Thoughts on Computational Creativity

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Abstract

There is a close relationship between computational creativity in the arts and generative art. Prior work is summarized here as to how complexity theory can serve as a theoretical context for generative art. This is extended to show how complexity theory can also illuminate discussions regarding computational creativity.

Another prior proposal is also summarized. It suggests that a world-view called "complexism" can reconcile the current differences between the modern culture of science and the postmodern culture of the humanities. This line is also extended to considerations regarding computational creativity. Particular attention is extended here to the issues of authorship, progress, and aesthetic measurement in computational creativity.

Finally, under artistic license, I discuss some very speculative ideas regarding computational creativity that I explore in my current artwork.

1. Definitions and Theories

Some find a sense of intellectual security from the somewhat expected procedure of first defining terms and then proceeding with theoretical exposition. In a usual academic context where there is a preexisting technical language that includes commonly accepted definitions this is good standard practice.

However, in an unusual discussion that breaks existing paradigms[1], crosses disciplines, and ultimately requires the invention of new language, it's useful to remember that neither word meanings nor theory can stand alone. Both are rooted in the other and inseparable. It could well be that in a full

[1] The difference here being similar to Kuhn's notion of "normal science" and "extraordinary science." [1.]

Dagstuhl Seminar Proceedings 09291
Computational Creativity : An Interdisciplinary Approach
http://drops.dagstuhl.de/opus/volltexte/2009/2193

account of computational creativity its definition will not be the first thing presented. It may, in fact, be the last. And that is the case here.

II. Defining Generative Art via Complexity Theory

Closely related to the topic of computational creativity in art is generative art. It is, among other things, where those in the arts study and put to work presumed computational creativity. And in the field of generative art some standardization of the language, and corresponding consensus around theory, has occurred. But even within generative art there is controversy. Definitions, i.e. theories, of generative art in circulation include:

- Generative art involves the use of randomization in composition.
- Generative art involves the use of genetic systems to evolve form.
- Generative art is art that is constantly changing over time.
- Generative art is created by running code on a computer.

In a previous paper [2] I introduced a theory of generative art that offered what is now likely the most widely cited definition of generative art. In a more recent paper [3] I didn't modify the underlying theory, but I did offer the following to disambiguate a few aspects of the previous definition:

> *Generative art refers to any art practice where the artist cedes control to a system that operates with a degree of relative autonomy, and contributes to or results in a completed work of art. Systems may include natural language instructions, biological or chemical processes, computer programs, machines, self-organizing materials, mathematical operations, and other procedural inventions.*

This theory of generative art casts a very wide net that is independent of any particular past or future technology. By including systems such as symmetry, pattern, and tiling, generative art is theorized to be as old as art itself.

This view of generative art also includes 20th century chance procedures as used by Cage [4, 5], Burroughs [6], Kelly [6], Duchamp, and others. Along with notions of symmetry, this helps to tightly bind generative art to the standard art canon rather than leaving it isolated as an awkward art world orphan.

Next, if generative art turns on the use of systems, then the contemporary scientific program for the general study of systems, complexity theory, provides a context for the consideration of generative art. In brief, scientists such as Murray Gell-Mann [7] classify simple systems as being either highly ordered or highly disordered, and hold that complex systems exhibit a dynamic tension between order and disorder. This is sometimes called "effective complexity."

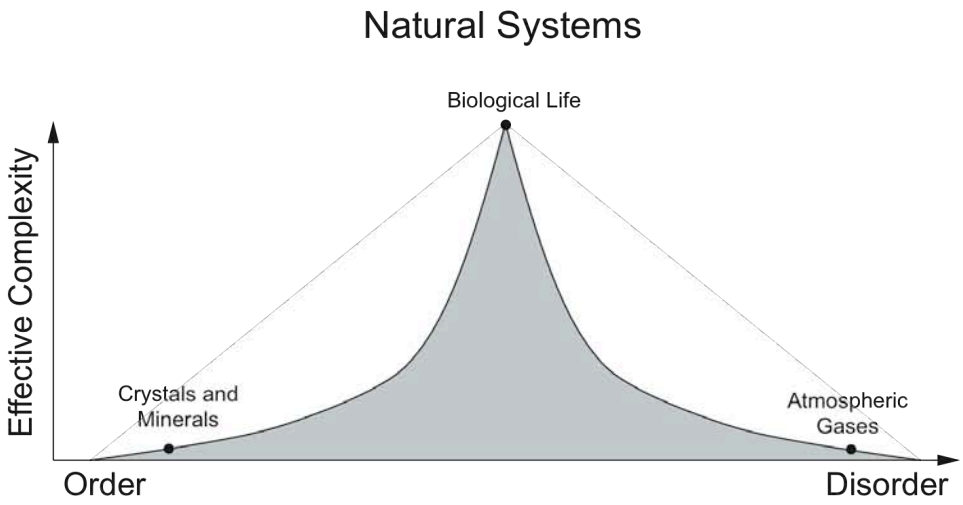

Figure 1

The earliest forms of generative art, those noted above as involving symmetry, pattern, and tiling, exploit simple highly ordered systems. In the 20th century the use of chance procedures, i.e. randomization, introduced highly disordered systems in generative art. Those interested in computational creativity in art tend to currently focus on generative art that involves complex systems such as genetic algorithms and evolution, artificial life, chaotic systems, emergent behaviour in networks, and so on.

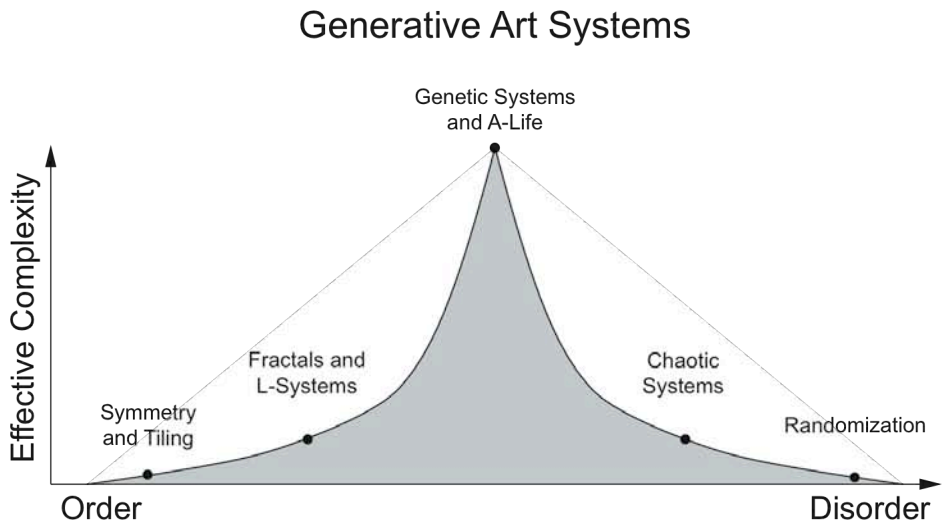

Figure 2

III. Modern Science Culture versus Postmodern Humanities Culture

In any discussion of creativity, computational or not, both those in the humanities and the sciences will have contributions to make. Many writers have commented on the current fundamental split in worldview we now find between the humanities and sciences, and this split will no doubt be reflected in any discussion of creativity.

In previous writing [3, 8] I've proposed a new synthesis inspired by complexity theory that can potentially reconcile the current differences. Here I will quickly review this split, the proposed synthesis, and the relevance to the question of creativity.

The first popular airing of the growing 20th century rift between the humanities and science is usually attributed to C. P. Snow's 1959 Rede lecture "The Two Cultures." In this lecture he captures a difference in attitude that has only become greater in the intervening years.

Literary intellectuals at one pole – at the other scientists, and as the most representative, the physical scientists. Between the two a gulf of mutual incomprehension – sometimes (particularly among the young) hostility and dislike, but most of all lack of understanding. [9]

The culture of science is rooted in rational Enlightenment values that arguably reached their fullest flower in the era of modernity. Modern science posits a noumenal world that allows real progress in its understanding. While such understanding may be by way of increasingly more accurate models and approximations, it is believed that they approach a real and fixed external truth.

Meanwhile the culture of the humanities has extended Hume's skepticism as part of a journey into deep postmodern waters. Postmodernism, and related notions of deconstruction, post-structuralism, and critical theory, introduce notoriously elusive, slippery, and overlapping terms and ideas. Most adherents would argue that this must be the case because each is not so much a position as part of an attitude and an activity; an attitude of skepticism and activity that is in the business of destabilizing apparently clear and universal propositions. [10]

The modern culture of science stands in stark contrast to the postmodern culture of the humanities.

Modernism	Postmodernism
Absolute	Relative
Progress	Circulation
Fixed	Random
Hierarchy	Collapse
Authority	Contention
Truth	No Truth
The Author	The Text
Pro Formalism	Anti Formalism

Figure 3

Where modernism seeks the absolute postmodernism explores the relative. Even as scientists posit real progress towards understanding the fixed laws of the universe, those in the humanities emphasize the circulation of constructed cultural realities that are ultimately unanchored traces drifting randomly.

The modernist culture of science has a tendency towards the hierarchical, expressed, for example, as taxonomical systems of categories and reductionist research methods. The postmodern culture of the humanities seeks to collapse hierarchies. This can be seen in the arts, for example, with the leveling of high art and low art, the ironic appropriation of both, and the celebration of arbitrary cross-cultural mash-ups. While it provides venues for conceptual competition, the culture of science creates and embraces authority both in terms of expert practitioners and totalizing theories. The culture of the humanities embraces never-ending contention through deconstruction and other post-structural strategies. It tends to view authority as a function of (political) power rather than meaningful expertise.

Ultimately this leads to a state of affairs where the culture of science expresses a modern optimism that Truth is within the reach. And the culture of the humanities takes the opposite position; a postmodern pessimism that no single truth can ever be arrived at because the very notion is absurd. At best, one can be aware of a multiplicity of equally valid, equally constructed, differing truths.

At the extreme postmodernism reduces the entire Enlightenment/scientific program to mere social construction, no better, certain, or important than the "mythologies" of other cultures now or in other times. [11, 12]

IV. Complexism

Without any specific commitment to literal Hegelian philosophy, complexism's reconciliation of modernism and postmodernism can be best understood as the third stage in a thesis-antithesis-synthesis model. As a paradigm for the arts and humanities complexism is informed by contemporary science, but is put into practice as a form of qualitative cultural study.

Complexism is shown here as a point-by-point synthesis that in its totality suggests a new paradigm. A synthetic attempt like complexism should be expected to take many years to develop, but a first approximation is offered in the table and discussion below.

Modernism	Postmodernism	Complexism
Absolute	Relative	Distributed
Progress	Circulation	Emergence & co-evolution
Fixed	Random	Chaotic
Hierarchy	Collapse	Connectionist networks
Authority	Contention	Feedback
Truth	No Truth	Statistical truth known to be incomplete
The Author	The Text	The generative network
Pro Formalism	Anti Formalism	Form as a public process and not privilege

Figure 4

Modernity, in both the sciences and in the hands of painters such as Rothko and Pollock, reflects Enlightenment values in reaching for the absolute, the sublime, and the fixed. The postmodern attitude rejects the absolute and instead posits a multivalent view of arbitrary relative positions that are no better than random. Complexism reconciles the absolute with the relative by viewing the world as a widely interconnected distributed process. Complexism posits processes that are neither fixed nor random, but are instead complex feedback systems that often lead to deterministic chaos. In the broader culture complexism can nurture a visceral appreciation of how the world can be mechanical and yet unpredictable.

Where modernity posits progress, and postmodernity rejects progress for multiple contingencies in perpetual circulation, complexism looks towards the emergence of co-evolved solutions. Co-evolved entities achieve real

progress in the relative context of each other, even while success remains a moving target rather than a fixed end-state.

Modernism posits hierarchies, and postmodernism seeks to collapse them. Complexism doesn't erase relationships, but it doesn't mandate hierarchies either. Complexism emphasizes connectionist models and networks, creating systems of peer agents rather than leaders and followers. Modernism aspires to absolute truth while postmodernism denies any possibility of a single final truth. Complexism embraces known limits to human knowledge [13, 14], but takes seriously the incomplete and statistical scientific truths that are achievable.

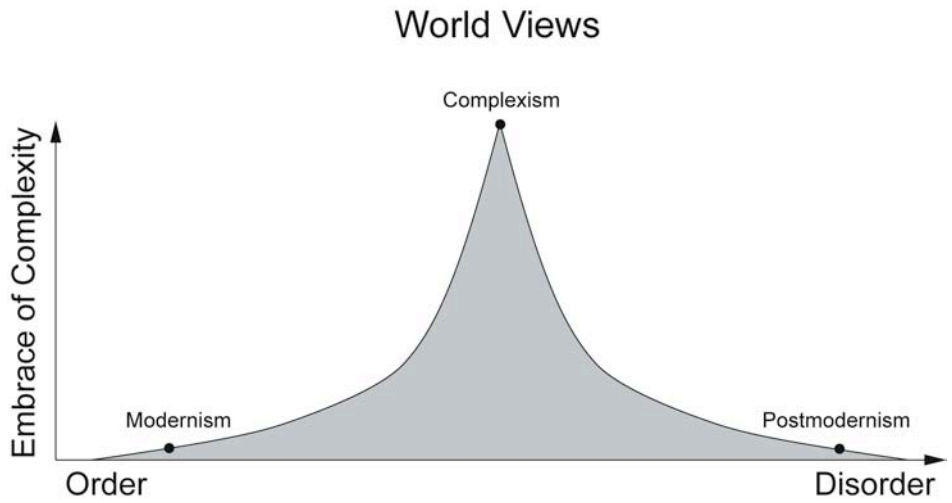

Figure 5

As suggested in Figure 5 complexism views both modernism and postmodernism as committing similar and yet opposite errors. Modernism moves towards understandable simplicity by creating crystal-like systems that are highly structured and highly ordered. Postmodernism moves towards understandable simplicity by breaking down and leveling structures leading towards something like a cloud of mist.

In trying to gain partial understanding the modernist seeks to avoid the disorder that is clearly part of our world, and the postmodernist seeks to avoid the order that is also clearly part of our world. Both modernism and postmodernism commit an error of reductionism leading to oversimplification and away from an overall understanding of the complex systems involved.

Following are three examples of how the complexist view impacts issues around creativity.

IVa. Theories of Authorship

The modern scientific community views problems around the notion of authorship as being mostly ethical and legalistic in nature. There are discipline specific practices for giving due credit in the ordering of the names on research articles. There are prior art concerns when pursuing patents. And there are notions from the relatively recent open source and copyleft movements that seek to modify, weaken, or eliminate the linkage between authorship and property rights.

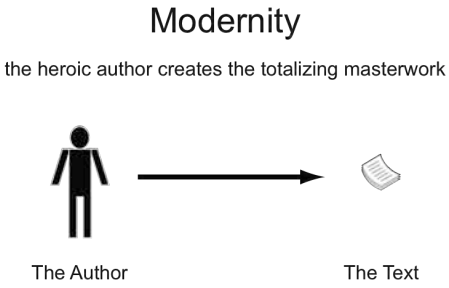

Figure 6

In modernity the focus of attention is on the author who, at the highest levels of achievement, engages in a high-stakes battle to create a totalizing theory and masterwork. Those working in highly specialized incremental scientific research also don't consider the reader to have a role in authorship per se. The readers are merely the fortunate beneficiaries of the results. And when modernity reigned supreme over the arts, artists were similarly viewed as being singular, potentially heroic, and relatively unconcerned with their audience.

From such a view creativity is seen as being solely the domain of the author.

In the postmodern humanities this theory of authorship has been "problematized." Poststructural theory diminishes the author to the point of figurative "death." What is seen as important is the text and the way it can be deconstructed by the reader yielding new, multiple, and possibly contradictory meanings.

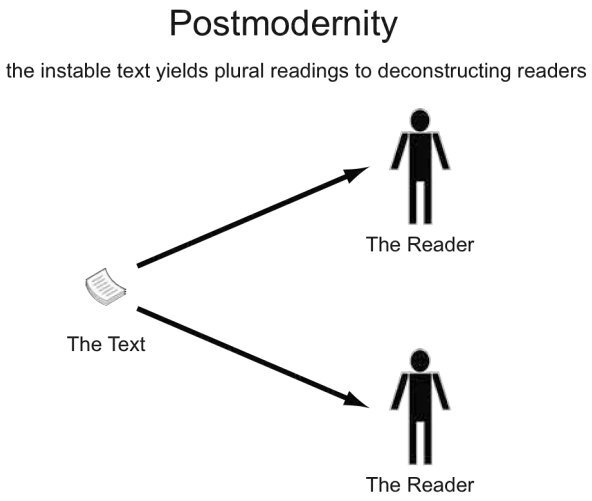

Figure 7

Given such a view the creativity of the author is of less interest than the creativity of the reader. It's the reader who creates the meaning(s) of the text, and thus it's the reader who must exercise creativity in the practice of close reading, i.e. deconstruction.

Relative to complexism both modernism and postmodernism commit an error of reductionism leading to misleading oversimplification. One eliminates the reader and the other eliminates the author. The complexist view includes the author, the reader, and the text as all being essential.

From a systems view it becomes obvious that each individual is both a reader and a writer. This creates large networks of author/readers connected by flowing texts and feedback loops

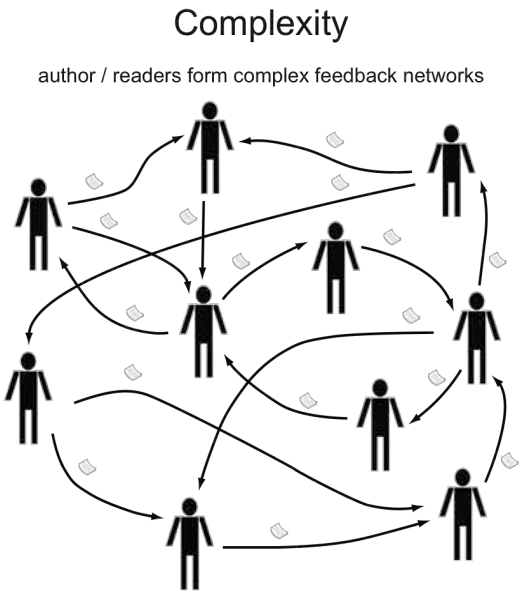

Figure 8

This suggests that any complexity-based account of creativity has to not only consider the brain function of the author, but also the social context of the creative activity, and the "inputs" to the author prior to a given creation. Of special interest is the nonlinear amplification and modification of creative ideas by readers who go on to contribute to feedback loops.

IVb. Theories of Progress

Discussions of creativity typically stipulate that a creative act must yield something new that is of value. Creativity is thus seen as contributing to progress in that it helps to move people to some kind of new and improved state.

And so too modern science is viewed as offering real progress as old theories are replaced by new theories offering more in the way of explanation and prediction.

In the postmodern humanities progress is viewed with extreme skepticism. The preference in the humanities is to recognize a plurality of theories in perpetual circulation. Discourse is always viewed as an exercise in

(political) power as much as anything, and there is no fixed origin from which progress can be measured.

The clear challenge related to a discussion of creativity is the following. Any account of creativity that includes real progress as a definitional prerequisite will immediately run into trouble when considered by those steeped in the culture of the postmodern humanities.

Complexity theory can offer the process of evolution, and especially coevolution, as a way out of this dilemma. In biology coevolution refers to the way a given adaptation in one species will occur as a response to an adaptation in another species sharing the same ecosystem. This can sometimes lead to a symbiotic relationship, or it can also result in a sort of "arms race" among predator and prey or species competing for common resources.

In the broadest view a given genetic adaptation never represents absolute progress. Adaptations can only represent progress relative to a given environment. In a similar way creativity need not be viewed as contributing something of absolute value. Instead creativity can be viewed as contributing something of value in the relative context of the particular society and situation. This reconciles the modernist requirement that creativity produce something of value while also allowing postmodern skepticism towards absolute value.

IVc. Complex Aesthetic Measures and Evolutionary Algorithms

One implication of the above is that aesthetic evaluation is relativistic but not arbitrary. Within a given society over time, or across societies at a given time, aesthetic differences arise from a context, and co-evolution dominates rather than some unchanging standard of aesthetic quality. Indeed definitions and the implied theories of art itself have changed over time.

This makes the construction of an automatic function to evaluate aesthetics fitness and produce an aesthetic measure very difficult unless some deeper and higher level principle can be found. In this regard a commonly cited component of proposed universal aesthetic measures is "complexity." But without further specification the term is ambiguous.

In earlier papers I've discussed some measures of complexity and why they do not correspond well with what is meant by complexity in contemporary scientific studies of complex systems. A first meaning is that from information theory where complexity is inversely proportional to the degree to which a signal (i.e. a collection of symbols) can be compressed without information loss. [15, 16] A second meaning is that complexity is inversely proportional to the degree to which an algorithm that produces a given output can be compressed without output loss. [17-19]

Both definitions end up assigning the highest complexity to random data, in the first case considering the compression of the data itself, and in the second an algorithm to produce the data. While such measures have their place, they do not correspond well with our everyday sense of complexity or complexity in art.

For example, such views would imply that a digital image of the Mona Lisa could be made increasingly more complex by randomizing more and more of its pixels. In actual human experience all images of random pixels are essentially the same, and it is the structure within the Mona Lisa that contributes to its complexity. What we would like is something akin to a measure of engagement. I.e. given a system of a great many parts, how much comprehensible variation is in the holistic result.

If a universal measure of complexity is to be used as part of an aesthetic measure it should probably correspond to something more like Gell-Mann's proposed "effective complexity" measure. Artists working in all forms have an intuitive understanding that an effective piece needs regularity to not lose the audience to confusion, but also surprise to not lose the audience to boredom. This is analogous to the balance of order and disorder that is referred to as "complexity" in complexity science.

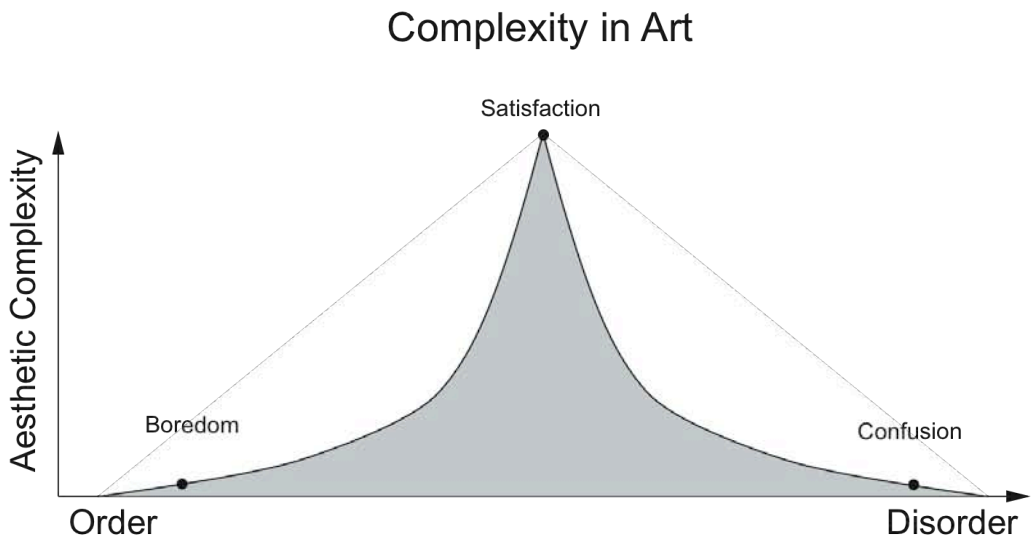

Figure 9

As a practical matter being able to measure aesthetic quality will be an important component of computational creativity as applied to art. For example, in the field it's well understood that evolutionary systems can be effectively applied to the creation of art. The components of such a system include (1) the ability to encode instructions for an artwork in a genetic data structure as genotype, (2) the ability to express the piece as phenotype, (3) the ability to add variation to the gene pool via operations such as mutation and crossover, and (4) the ability to assess fitness in a population to enforce "survival of the fittest." Of these four components only the first three are essentially solved problems in generative art.

A measure of aesthetic quality would greatly contribute to, or serve as, a fitness function in an evolutionary art system. As it now stands human judgment is "in the loop" and evolutionary art systems cannot freely iterate for thousands of generations across large populations the way genetic algorithms can when applied to other kinds of problems.

Getting the human "out of the loop" in an evolutionary art system would be a step forward in art-oriented computational creativity. Lest the point above be lost, using compressibility alone as a measure of complexity towards an aesthetic measure is probably mistaken, and a measure of effective complexity seems closer to the aesthetic judgments humans make.

V. What is computational creativity?

From my point of view thinking about computational creativity inevitably rests upon some arguably larger questions that remain closer to mystery than not. One of the things art on the cutting edge does well is to raise the right questions without necessarily answering them. Acting as an artist I feel free to explore the hypothetical in a way that would be considered speculative, reckless, and irresponsible in the sciences or humanities. I've always viewed my work in the arts as a sort of "experimental philosophy" where philosophical speculation can be thrown into the physical world to see how well it fares and what new ideas it may lead to. In this spirit, here are questions and speculative propositions I'm currently pursuing in my work.

(1) – Aesthetic measures, if possible at all, will be very complicated because they will have to involve a combination of factors such as effective complexity, design principles, psychological models, and a matrix of social context factors.

(2) – The question of creativity is difficult for many of the same reasons that the question of intelligence is difficult.

> At one time the notion of animal intelligence was viewed as absurd. Even now the intelligence gap between man and other animals is apparently so broad that some assume they are essentially different.
>
> Is it the case that animals are, in fact, not only intelligent but also creative?
>
> If intelligent machines are possible can machines be creative in a similar way, or with a similar meaning?

(3) – Computational creativity is difficult because we don't yet understand consciousness and the related phenomena of self-awareness and the experience, of qualia.

> Is unconscious creativity possible?
>
> Is conscious creativity possible?
>
> Are non-neural systems unconscious or something else?

(4) – The essential aspects of consciousness, the experience of qualia and self-awareness, remain a mystery that cannot be made irrelevant by attempts to explain or define them away. Here is my tentative position:

> *Consciousness is more an observer than an actor.*
>
> *Most mental activities and associated actions are already in motion before, if ever, becoming conscious.*
>
> *Consciousness as purely an observer without any ability to take action seems unlikely. (e.g. What competitive advantage would entirely passive consciousness provide in the context of evolution?)*
>
> *Consciousness is related to feedback at the highest neurological levels.*
>
> *In the above model creativity then involves both the unconscious and conscious.*

(5) - Creativity isn't as special as some might think. All complex adaptive systems are creative. All human forms of creativity, including creativity in the arts, are much more similar than not.

Complex adaptive systems are those complex systems that both sense the changing nature of their surroundings and take actions to maintain their existential integrity. These adaptive actions are examples of creativity. In lower life forms the adaptation, intelligence, and creativity involved may be quite basic. But they exhibit adaptation, intelligence, and creativity nevertheless.

At the human level maintaining one's existential integrity involves congruity with social expectations, and creativity is always judged relative to a social context. Here social context can also be thought of as culture. Creativity in the arts is especially tied to culture, as its practical function is minimal.

(6) – To the extent a computer can be considered a complex adaptive system it can also be considered creative.

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