Empathy in the Ergodic Experience of Computational Aesthetics

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Abstract

Computational artworks develop very particular relationships with their readers. Being able to encode and enact complex and contingent behaviours, a computational artwork exists in a dual state between two layers that are inextricably connected, a computational subface that is often a black box which can only be peeked at through an analogue surface, that mediates but also isolates it. But the procedural layer of the subface can be unearthed through a process of *virtuosic interpretation*, through which readers are able to develop some empathy with the system and arrive at a *theory of the system* that ultimately allows the transferring of some of the artwork's processes to human minds. This paper focuses on how this process is developed and how it is the basis for a unique type of aesthetic experience that leads computational media and art to involve readers in anamorphosis and in a dialectics of aporia and epiphany, that mirrors the superimposition of subface and surface, and from where narrative experiences emerge.

Keywords

Computational Art, Ergodic Media, Artificial Aesthetics, Narrative, Reading, Virtuosic Interpretation, Interaction, Theory of the System.

Introduction: Computational Art and the Ergodic Experience

We may define computational art as art that uses computers, computational systems, or computational media in its creation or deployment. This is a somewhat vague definition, particularly at a time when computational systems are ubiquitous to the point of touching nearly all aspects of our lives and cultures, spawning a bewildering variety of unprecedented forms that challenge the established notions of artistic medium. Vague and encompassing definitions such as this are however well suited for these shifting forms, which have also given rise to a diversity of alternative terms such as e.g. *digital art*, *software art*, *computer art*, *algorithmic art*, *rules-based art*, or *new media art*, among others, to describe either process-based or processor-based artistic practices and forms. Attempts have been made to clarify this apparent terminological disarray, as e.g. in Galanter (2006), Boden and Edmonds (2009), or Lopes (2010), but ultimately, anything close to a terminological agreement seems hard to come by, perhaps even unnecessary.

In light of this, without digressing too much, and not attempting to definitively solve the issue, we nevertheless need to make a brief terminological point so that we are able to focus the discussion. If there seems to be nothing but a slight distinction between designations as *processor-based art* and *process-based art*, we find this to be illusory, as the first of these terms simply brings the medium to the fore, while the latter focus on the nature of the artworks themselves. Similarly, a term such as *digital art* emphasises the codification used in most contemporary computational technologies, while terms such as *computer art* or *software art* emphasise the media, the tools, or the technological infrastructure within which artistic production may be developed. And why is this relevant? Because of the ubiquity of processor-based, digital, computer tools and media upon which much of our culture current develops. Because digital computers and computer networks are pervasive and, acting as a universal solvent for media (Hayles, 2005), have been replacing many of the media technologies in our lives, nearly everything is now mediated by digital computers. Consequently, many art forms inevitably tend to become some kind of digital or computer art, regardless of how much one tries to split the terms and fine-tune definitions.

The capability that computers have to mediate information is quite remarkable. Through the digitisation of media contents and the simulation of media forms, computers and computer networks allowed us to weave an encompassing cultural substrate that surrounds much of our daily activities and is within reach at nearly every moment. However, most of the contents of this *infosphere* are not computational, although they reside in computers (Flichy, 2007; Floridi, 2014). They depend on computation to be archived, transmitted, and enacted, but they ultimately emphasise data and not processes, bringing to mind Chris Crawford's useful notion of *process intensity* (1987), the degree to which a system does the exact opposite, i.e. emphasises processes over data. Process intensity is fundamental in computational media forms and artworks in the same measure as computation is fundamental for their creation or deployment, exactly because it is an expression of computation. Computation in computational art is not merely used for its immediate qualities of speed, economy, versatility, etc., but also because it is understood to be meaningful, and as we will see, additionally becomes one of the aesthetic outputs of artworks, sometimes even their fundamental aesthetic output, their essence and *raison d'être* (Kawano, 1976).

Computation is often a loosely defined term that we may define as any "process that obeys finitely describable rules." (Rucker, 2005, p. 11) The term refers to the abstraction of these processes, not to the actual processes being described, therefore a given "computation is the same regardless of how it is executed." (Lee, 2009, p. 5) This means that although digital computers are often used in computational artworks, the term does not exclude works that do not resort to digital computers, program code, algorithms or effective procedures (Weizenbaum, 1976, p. 46) but that rely instead on computation as a medium to describe structure and process (Mateas, 2005). In this sense, we do not regard this so much as a technological description, but we rather agree with Kevin Kelly's view of considering computation a formal arrangement of matter and energy that may occur in every substance and be communicated between systems that are somehow able to compute (2009). As a result, works that resort to classical media[1] and that are apparently non-computational, may sometimes be found to have a high process intensity, not exactly deploying processes but rather giving human readers[2] the means to deploy processes, with or without the support of the physical infrastructure of the work. We can find examples of this in works as Raymond Queneau's *Cent Mille Milliards de Poèmes* (1961) or Marc Saporta's *Composition Nº 1* (1962), two books that present readers with data and process descriptions and allow them to *execute* the pieces by enacting processes (through the rearranging of verses in the first case and the reordering of pages in the second).

What we then describe as computational art are not only artefacts, accompanied by their inevitable paratexts and subtexts, but rather *abstract machines* that are able to process information but that do not necessarily need to be physically instantiated in the artworks themselves, but may alternatively be instantiated *by* and *in* human readers.

> Computer art runs on computers, so if brains are computers then some computer art runs on brains. This reasoning will give you pause if you reject the assumption that brains are computers; but remember that we've defined computers simply as devices designed to run computational processes, not as silicon circuit boards, and brains are certainly designed to run computational processes. (Lopes, 2010, p. 48)

What we find fundamental is for process and structure of artworks to be computationally defined. This will not only affect the nature and form of the artworks but also the relationships that both authors and readers will be able to develop with them through their media. Espen Aarseth's (1997) definition of *ergodic* is very useful here, as it is able to describe these works in ways that are more focused on these relationships than on their technological infrastructure. The term ergodic is used to describe texts where readers are required to develop a "nontrivial effort" in their reading or, as Aarseth puts it, in their *traversal*, the crossing of the text, which encompasses not only reading as, very often, also its literal construction (Montfort, 2003). During the traversal readers effectuate "a semiotic sequence", that "is a work of physical construction that the various concepts of 'reading' do not account for." (Aarseth, 1997, p. 1) Therefore, ergodic media are characterised by the existence of an ergodic level that may develop concurrently to other levels such as description or narration:

> Narratives have two levels, description and narration. A game such as football has one level, the ergodic. A video game has description (the screen icons) and ergodics (the forced succession of events) but not narration (the game may be narrated in a number of ways, but like football, narration is not part of the game). A hypertext such as *Afternoon* has all three: description ("Her face was a mirror"), narration ("I call Lolly"), and ergodics (the reader's choices). (Aarseth, 1997, p. 95)

If on *Cybertext* Aarseth studies textual forms, it seems clear that we do not need to limit the use of *ergodic* to literature and textual artefacts, and that we may be able to apply it to *all* communicational artefacts, media, or artworks in which similar behaviours may be developed.

Computational Artworks as Black Boxes

At a time when so many cultural and media forms are developed in computational systems, it is almost inevitable that some of them acquire ergodic traits. As a larger number of artefacts are created, developed, distributed, and experienced in computational contexts, we gradually find that classical forms and those forms that are native to computational systems, start sharing traits. There is certainly something of a strong wish to preserve historical models or patterns (such as the novel, the film, the musical album, etc.) but it is hard to counter the effects that the "procedural attractor" has in the digital medium, and the transformations caused that this causes.

We therefore find that in computational contexts contingent and complex behaviours not only become possible, as they are almost inevitable. Empowered by procedurality, the new media forms express the remaining affordances of the digital medium, becoming *participatory*, *spatial* and *encyclopaedic* (Murray, 2012). And *all* the artefacts developed in these contexts become characterised by a *surface* and *subface* duality (Nake, 2016). The surface is the analogue sensorial layer through which signs can be communicated to humans, and the subface is the immaterial and algorithmic substrate of the medium, where computation, code, and processes are developed.

[1] That we could also describe as *analogue*, or *molar* (Lévy, 1997).

[2] We could describe the human counterparts in these cybernetic processes using terms as *users*, *interactors*, or even *players* but we find that none of these terms adequately describes them in all contexts. We have thus preferred to use the more generic term *reader*.

> We do not usually have access to the subface. It is hidden, internal to the computer or the software system. (…) In ordinary terms, we may say that the subface is the algorithm, the description of the class, the program-and-data. In the same manner of describing the situation, the surface is the image on screen, in projection, be it still or dynamic, passive or interactive. (Nake, 2016, p. 16)

The subface is inextricably linked to the mediating surface, but it is also inevitably secluded by it[3] and therefore it becomes a *black box* that readers are only able to explore through its outputs, its surface effusions. If on some black boxes one may not be very interested on the inner workings as on their results or outputs, in computational artworks the mechanics of the black box become something fundamental to grasp.

The Aesthetics of Mechanics

The layer of the *mechanics* of a computational system is defined as its "particular components (…) at the level of data representation and algorithms." (Hunicke, LeBlanc, & Zubek, 2004) The "run-time behavior of the mechanics" is then described as a system's *dynamics*, which in turn will give rise to a layer of *aesthetics*, where one will find the "emotional responses evoked" in readers during the traversal.

Hunicke, LeBlanc and Zubek's MDA framework was developed in the context of game studies, focusing on videogames and particularly on the idea that they are "*more like artifacts* than media", i.e. that their central content is *behaviour*, "not the media that streams (…) towards the player." As such, MDA also becomes relevant to the study of other computational and ergodic forms, precisely because of how it establishes each of the three layers of mechanics, dynamics, and aesthetics as a "view" of the system that stands separate from the others but causally linked to them, both from the designer's as from the readers' points of view.

> From the designer's perspective, the mechanics give rise to dynamic system behavior, which in turn leads to particular aesthetic experiences. From the player's perspective, aesthetics set the tone, which is born out in observable dynamics and eventually, operable mechanics. (Hunicke, LeBlanc, & Zubek, 2004)

The layer of *dynamics* is observable by readers, but that of *mechanics* is not directly perceivable. Regardless of this, mechanics is as relevant to the aesthetic experience as dynamics, but like the subface, it is hidden from view. We should note that the mechanics layer is not the subface, or at least all of it. Our interpretation is that what Nake describes as the subface encompasses not only the mechanics as well as part of the dynamics layer. The surface, on the other hand, starts at the perceivable phenomena in the dynamics layer, and overlaps that of aesthetics, not including however the totality of this, because the aesthetics layer also includes phenomena that lay outside of the artworks, within the readers' minds.

Computational artworks are often open-ended systems that are able to generate seemingly endless outputs and variations. While reading these, if one only follows the systems' surfaces, one may be confronted with traversals that may either be infinite or at least potentially infinite at the human scale. In such cases, regardless of the time and effort put on traversing a system, no single human will be able to fully peruse the entirety of its outputs when facing something like the 10^{14} different sonnets that can be generated from Queneau's *Cent Mille Milliards de Poèmes* (1961), or the 1.8×10^{308} unique icons that are eventually produced by John F. Simon Jr.'s *Every Icon* (1997). As a consequence of this, a *full* and *complete* reading of all the outputs produced by systems such as these is not only often impossible, as it is not even desirable. What then may constitute the focus of the aesthetic experience of these artworks? How is it that readers may be able to experience closure?

Our hypothesis is that the aesthetic enjoyment of computational artworks, and the sense of closure, are linked with an understanding of their subface. The surface remains fundamental, firstly as a focus of aesthetic enjoyment in itself, but predominantly because it is the only gateway available for readers to understand what may be happening at the subface. The relationship between subface and surface is arbitrary (Aarseth, 1997, p. 40), i.e. not constrained in principle by the physical materiality of any particular medium or material, but the subface ontologically precedes the surface, and sets the field of possibilities for everything that may there happen. The surface phenomena can only be "fully understood (…) in light of the internal" level, and from the readers' points of view, whatever is at the subface level "can only be fully experienced by way of the external, expressive level" of the surface (Aarseth, 1997, p. 40).

As readers are unable to exhaust the surface signs, it follows that an understanding of the subface may allow them to anticipate the artworks' formal development, their behaviours and outputs. If systems are interactive, this understanding may also allow them to grasp the "repertoire of possible steps and rhythms" with which they may "improvise a particular dance among the many, many possible dances the author has enabled" (Murray, 1997, p. 153).

Computational artworks are not merely objects but rather *machines*, systems of interdependent processes that evolve autonomously from readers (Boden & Edmonds, 2009, p.

[3] This happens because readers are unable to directly access the subface. We could argue that even in systems such as those described in the following pages, where readers are given direct access to representations of program code, the subface is still mediated by a surface, in this case the representation of the subface as program code that still needs to be interpreted or compiled. The subface is not the program code in itself, but rather those processes that are instantiated in the computational machine, and although these are represented by the program code, they are not *the* program code.

30). It follows that developing some degree of empathy with the artworks, developing *models* or *mental simulations* of their subfaces, a *theory of the system* (ToS), may allow readers to achieve a functional understanding of the artefact, and through this, to attain some closure.

This ToS is not necessarily a full mental simulation of the mechanics, something that in most cases would probably not only not be useful, as would also result in an excessive cognitive burden. It is not a formal description of the artworks' system or of their actual code, but rather an intuitive understanding of their subfaces, a collection of mental models of the system, of heuristics that may help to predict their behaviours. It also does not envision to model all of the computational processes in artworks, but only those that are perceived to be relevant from an aesthetic point of view. Many processes, perhaps even a majority of those that constitute the artworks, are either uninteresting or transparent from this point of view, and as such are not considered in the ToS.

Reading Processes: White Boxes vs. Black Boxes

Gathering some understanding of the subface of a system therefore becomes fundamental in its aesthetic enjoyment. If the artworks' surfaces are the only entry point readers have to their subfaces, reading becomes a more challenging and complex process, as it turns into an exercise of inferring the subfaces from the surfaces. How is this process developed?

We may regard some artworks as being potential *white boxes*, given how they present readers with code or pseudo-code descriptions of the processes. A work as John F. Simon Jr.'s *Every Icon* (1997) describes its process with a simple, straightforward and clear caption:

Given: An icon described by a 32 × 32 grid.
Allowed: Any element of the grid to be colored black or white.
Shown: Every icon.

Other works present actual code, as in Pall Thayer's *Microcodes* series, from which *Sleep* (2009) presents itself as two lines of Perl:

```
#!/usr/bin/perl
sleep((8*60)*60);
```

Finally, other pieces, such as Casey Reas's *Process* series, are accompanied by pseudo-code descriptions of elements and processes such as:

Element 1
Form 1: Circle
Behavior 1: Move in a straight line
Behavior 2: Constrain to surface
Behavior 3: Change direction while touching another element
Behavior 4: Move away from an overlapping element

Process 4
A rectangular surface filled with varying sizes of Element 1. Draw a line from the centers of Elements that are touching. Set the value of the shortest possible line to black and the longest to white, with varying grays representing values in between.

But white boxes are somewhat rare. Not only they demand that readers be able to understand the code or the code descriptions, as they may easily become black boxes due to the complexity of the processes presented. Even if one is able to grasp the entirety of the procedural descriptions and is able to mentally imagine its deployment, beyond what seems to be a somewhat low threshold of complexity, the complete computational development will likely be impossible to grasp. If the processes in *Every Icon* or *Sleep* can be easily followed through to their ultimate consequences,[4] those on *Process 4* (2005) are far more complex. Even if readers understand the pseudo-code descriptions, they will almost inevitably have difficulties in predicting the full formal development of its possible outputs. Given some clues regarding e.g. colours or shapes, we may expect some understanding of the field of possibilities to be attained, but this will most certainly not be enough to successfully anticipate the final forms and behaviours of the artworks.

When readers are faced with *black box* systems, if the system is interactive, they may be able to directly peruse the surface and through interaction try to probe the subface, testing the system in order to understand its mechanics. But even direct interaction may not suffice to correctly grasp the subface, and furthermore, not all systems are directly interactive.[5]

The process we described elsewhere as *virtuosic interpretation* (Carvalhais & Cardoso, 2015b, 2017) starts, like every reading process, with the *interpretative function* (Aarseth, 1997, p. 62), through which information starts

[4] Readers are in principle able to follow the processes step by step or to quickly imagine the gamut of all their formal outputs or, to be more precise, to understand the complete field of possibilities within which a system's behaviours will happen and within which the outputs will be generated, and to imagine possible articulations to be developed inside this field, which is to say, consequently, to also imagine all the behaviours and outputs that the system will not be likely or will not be able to produce.

[5] We will follow a stricter definition of interaction than e.g. that proposed by Dominic McIver Lopes (2010), defining interactive systems, or systems that allow for direct interaction, as those that are able to instantiate their code and processes, and to develop bi-directional communication with their readers. Although we sympathise with Lopes's argument of interactive artworks that use "brains to achieve interactivity" (2010, p. 49) we would, in this context, classify these works as non-interactive.

flowing to readers. This interpretative function is omnipresent in all media forms, and often it is the only function accessible to readers (Bogost, 2006, p. 108). What characterises ergodic forms is the presence of further reader functions, such as the *explorative* and the *configurative* (Aarseth, 1997, p. 62; Carvalhais, 2016, p. 244). Through the first of these, readers will be able to decide which paths to follow along the traversal, while through the second they will manage to select or create new surface units in the system.

The balance between functions depends on the dynamics of a system, and on whether direct interaction is allowed. In non-interactive systems, or in contexts of vicarious interaction[6] (Kwastek, 2013, p. 94; Carvalhais & Cardoso, 2015a), the interpretative function will take the lead role, otherwise, any of the other functions may lead, as will often be the case with games or with game-like experiences. But even if the explorative and configurative functions are not directly accessible to readers, the procedural modality (Strickland, 2007; Carvalhais, 2016), our penchant for pattern detection (Eagleman, 2011; Shermer, 2011, p. 5) and for identifying intentional stances and causal relations and affinities (Pinker, 1999), will still allow us to develop them even if indirectly.

As readers interpret surface signs and from them deduce causal relations, they will amass information from these, from mechanics that may be previously known from other systems and that may be remembered and adapted to the current context,[7] and will develop tentative mental models of the system, a conjectural and provisional ToS. This ToS will then be iteratively refined through the confrontation with the actual system, a process that will allow the confirmation, fine-tuning, or falsification of the hypothesis it encapsulates.

This effort is dependent on the possibility to establish multiple contacts with a system, so that the ToS may be effectively evaluated. As computational artworks are performative and time-based systems, multiple contacts are usually required for their thorough reading.

This is a gradual process of creation of meaning. This interpretation of signs, behaviours, and processes is by and large a subconscious process of learning, of building knowledge about the system and of progressively reducing the uncertainty one has about it, of gradually getting to understand its machine through direct contact with its surface or through indirect contact with simulations in the ToS.

Towards Empathy

As a consequence of this process of virtuosic interpretation, artworks become something more than their mechanics, dynamics, and aesthetics layers, being expanded by two concurrent virtual layers that are continuously confronted with them: a layer of *simulated dynamics*, and one of *simulated mechanics*.

Systems also become more than just their surface representations and the particular computational instantiations that readers are confronted with. As readers develop empathy with the systems of the artworks, some of their mechanics are effectively transferred to the readers' minds, where processes can then continue to be developed far beyond the duration of the actual contacts with the artworks. We can regard this dissemination or replication of a work's procedural foci to human minds as one of the goals of computational artworks, perhaps even their quintessential goal.[8]

Furthermore, during the process of virtuosic interpretation, during the trial-and-error stage of developing a ToS, readers are as likely to find models capable of producing good previsions as they are of running into models that do not and that are quickly falsified when confronted with the artworks. Finding that a model is false or incorrect will of course allow for its revision and correction, but it will inevitably also lead readers to experience aporia (Aarseth, 1997, p. 91). Conversely, the confirmation of a model through the verification of its predictions will lead readers to experience epiphany.

The aporia-epiphany dynamic thus generated leads to the development of a unique kind of aesthetic experience, that resorts to cognitive processes that are somewhat rare in other media. Not being in itself a narrative structure, it "constitutes a more fundamental layer of human experience, from which narratives are spun." (Aarseth, 1997, p. 92)

Consequently, computational media become *narrative games* that involve readers in processes of anamorphosis[9] by leading them to assume unconventional stances towards the media of the artworks, ultimately forfeiting the original media altogether, once that the processes are transferred to the readers minds. Computational artworks are therefore not only instantiated multiple times, in their own systems and in readers' minds, as they also spawn variable and divergent instantiations, mutating and becoming individualised in each ToS.

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[6] From the point of view of virtuosic interpretation, we regard vicarious interaction as being very similar in principle to the experience of non-interactive systems, as readers are not able to directly peruse the system but are limited to the observation of the interactions between two systems, one of them a human.

[7] These may include mechanics from physics, and other real-life examples that may be in some way analogous to the system being read.

[8] We could establish a parallel with conceptual art, given that the main goal of both art forms seems to be the transmission of concepts, procedures or instructions (Albert, 2009). Both in conceptual art as in computational art, very often the artist's attention "is focused on exploring systems for their own intrinsic value" (Galanter, 2003, p. 18) but in computational art, code and processes are almost never communicated directly to the reader but are rather mediated by artefacts that embody and instantiate them, that mediate them through computation. Therefore, computational art becomes so because it communicates computation through computation, *expressing* computation.

[9] *Anamorphosis*, as defined by Aarseth consists in hiding "a vital aspect of the artwork from the viewer, an aspect that may be discovered only by the difficult adoption of a nonstandard perspective." (1997, p. 181)

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