CYBERNETIC CONFIGURATIONS: CHARACTERISTICS OF INTERACTIVITY IN THE DIGITAL ARTS

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Abstract

Cybernetic theory and interactive media art share much in common, including an interest in human relationships with technology, and in what their interactions reveal about both human and technological agency. In this paper we identify four characteristics of cybernetic systems and discuss their relevance to interactive sound art. We hope to contribute to a critical lexicon around the cybernetic nature of interactive artworks more broadly, and to promote further engagement with the principles of cybernetics amongst electronic and digital arts practitioners and scholars.

Keywords: cybernetics, new media, interaction, systems theory, agency

"*We have decided to call the entire field of control and communication theory, whether in the machine or in the animal, by the same 'cybernetics', which we form from the Greek 'kubernetes' or steersman*" Norbert Wiener [1].

The term 'cybernetics' was first used to describe a field of experimentation in interactive systems that emerged in the 1940s [2]. At that time the explorations were focused on mechanical and robotic systems that were able to self-regulate in response to sensory input from their environment. Many of the early cyberneticians were, as Pickering [3] points out, practicing psychiatrists who sought to model (with their machines) human cognition and behaviour. In the decades that followed, peaking in the 1970s, cybernetic theory evolved to include humans, and other living systems, as part of the system rather than simply observers. The implications of this approach on the arts did not go unnoticed at the time [4] even if it was not mainstream. This second wave of human-in-the-loop cybernetics is referred to as second order cybernetics [5]. It is on the basis of this extended definition that interactive electronic and digital artworks can be seen as potentially cybernetic.

The prefix cyber, from cybernetics, has continued to be used with reference to human-machine systems. Particularly as a result of the use of the term cyborg in science fiction, the field of cybernetics took on an oft dystopian complexion. Interactive art works such as Stelarc's *Third Hand* [6] reinforced the transhumanist perspective on cyborg culture as one of extension through prosthesis, and deliberately played on concerns about human control (or lack thereof) over such hybrids.

However the past decade has seen the reinvigoration of interest in cybernetics viewed optimistically as human-machine partnerships. This has been evident in the recent works of a number of digital artists, including the authors; in the theme for the 2012 Re-New digital arts festival, "Cybernetics Revisited - towards a third order?"; and in various publications such as "Cybernetic Aesthetics and Communication" [7] and, most notably, "The Cybernetic Brain: Sketches of another future" by Andrew Pickering [8].

Given the diversity of interpretations of cybernetics and its myriad offshoots, including cyber-art, cyber-reader, cyberculture and more, we are keen to establish more clearly the features of cybernetic systems and how they manifest as characteristics of interactive art works. We propose that such a clarification might assist in the description and analysis of interactive art works both as being (or not) cybernetic in character and also to more clearly distinguish different kinds of cybernetic interaction.

Our background is in music, and so we populate this article with examples of interactive music systems because this is what we know well, however we believe the principles outlined apply more broadly to visual and performing arts.

Interactivity

Interactivity in the arts is a broad topic - its meaning nebulous, and its applicability to particular works often contested. As with cybernetics, "interactivity is a much used and abused term" [9]; in many cases 'reactivity' is more apt.

Garth Paine suggests a sharper definition of interactivity, where "in order for the system to represent an interaction, it must be capable of changing and evolving ... a response–response relationship where the responses alter in a manner that reflects the cumulative experience of interrelationship" [10]. Both human and technological parties in a truly interactive system should have the ability to *improvise* rather than simply *respond*.

We adopt and adapt this perspective by defining *interaction* as *mutual adaptation*. There are various configurations of artist, artwork and audience that fit this definition, though the human experience of different configurations may be quite disparate. When the interactive artwork comprises an audience member interacting with a physical or digital machine - as is often the case for interactive installations in a gallery exhibition, the human participant is both interactor and audience. Contrastingly, in a performance context, an interactive artwork may consist of a human performer interacting with technology - so the roles of audience and interactor are distinct.

The assumption that a system includes a person interacting with technology aligns most strongly with the second (rather than first) order cybernetic approach where the 'observer' is considered to be inside the loop of interaction, rather than an external observer. This participatory viewpoint is common to both modern cybernetics and to interactive arts.

Example: PIWeCS

The *Public Interactive Web-based Composition System* (PIWeCS) project, developed by Ian Whalley [11], is designed to "increase the sense of dialogue between human and machine agency through integrating intelligent agent programming" [12]. PIWeCS and a human performer enter a musical 'dialogue'. The computer, with a repertoire of prerecorded sound samples, and the human performer, using an acoustic instrument, engage in concurrent playing, listening and analysing as the performance proceeds. A technical feature of this software is that visual interfaces are web-based and audio is streamed allowing participants to be geographically separated.

Cybernetic Features

In the remainder of this paper we outline four characteristics of cybernetic systems and provide examples of their application to interactive music systems. These characteristics are; a reliance on *feedback* as a mechanism for ongoing self-regulation, a *systems view* that promotes interaction and partnership over reactivity and control, the recognition of *agency* and autonomy in each component of the system, and a degree of *symmetry* amongst the components of a system including some shared responsibility and shared objectives.

Following discussion of each characteristic we describe an interactive electronic art work exhibiting the discussed characteristic. These case studies include outputs from our own creative practices and highlight the types of cybernetic

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interactions that are of particular interest to us. We think these types of 'cybernetic' works deserve further attention, because the ideas remain vital even almost a century after the initial cybernetic explorers began their investigations.

Feature 1: Feedback

Feedback is a basic characteristic of all cybernetic systems. Early descriptions of cybernetic systems considered the 'system' to be a machine with some self-regulatory capacity, so as to achieve *homeostatis;* the stabilisation of a system parameter despite varying environmental conditions.

Homeostatis was implemented through dynamic error-correction, conceptualised as feedback from the environment, rather than pre-calculated actions. Taking inspiration from Watt's steam-engine governor, which utilised corrective feedback to maintain an approximately steady steam-engine speed in the face of varying loads, Weiner coined the term cybernetics from the greek *kubernetes* meaning "the art of steersmanship" [13].

In these early cybernetic configurations, described as first-order, the system (comprising a machine) and the environment, participated in a causal-loop "in which each of the elements contained in the loop act upon the others in a constant and varying fashion to maintain equilibrium" [14].

Second order cybernetics expanded the boundary of the 'system' to include human-machine configurations, and also machine-machine configurations in which components of the system were considered as independent 'agents', coordinating their behaviour through mutual feedback. A precursor was Ashby's [15] *homeostat*, in which four mechanical 'agents' interacted with each other to maintain a stable state—again utilising a closed causal feedback loop, which Paine suggests is "one of the principal concepts of cybernetics" [16]. The original homeostat had no particular purpose – it simply operated as a proof-of-concept for Ashby's theories of multi-agent system stability through mutual feedback.

Example: Fond Punctions

An interactive music system directly inspired by the homeostat is Alice Eldridge's *Fond Punctions*. The work is an improvised performance of a human-computer electroacoustic partnership, comprising live cello and processing. The computer system implements a digital simulation of Ashby's homeostat to create semi-stable patterns (simply by observing the homeostat's internal state variables), mapped to rhythmic parameters of a granular synthesis engine. Eldridge describes her motivation for designing the system: "it is very hard to pre-programme digital systems that both avoid repetitious tedium and can be 'trusted' to behave appropriately in a live musical setting. The beauty of generative systems is that they allow a designer to compose a space of possibilities in which the machine is free to roam. Some regions of the space may be richer than others, but the use of simple adaptive generative mechanisms seems to provide a workable balance of reliability and unforeseen inspirational novelty" [17].

Eldridge's system also generated live visual projections of "bubbles and buoyant cell-like aggregations that twitch to the pulse of the homeostatic oscillations" [18].

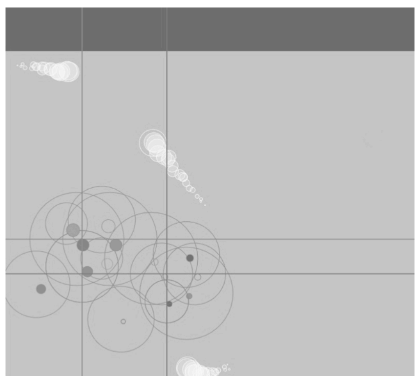

Fig. 1. Fond Punctions video projection. © Alice Eldridge 2005.

Feature 2: Systems Perspective

Second order cybernetic systems are seen as collections of collaborating agencies. The elements of a system are coupled through interaction such that they are mutually influencing. In human-machine or human-computer partnerships the systems view is concerned with the overall behaviour of the system or its output. In artistic systems the output can be a dynamic visual and/or sonic rendering. From the systems perspective there is not only interest in a particular artistic output, but in the range of possible outputs the system might produce.

Generalising from the idea of homeostasis (interaction that maintains a stable parameter), coordination amongst the agencies in a system can be seen as oriented toward achieving a shared goal. Shared objectives may, of course, be deliberately thwarted at times; as in the case of a duet musical performance where one performer may choose either to play in sympathy with, or in contrast to, the other performer. Nevertheless, this feature of cybernetic systems may provide a distinction between interactive systems where agencies operate in parallel and those designed to converge or complement.

Example: _Derivations

_Derivations by Ben Carey (see http://derivations.net/) is interactive music performance software that is particularly reliant on the human as part of the musical system. It uses recorded sonic material from prepared and live recordings of the instrumentalist as the basis for its output. The software is designed to facilitate collaboration between musician and machine where the software learns to adapt to the sonic and gestural aspects of the performer in a process forged over periods of rehearsal that culminate in performance. Carey writes that _Derivations is designed "to encompass the cumulative interrelationship present both inside and outside of a performance time interaction. By definition this then includes a privileging of the role of the performer as an active and creative decision maker in this process" [19].

Fig. 2. _Derivations (Photo © Ben Carey)

Feature 3: Agency

In cybernetic systems each component has some autonomy, some responsibility, or some impact on the overall system behaviour and therefore on the output. While humans, and other living systems, are generally assumed to possess agency, it is less clear that machines or software possess agency. Cybernetic relationships involving shared agency contrast with human-tool relationships where the tool is considered to be subservient to the human intention.

The question of agency in materials and technologies is by no means straightforward. There is an argument that even static artistic objects can exercise agency through their signification and its effect on human behaviour [20]. There is also the influence of features in artifacts and processes that suggest or *afford* particular actions or ideas [21]. Finally, there is the material agency, or constraints, that objects and technologies possess that guide the outcome of human users.

In cybernetic systems, the agency of a technological partner is typically considered more than merely its ability to influence human perception or action, but rather its active contribution to the partnership. Agency, in the cybernetic sense also assumes some kind of goal orientation and the systems approach implies some shared, or at least symbiotic, goals amongst the agencies in the system.

Example: CIM

The *CIM* (Controlling Interactive Music) software developed by the authors is an interactive music improvisation partner [22]. Based on a model of musical duet interaction that provides it with a repertoire of ‘activities’ and parametric controls over balance and independence, CIM is designed to impart a sense of musical agency for both its performing partner and for the audience. As well as relying on the duet interaction model to help structure is behaviour it uses a reflexive approach to content generation where its musical material is largely based on its memory of what the human performer has played.

Feature 4: Symmetry

Even when each agent in the cybernetic system makes an active contribution, these contributions may not be the same, nor may they be of equal significance to the outcome. It is this balance (or imbalance) of influence that we term the symmetry within the cybernetic system. Most straightforwardly it is a symmetry of agency within the system.

Interactive art works can be designed to operate with particular degrees of symmetry or asymmetry. For example, Jeff Albert’s *Interactive Music Partner* (IMP) was designed to be generally symmetrical but with an ability to range between moments of greater or lesser prominence. He explains IMP “should be a partner, meaning that it is equal parts leader and follower, not always simply accompanying the improvising human, and at the same time, not always requiring the human to accommodate its output” [23].

Example: Jambot

The *Jambot* [24], developed by the authors, is an interactive music system, designed to have substantial agency, and yet also afford substantial control to the human performer. Here the symmetry of agency lies somewhere between the poles of symmetric and asymmetric. The Jambot augments musical audio input in real-time, and implements a number of musical goals for the ensemble as a whole.

Fig. 3. The Jambot (Photo © Australian Broadcasting Corporation)

Conclusion

Cybernetics and interaction are oft-used yet loosely defined terms, covering a broad range of phenomena. We have outlined features of cybernetic systems and shown how these features have been applied to some media art works.

The features of cybernetic systems outlined are *feedback*, a *systems perspective*, *agency* and *symmetry*. We suggest these features provide both a set of useful cybernetic design ideas for interactive media art, and a critical lexicon for analysing extant works.

As artists and scholars we are interested in cybernetic human-computer partnerships because they present an interesting balance between control and unexpectedness, between authorship and collaboration. The behaviour and outcomes of such systems prompt us to reflect on what is it is be creative, interactive, and even human.

References and Notes

1. Norbert Wiener, *Cybernetics; Or Control and Communication in the Animal and the Machine*. (Oxford, England: John Wiley, 1948). p. 19.

2. William Ross Ashby, *An Introduction to Cybernetics*. (London: Chapman & Hall, 1956).

3. Andrew Pickering, *The Cybernetic Brain: Sketches of another future*. (Chicago: The University of Chicago Press, 2010).

4. Roy Ascott, “Behaviourist art and the cybernetic vision,” *Cybernetica, Journal of the International Association for Cybernetics*, (*Namur*) 9, (1966)

5. Francis Heylighen and Cliff Joslyn, “Cybernetics and Second-Order Cybernetics,” in R. A. Meyers, ed., *Encyclopedia of Physical Science & Technology 4* (3rd Edition., pp. 155–170). (New York: Academic Press, 2001)

6. Stelarc, *Third Hand*. (1980) <http://stelarc.org/?catID=20265>

7. Claudia Giannetti, “Cybernetic Aesthetics and Communication,” *Media Art Net*. (2004). Retrieved from<http://www.medienkunstnetz.de/themes/aesthetics_of_the_digital/cybernetic_aesthetics>

8. Pickering [3].

9. Steve Dixon, *Digital Performance : A History Of New Media In Theater, Dance, Performance Art, And Installation*. (Cambridge, MA: The MIT Press, 2007) p. 561.

10. Garth Paine, Interactivity, where to from here? *Organised Sound*, 7, (2002) p. 298.

11. Ian Whalley, “PIWeCS: Enhancing Human/machine Agency in an Interactive Composition System,” *Organised Sound* 9, No. 2 (2004) pp. 167–174.

12. Ian Whalley, “Software Agents in Music and Sound Art Research/Creative Work: Current State and a Possible Direction,” *Organised Sound* 14, No. 2 (2009) p. 162..

13. Ashby [2] p. 1.

14. Paine [10] p. 302.

15. William R. Ashby. *Design for a Brain*. (London: Chapman & Hall, 1960).

16. Paine [10] p. 302.

17. Alice Eldridge, “Fond Punctions: Generative processes in live improvised performance,” in *Ernest Edmonds, Paul Brown, and Dave Burraston, eds. Generative Arts Practice* 5 (2005) p. 46.

18. Eldridge [17] p. 44.

19. Ben Carey, “Designing for Cumulative Interactivity: The _derivations System,” in *Proceedings of NIME ’12*. Presented at *New Interfaces for Musical Expression* (Ann Arbor, Michigan: University of Michigan, 2012). p. 1.

20. Alfred Gell, *Art and Agency: An anthropological theory* (Oxford: Clarendon Press, 1998).

21. James J. Gibson, *The Senses Considered As Perceptual Systems* (Boston: Houghton Mifflin, 1966).

22. Andrew R. Brown, Toby Gifford, and Bradley Voltz, (2013). “Controlling Interactive Music Performance (CIM),” in *Proceedings of the Fourth International Conference on Computational Creativity* (Sydney: The Association for Computational Creativity, 2013) p. 221.

23. Jeffry V. Albert, Interactive Musical Partner: A system for Human/Computer duo improvisations. (PhD Thesis, Louisiana State University, Louisiana, 2013) p. 22.

24. Toby Gifford, Improvisation in Interactive Music Systems. (PhD thesis, Queensland University of Technology, 2011).