct novel ways of reflecting upon the human condition. Further, we can see from the increasing complexity of the algorithmic frameworks with which artists compose mechatronic art systems – a far cry from the simplicity of Haacke's *Condensation Cube* – that artists are able to operate in realms that are considerably different to conventional artistic territory. We can now contemplate work that extracts poetic experiences from processes that were previously too small, too slow, or too fast for us to be aware of.

We are no longer painting a picture of reality, or even appropriating it for display; rather, we are beginning to author reality, using reality. Taking an example from my own work, via the cameras in *(re)collector*, it was possible to extract specific narratives from people's everyday behaviours, organize them into linear films, and then insert those narratives back into the city in such a way as to influence people's actual behaviour. Essentially then, through mechatronic art's direct intervention in reality, it is possible to establish an iterative feedback loop that can call into question what is real and what is art.

If Burnham's idea of systems art focused on a feedback loop between art and nature, i.e. input and output, then in the case of mechatronic art, as the next stage of systems art, we add a layer of intelligent processing in between input and output. Here we encounter very contemporary points of reference: neural networks, agent-based programming, artificial intelligence, etc. Typically software agents are considered in terms of the possible states, behaviours, and goals that they seek to achieve or maintain. For example, a software simulation of a person walking could be considered an agent due to its states (e.g. speed, position), behaviours (e.g. moving faster or slower, turning left or right) and goals (e.g. trying to get somewhere specific, trying to maintain a particular speed). When several software agents are put into a single environment, all with the same possible states, behaviours and goals, we get a multi-agent system. Pursuing the walking example further, we could end up with a simulation, for instance, of crowd behaviour, as each agent attempts to navigate around the others to get to their destination. Multi-agent systems such as these are capable of modelling patterns of behaviour that may not be immediately apparent to us, and consequently can be said to demonstrate emergent properties. Agents in multi-agent systems are generally defined as having (at least partial) autonomy due to the fact that the decisions they make are determined by their internal response to their environmental conditions: as having a local perspective upon the system due to the fact they cannot have a full view of the entire system they find themselves within; and as participating in a decentralized environment over which no single agent has control. Effectively therefore, multi-agent systems demonstrate complexity from sets of simple parts: we may understand the individual behaviours and goals of the agents, but that of the system as a whole may be less predictable.

Software agents are characterized by their ability to perceive and act within a computational environment. In mechatronic art systems, they are a very useful means of programming intelligence into systems of sensors, video and audio: such works typically demonstrate states, behaviours and goals. Again here an important distinction must be made between simple reflex agents such as those used in the majority of interactive installation art, where no differentiation is made between audience members; and emergent multi-agent systems in which more complex outcomes can develop. To close I'd like to identify three different strategies used in mechatronic art that demonstrate this complexity, in the process I hope to identify some of the challenges for the field as we look towards future mechatronic art projects that synergize art and reality in new and important ways.

Firstly, a *repetitive* strategy involves taking a single process that may evolve in response to its environment – plant growing, visitor interaction with audio/video, data gathering, etc. – and repeating it in order to heighten our awareness of the difference between each repetition. As an example, we could consider Robert Smithson's *Spiral Jetty* (1970), in which the natural cycle of erosion and change causes the jetty to be different each time we see it. As each stage appears to be similar, yet subtly unique, we are drawn in to the drama of its transitional moments. Here, beauty is derived from its enduring quality across time. *Spiral Jetty* offers an interesting example, largely because it is an analogue work, and would be best described as a systems artwork in Burnham's sense rather than as a mechatronic artwork in the sense I have been describing. Each year, the Jetty erodes and changes, sometimes disappearing altogether. Here the balance between top-down and bottom-up is erratic: compositionally, there is no guarantee that the work in each repetition (i.e. each cycle of change) is statistically similar and different enough for it to have an enduring quality across many years. Building such a work today, and using some of the technologies available, we could certainly imagine a much greater degree of algorithmic control being exerted, bringing it closer into line with examples of mechatronic art.

Secondly, a *divergent* strategy uses several instances of an identical process – e.g. multiple identical plants, multiple screens showing identical data, multiple responses to the same question. Natalie Jeremijenko's *One Tree* (2003), in which one thousand cloned trees were planted throughout the Bay Area, demonstrates the effect of different environments upon identical instances of the same thing. As each instance of the process achieves its goal, either in a shared environment or in a range of different environments, the results can be directly and visually compared and contrasted. This unravels the decision-making process that occurred along the way, essentially creating a non-linear narrative as the different possibilities of the system are presented side by side.

Lastly, a *convergent* system would show different parts of a single system simultaneously – multiple camera angles of a single object, multiple sounds derived from the same environment, streams from multiple cameras in the same city, such as in *(re)collector*. The viewer, in acquiring a bird's eye view of the system in its entirety has a perspective that is not shared by any of the parts in isolation. An example of this would be *The Listening Post* (2003) by Mark Hanson and Ben Rubin, in which chat room conversations are simultaneously displayed on a grid of LCD displays. Here, the viewer completes the work in his own mind, finding the relationships between the parts to construct a whole. In such a system, the parts do not need to be individually resolved, but rather crafted in order to sufficiently contribute towards the whole. Importantly these strategies do not sacrifice representational integrity: they are not simply an illustration of the process as experience; rather they are the process, occurring many times, simultaneously. Some art works consist of combinations of these different strategies. *Alchymeia* (1998) by Shawn Brixey, comprised a series of ice crystal ‘portraits’ engineered using steroid samples from Olympic athletes. Each portrait contains the unique DNA of a single human being, and can be seen as an agent within a visual and biological system. The serial repetition of portraits in a freezer allows us to perceive what make each one unique and divergent, as well as what makes all of them the same.

Each of these examples require the invention of a customized physical process or device – be it a jetty, a cloning and monitoring system or a statistical data mining system routed to LED displays – which is then interfaced with an algorithm capable of transforming reality into something that is not visible without the physical process being in place, before then reinserting it into the same reality. For the digital artists, qualities such as repetition, divergence and convergence become new aesthetic tools with which to explore the expanded potential of mechatronic art. And further, such an approach becomes an important aesthetic device with which to explore a society in which notions of originality, reproduction and replication are of great debate and concern.

Mechatronic art is not simply about making work that is ‘interactive’, ‘interdisciplinary’, ‘responsive’, ‘kinetic’, ‘mechanical’, etc. There is also an important aesthetic and theoretical rigour to be taken into consideration. In this paper I have argued that in establishing a critical vocabulary for mechatronic art, it is important for the work to be generative. Simply combining methods, processes and materials from different disciplines is not sufficient: the combination must generate something new that is a necessary function of the art system. We find ourselves now at a point in the evolution of art where simply being digital provides sufficient information with which to understand it. Therefore it is very important that we can locate and distinguish practices such as mechatronic art from 'traditional' digital art, and establish a vocabulary appropriate for evaluating its contribution to the field.