# PROCEDURAL SIMULATION AND ITS REVERSAL APPLIED TO GAME DYNAMICS: EXPLORING RULES-BASED SYSTEMS THROUGH PLAY

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This paper documents a project focused on the use of rules as a structuring element of systems and on promoting a playful interactive experience as a strategy for the creative exploration of those systems. The project contemplates the application of computational principles to physical space through the mediation of human execution. It makes reference to *Game of Life* (Conway 1970) and *Reverse-Simulation Music* (Miwa 2002) as case studies: two opposite poles that illustrate both human and machine execution through procedural simulation and its reversal. Our approach is based on a practical exploration of strategies analogous to both examples. It aims to contribute to an understanding of software code as a creative field inside and outside the computer.

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## 1. INTRODUCTION

This study was developed under the MA in Communication Design and New Media at the Faculty of Fine Arts, Lisbon and relies on the premise that the same instruction code can be executed by both machines and humans. It is inspired by how contemporary artists seek to reverse computational principles through the mediation of human procedural execution. It reinterprets ideas explored by artistic vanguards of the 1960s, which used the human body as a medium for creation.

From then onward, the spread of electronic media polarized artistic perspectives: either exploring the disappearance of the physical body brought about by media, or emphasizing corporeal presence and materiality (Frieling 2003), as strategies that were transposed to contemporary practices that refer to concepts of process-based art. New forms of computer-based interaction seem to expand the concept of the "open work" (Eco 1989) often resulting in evolutionary systems which are able to learn and act for themselves (Arns 2004), such as the *Game of Life* (*GoL*). This piece exemplifies how, by means of simple rules, it is possible for an artist "to cede some degree of control" to a system, endowing it with the ability to generate complex patterns and behaviors (Galanter 2006). This idea is transposed outside of the computational context, as reflected by methodologies such as the *Reverse-Simulation Music* (*RSM*) that explores the way in which a human system "reproduces in the natural world phenomena based on certain laws that have been investigated within computer space" (Miwa 2007).

This approach proposes a reflection on what software is and how algorithmic instructions can, in theory, be executed by humans as well as by machines; thus resembling the procedural nature found in former practices, such as happenings and performances, namely through the use of instructions and notations for actions. Based on this idea, this project aims to consider the procedural implementation of rule-based processes, revealing how they can be reinterpreted and performed by different types of systems, whether real or virtual.

We focus on the generative and adaptive potential of rule-based systems and the way they "exponentiate" results, leading to self-organization (Galanter 2003). This approach seeks to emphasize the creative potential of rules. We also have a particular interest in promoting a playful interactive experience in order to enhance the engagement between audience, artist and his work. To this idea, we associate the notion of collective experience and free interpretation in order to explore how these can promote specific "pleasures" associated to the system's gameplay (Costello and Edmonds 2007:82). We therefore assume procedurality as a key concept, common to both human and computational execution that extends to software code, variable systems and games as systems. This approach is followed by an analysis of the two case studies mentioned, which seeks to define a set of principles and strategies to be applied to a creative reinterpretation of the *GoL*.

## 2. OVERVIEW

### 2.1. PROCEDURALITY

Procedurality is the computer's "defining ability to execute a series of rules" (Murray, 1997). The term arises from the function of the processor, "the 'brain' or 'heart' of a computer" (Bogost 2008:122). According to Bogost, procedurality "creates meaning through the interaction of algorithms". These are the "sets of constraints" that structure the system's behavior and allow the creation of representations and "possibility spaces, which can be explored through play" (2008:122). This term points to the formalization of abstract processes, which we call algorithms (as treatable procedures or methods); abstractions which can be considered independently from both programming languages and the machines that execute them (Goffey 2008:15-16).

### 2.2. CODE

According to Cramer (2002) we consider that "the concept of software is by no means limited to formal instructions for computers". These instructions "only have to meet the requirement of being executable by a human being as well as by a machine". This idea is tied to what Berry (2008) calls the "dual existence" of code, distinguishing human-readable "delegated code" (source code) from machine-readable "prescriptive code" (executable code). The author distinguishes several "ideal-types" in order to understand "the kinds of ways in which code is manifested", thus demonstrating its "translation quality" from an “atomic” to an “articulatory” form. In other words, from a “non-algorithmic digital code” to an “algorithmic instruction code” (Cramer 2002).

### 2.3. VARIABLE SYSTEMS

On a computational level this study focuses on “media for which digital computation is required at the time of audience experience (…) in order to be itself” (Wardrip-Fruin 2006:7-18) and whose behavior varies “randomly or otherwise (…) with input from outside” (Wardrip-Fruin 2006:398-399). According to this, we can distinguish autonomous systems from data-driven systems (Carvalhais 2011), which also might be called interactive: these can vary with input from external data or processes, namely, human input (Wardrip-Fruin, 2006:399). In this context, Casey Reas’ notion of “expressions of software” (2003) and Wardrip-Fruin’s concept of “expressive processes” become relevant for understanding these computational forms and their focus on “processes themselves, rather than simply their outputs” (2006:1) – as systems whose software has creative potential on an interactive and generative level. In order to access these processes we consider “close interaction” as a useful strategy for analyzing games, because it allows us to evaluate if the agency (Murray 1997) – a key pleasure in a system’s gameplay – is identified by the players (Wardrip-Fruin 2006:45).

### 2.4. GAMES AS SYSTEMS

Games can be considered a “subset of the play”, therefore we focus on gameplay as a form of structured play; a “formalized interaction that occurs when players follow the rules of a game and experience its system through play” (Salen and Zimmerman 2004:72-73). In this context it becomes useful to resort to the notions of *ludus* and *paidia* proposed by Roger Caillois, considering two types of games, which may be experienced as *rule bound* or *free form* (Salen and Zimmerman 2006). We focus on the latter notion, as it does not necessarily involve “working with or interpreting a structure that exists outside oneself”, but rather “being creative with or within this structure”. This approach resembles the definition of play as “free movement within a more rigid structure”; an experience that oscillates between a rigid structure (where one questions what can this object do?) and the behavior the player chooses to adopt (what can I do with this object?) (Salen & Zimmerman qtd in. Costello and Edmonds 2009:40), from which different aesthetic pleasures can emerge (Costello and Edmonds 2007:79-82).

## 3. CASE STUDIES

### 3.1. GAME OF LIFE AND REVERSE-SIMULATION MUSIC

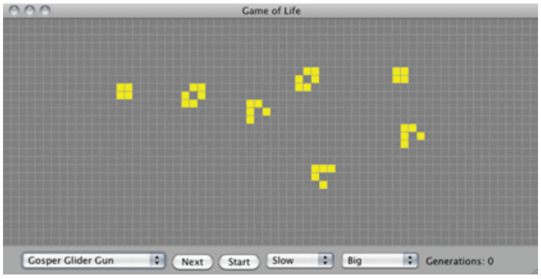



**Fig. 1** John Conway's *Game of Life* (Edwin Martin 1996-2004) **Fig. 2** All Koans of *Matarisama* (Method Machine 2005)

These case studies arise as opposite poles that illustrate the idea of simulation and its subsequent reversal. *Game of Life* (1970) is a cellular automaton developed by the mathematician John H. Conway.[1] It simulates life phenomena as a way of describing processes of emergence and self-organization. This represents a starting point for many artists involved in generative practices, such as Masahiro Miwa's *Reverse-Simulation Music*[2] (2002); a methodology that comprises "acoustic events born of intentional human actions (…) carried out according to sequences resulting from iterative calculations" (Miwa 2003a).

### 3.2. ANALYSIS

We started by considering the context, concepts and methodologies used in each of the examples and then developed an analysis on three levels – internal/ mechanical, interactive/dynamic and external/aesthetic – based on both the MDA framework by Hunicke *et al.* (2004) and the *Rules/Play/Culture* framework by Salen and Zimmerman (2004). In order to establish analogies between both examples, we confronted their different types of code according to Berry's (2008) terminology and his approach to the three compositional aspects of the *RSM* (rule-based generation, interpretation and denomination) as different manifestations of code; an analysis that we extended to the *GoL*.

**1** For a complete description see the GoL's first public publication (Gardner 1970).

**2** For a complete description see Miwa's (2003b) definition of the *RSM*.

Subsequently, we resorted to Dorin *et al.*'s (2012) *Framework for Understanding Generative Art*, which allowed us to describe these works not only in terms of their data representations and algorithms, but also in terms of their observable dynamic processes. According to this framework and its components (entities, processes, environmental interactions and sensory outcomes) we can contemplate the "natural ontology" of the two generative systems and compare them according to the ways in which they operate, taking *GoL* as an example given by the authors and extending this analysis to the *RSM*.

Finally, we conducted a survey of artistic reinterpretations of the *GoL*, in order to describe the "translation quality" (Berry 2008) of its rules and their occurrence and importance in artistic practices. We then compared the *GoL* with the *RSM*, considering the following aspects:

a) The creative potential of rules; contrasting merely illustrative reinterpretations of the game, such as *Life Dress* (Fuller 2009) with creative reinterpretations that adapt the game's original rules, in order to achieve different results, such as *Diamond Sea* (Villareal 2007);

**Fig. 3** *Life Dress* (Elizabeth Fuller 2009)
**Fig. 4** *Diamond Sea* (Leo Villareal 2007)

b) Materialization and extension into the physical space;

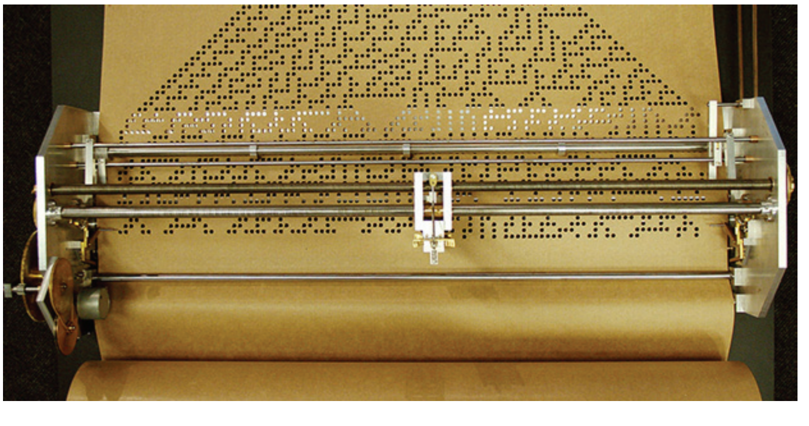


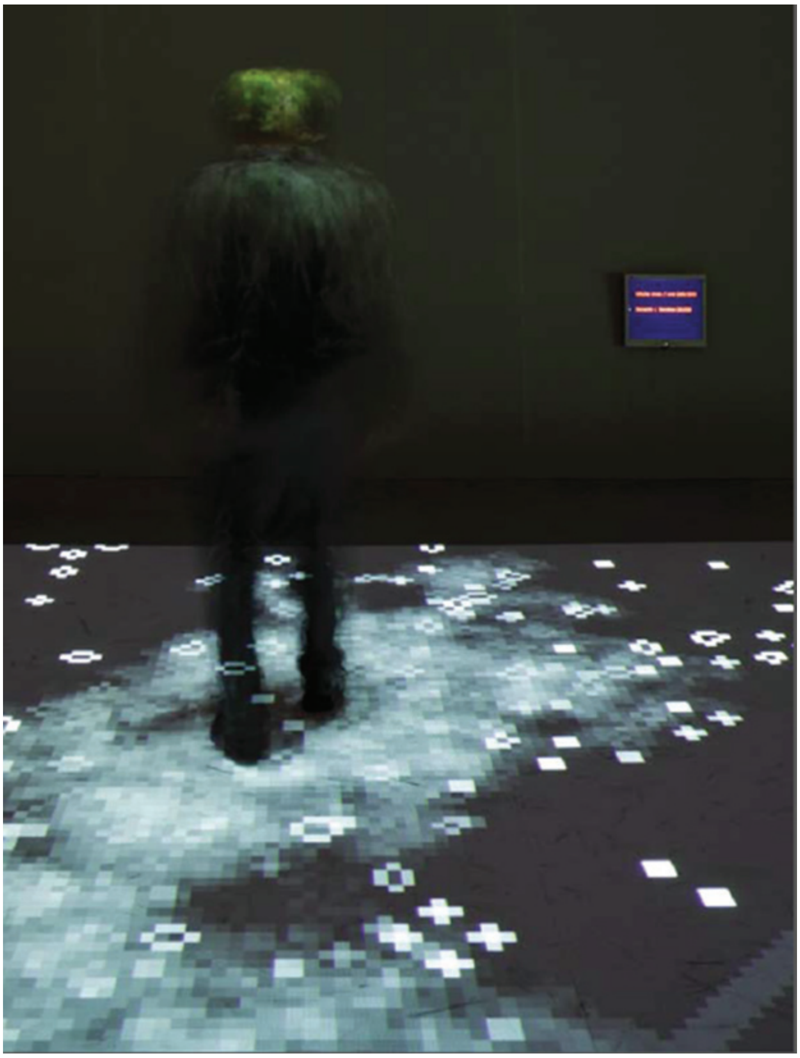
**Fig. 5** Rule 30 (Kristoffer Myskja 2008)

C) Human performativity;

**Fig. 6** [Radical] Signs of Life (Marco Donnarumma 2013)[3]

d) Interaction between human and machine;

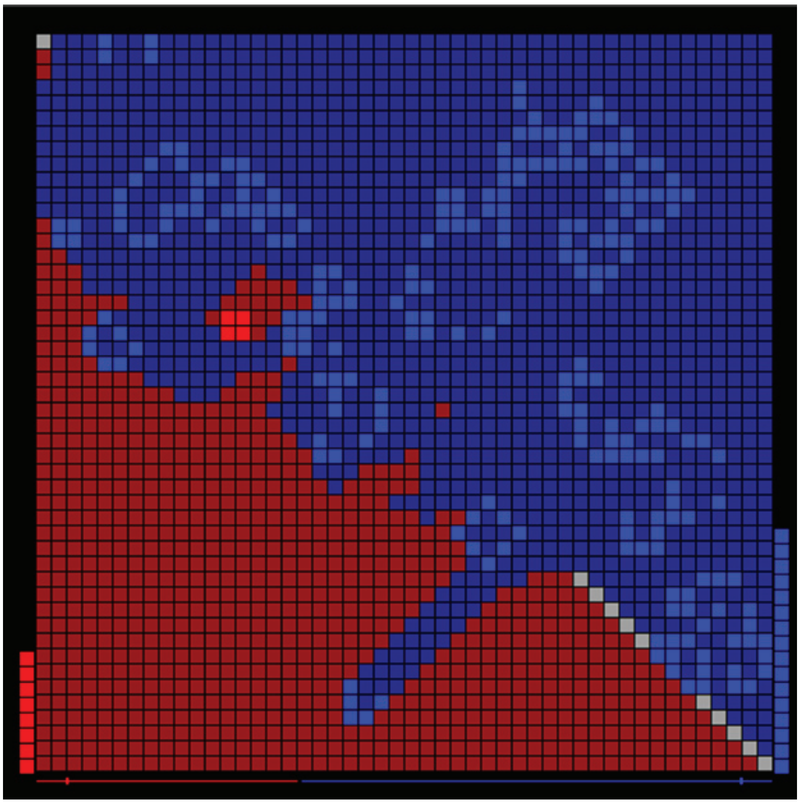
**Fig. 7** Floor Life (Román Torre 2008)



**3** *http://vimeo.com/65839165*

E) Playfulness.

Fig. 8 Life as War (Erik Hooijmeijer 2008)



### 3.3. CONCLUSIONS OF THE ANALYSIS

The *GoL* arises at both computer and non-computer levels, and according to Berry (2008), it is this "translational quality of digital representation and storage (...) that highlights the strong remedial qualities of digital representation". As Berry states, when translated from the computational framework to the human, a *RSM* piece becomes "performative rather than compositional", because it presents gaps in terms of: (1) *composition*, in the way Miwa adapts the logic of the XOR operator to the purposes of his composition (2) *reversal of the simulation*, as it requires an external agency for the synchronization of the process, (3) *transparency of the process*, considering how certain operations are hidden (like the system's initial state), (4) and *mediation of code*, made by the participants through a non-exact translation of the delegated code into prescriptive code (Berry 2008). In this sense, and according to Berry, the piece "becomes a representation of some idealized form of computer code", demonstrating how it is "not based on a passive cloning of conventional circuitry, but rather as a creative re-interpretation".

In a simulation process the formalization of real-world phenomena is made according to standardized "digital data structures" (Berry 2008). By attempting to reverse these specific procedures into more abstract processes there are 'open gaps' that can be filled by human interpretation. Conditioned by the system's internal rules, this subjective interpretation leads to the emergence of behaviors that generate novelty and unpredictability at each execution.

### 3.4. PRINCIPLES GUIDING THE PROJECT

In line with this view, we developed an experiment that seeks to highlight the notion of reinterpretation, which we called *Simulate-Reverse Play*. It considers a type of play that emerges from the simulation and reversal of a specific set of procedures. These procedures define the system's behavior considering both computer and human, while implying an openness (of the work) to chance, that is, its performance is complemented by the audience's active participation.

To this end, we propose an adaptation of the *GoL*'s algorithm through the construction of two co-dependent layers – a virtual computational layer and a real non-computational layer – that communicate with each other on the basis of this algorithm. Given that the project aimed at contemplating the nuances of human performance in the enactment of the work, through the implementation of implicit rules, we sought to recall certain emerging pleasures of play, as defined by Edmonds and Costello (2007:79-80). In particular, we considered the pleasures of *creation*, *exploration*, *discovery*, *simulation* and *camaraderie*, to which we add the pleasure of *immersion*. In order to achieve this, we drew strategies from a set of examples of self-regulating systems, such as *Lumibots* (Kronemann 2009-2011), *Remote X* (Kaegi 2013), *Pong Experiment* (Carpenter 1991) and *UP: The Umbrella Project* (MIT CSAIL and Pilobus 2013).

We established that the virtual entities should be visually simple, revealing how complexity can emerge from simple rules, while evoking organic behaviors in an allusion to the *GoL* and other simulators and how their entities are conditioned by different states of behavior.

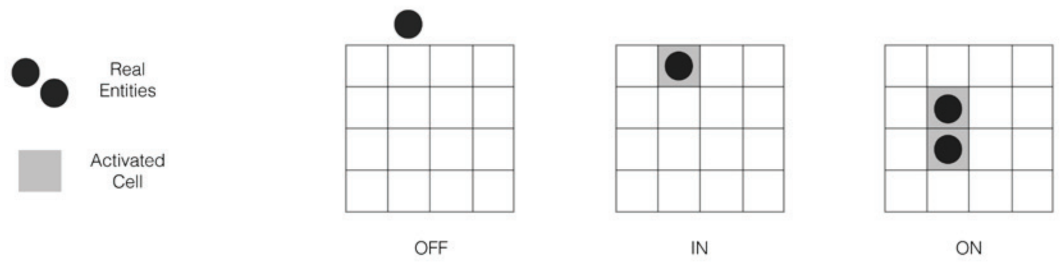



Fig. 9 States of the real entities

The project assumes a grid similar to the *GoL*'s and identifies its real entities as *off* (when outside the interactive area), *in* (when inside), and *on* (when within the group).

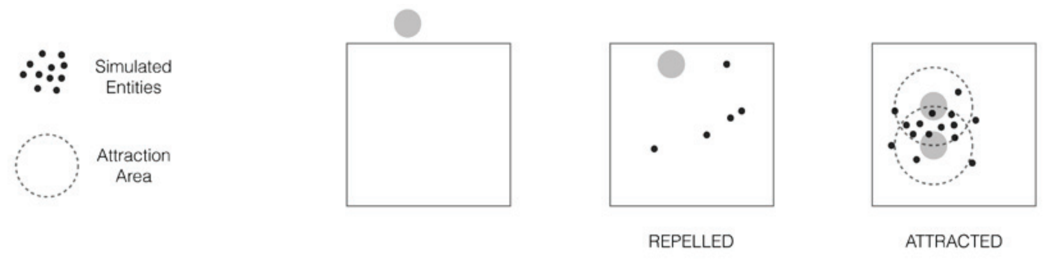



**Fig. 10** States of the Simulated entities

In turn, the simulated entities obey to simple rules that correspond to states of remoteness and proximity.

One of the goals was to promote a collective experience, as a form of playful interaction that could contribute to the participants' engagement with the system. Therefore, its operational rules (and formal aspects such as the grid) should be implicit and deduced through interaction, inciting the discovery and creative exploration of the system. In this sense, this procedural reversal differs from Miwa's since we, deliberately, do not provide instructions to the participants but let them figure them out on their own; let them deduce the operational logic of the system.

## 4. SRP (SIMULATE-REVERSE PLAY)

### 4.1. META-CODE

The project was developed by adjusting the *GoL*'s original rules into what we've metaphorically called *meta-code*;[4] the algorithm was initially implemented on a *mouse mode* (computational version) and subsequently adapted to a *camera mode* (installation version).

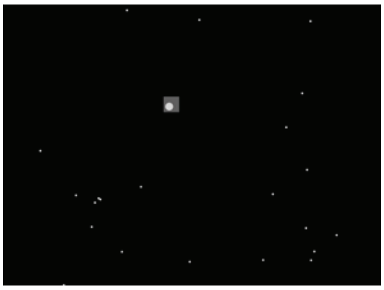
**4** The *Meta-code* was adapted using the framework by Dorin et al. (2012) and can be described according to a set of simple rules:
1. If an *off* entity enters the interaction area it turns *in* (is born);
2. If an *in* entity has 0 neighbors it remains *in* (is isolated/ survives);
3. If an *in* entity adds 1 to 3 neighbors *in* or *on* it turns *on* (grows/ reproduces);
4. If an *on* entity has more than 3 neighbors *in* or *on* it turns *in* (explodes);
5. If an *in* or *on* entity leaves the interaction area it turns *off* (dies).

### 4.2. IMPLEMENTATION AND TESTING

#### 4.2.1. MOUSE AND CAMERA MODE

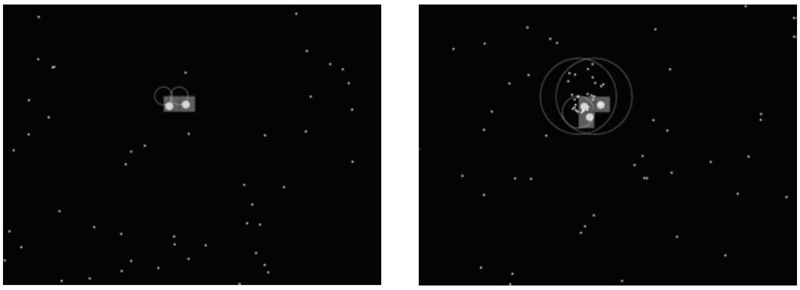
The first version allowed us to define and optimize the intended events, namely:

**Fig. 11** *Birth*



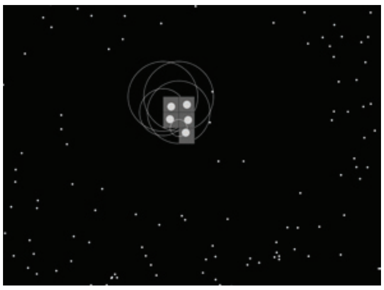
*Birth*, relative to the generation of particles triggered by the entry of a real entity into the interactive area;

**Fig. 12** *Growth/ reproduction*



*Growth* or *reproduction*, resulting from the agglomeration of those entities; these activate areas of attraction of particles whose strength increases as real entities are being added;

**Fig. 13** *Explosion*



*Explosion*, when the limit of neighbors of each entity is exceeded; *Isolation*, in case an entity gets back to its initial state of *birth* and looses attraction power; and *death*, when the entity leaves the interaction area and its originally generated particles are eliminated, leaving the screen empty.

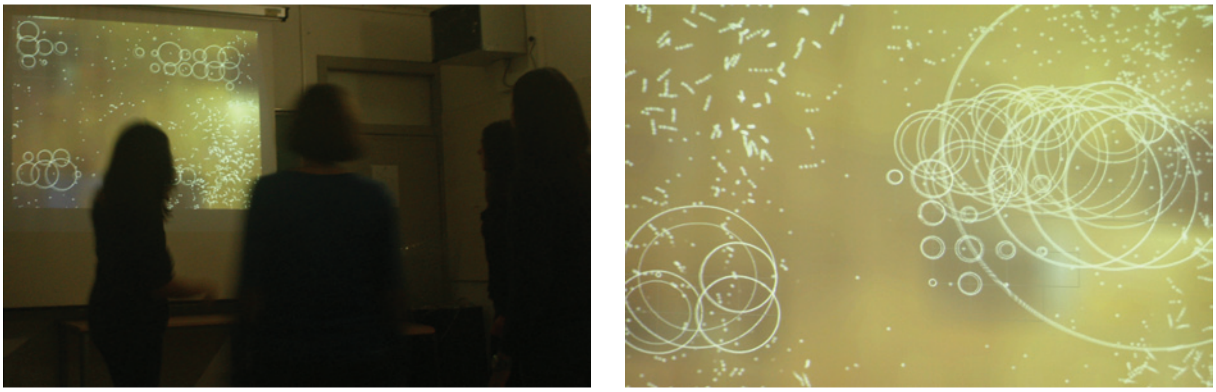


**Fig. 14** Images from the implementation of the *camera mode*.

The implementation of the *camera mode*[5] then entails the human mediation of the adapted algorithm. On this mode the real entities are represented by human participants whose image is captured by a video camera.

### 4.2.2. INTERACTIVE EXPERIENCE

The prototype was tested with a 'semi-expert' audience, meaning, an audience able to relate to or interpret this kind of work, however having no previous familiarization or contact with this specific system. This strategy, according to Costello and Edmonds, adds value to the development of the artwork during the prototype stage evaluation (2007:82). The experience was analyzed through video recall, along with a written questionnaire delivered to the participants. The method of analysis was based on the aspects identified by Edmonds (2010:257) considering artists concerns in the creation of interactive art, namely: "how the artwork behaves; how the audience interacts with it" and with each other (bearing in mind the pleasures of play proposed); the "participants' experience and their degree of engagement" with the work.

This analysis considers attributes of interactive artworks that incite different modes of engagement, such as *attractors*, *sustainers* and *relators*[6] (Edmonds 2010:262). Similarly, it adresses the different phases and modes of engagement experience by the audience over time, as addressed by Costello *et al*. (2005) and Bilda *et al*. (2008). Accordingly, it adresses transitions in engagement that can range from an "investigative exploration" about what the system does to a "diversive exploration" about what one can do with it (Costello 2009:40). These modes are interchangeable, depending on how the system meets or

5 *https://vimeo.com/91980308*

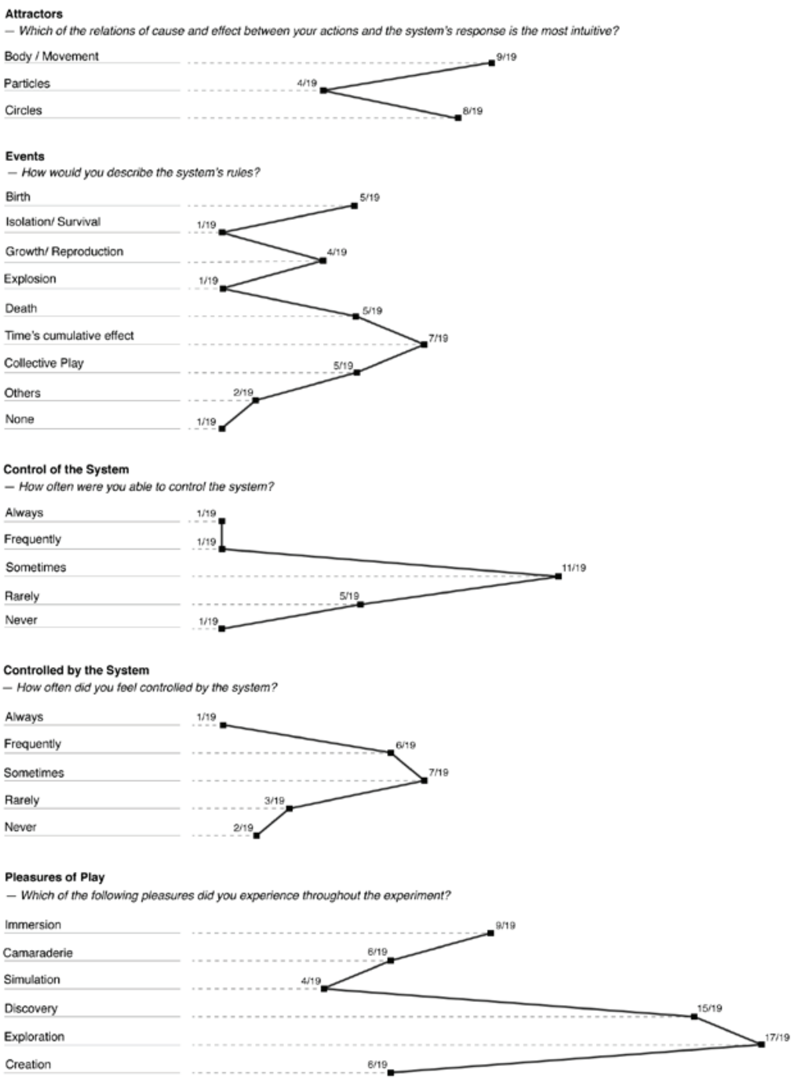
6 The *attractors* are the system's attributes that "encourage the public to pay attention and so become engaged" with it. Then, its up to the *sustainers* to hold that engagement "for a noticeable period of time". Finally, the *relators* are the attributes that extend that engagement "over long periods of time, where one goes back for repeated experiences" (Edmonds 2010).

subverts the expectations created by its users. This idea meets what Kwastek (2009) describes as the "oscillation between playful immersion and moments of distanced reflection" that characterizes the aesthetic experience of interactive artworks.

This analysis allowed us to assess whether the system encourages exploration and promotes engagement; if the users are able to deduce implicit rules and identify cause-effect relations; if the participants could control or were controlled by the system and if they experienced the proposed pleasures of play. We also recognized the different phases and modes of engagement or eventual "disengagement" (Costello, *et al*. 2005:55), as well as the emergence of collective and self-organized behavior.

## 4.3. RESULTS

**Fig. 15** Questionnaire results



Three elements were identified, as attractors to the system, in particular: the circles and the representation of the body's spatial movement. The latter was the most mentioned, possibly for being the element that connects the real entity with its virtual representation. Concerning implicit rules, the audience was able to recognize various cause-effect relations, highlighting the events of *birth*, *reproduction* and *death* as the most obvious. Similarly, they were able to deduce that the system responded to some form of interaction between the participants. The most frequently mentioned aspect was the "time" associated to these events, as the system's rules became more evident when the triggered events multiplied. This leads us to conclude that the responses resulted from an exploration of the possibilities of the system, and not necessarily from being in a controlled state.

The participants demonstrated a willingness to create something, although, when asked how often they felt in control of the system, the most frequent response was *sometimes* followed by *rarely*. However, when asked how often they felt controlled by it, the most common answers were *sometimes* and *often*.

Finally, the most recurrent pleasures experienced were *discovery* and *exploration* resulting from the recognition of implicit rules. In turn, *camaraderie* led to a more rapid and accurate *discovery*, as well as an emergence of playful behavior.

According to these observations, *Simulate-Reverse Play* therefore proposes something other than mere playful interaction with a system. Through the co-dependency of its real and virtual layers, the system both depends on its users to perform (according to a set of rules) but also conditions the users' behavior or performance (with its rules).

## 5. CONCLUSION

This project reflects on the double execution of instruction code by machine and human, by proposing an interactive system that explores procedural simulation and its reversal and by promoting collective play as a form of free and creative exploration. To meet this purpose we devised two layers that combine both real and virtual dimensions of the same instruction code, based on the *GoL*'s algorithm, as an object of constant reinterpretation.

On one hand, this approach sought to establish analogies between human and artificial systems, and on the other hand, to distinguish the qualities inherent to human and machine performance. In this manner, it highlights the intangible qualities of human performance (i.e. imagination and emotional engagement) by exploring how they can add something to the enactment of the work. This project therefore emphasizes the contemporary interest in process-based practices, addressing how technological virtuality can be articulated with corporeal performativity.

Through its reinterpretation of the *GoL*, and in its attempt to reverse its procedures, this project acknowledges, and takes creative advantage, of the open gaps left in this translation process by emphasizing its openness to interpretation. It explores how human behavior is incorporated in artificial systems, which in turn can condition and influence human behavior, as an essential dimension of the aesthetic experience of the work.

## REFERENCES


**Arns, Inke.** "Interaction, Participation, Networking: Art and Telecommunication." In, *Media Art Net* (2004). http://www.medienkunstnetz.de/themes/overview_of_media_art/communication/.

**Berry, David M.** "Fcj-089 a Contribution Towards a Grammar of Code." *The Fibreculture Journal*, nº. 13: After Convergence (2008).

**Bilda, Zafer, Ernest Edmonds, and Linda Candy.** "Designing for Creative Engagement"." *Design Studies* 29, nº. 6 (2008): pp. 525-40.

**Bogost, Ian.** "The Rhetoric of Video Games." Chap. Digital Me In *The Ecology of Games: Connecting Youth, Games and Learning*, edited by Salen, Katie. pp. 117-40. Cambridge, Massachussets: MIT Press, 2008.

**Carvalhais, Miguel.** "Procedural Taxonomy: An Analytical Model for Artificial Aesthetics." ISEA, 17th International Symposium on Electronic Art, Istambul, 2011

**Costello, Brigid.** "Play and the Experience of Interactive Art." PhD. University of Technology, 2009.

**Costello, Brigid, and Ernest Edmonds.** "A Study in Play, Pleasure and Interaction Design." pp. 76-91. Sydney, Australia: DPP '07, 2007.

———. "Directed and Emergent Play." 17th ACM Conference on Creativity and Cognition, Berkeley, California, USA, 2009.

**Costello, Brigid, Lizzie Muller, Shigeki Amitani, and Ernest Edmonds.** "Understanding the Experience of Interactive Art: Lamascope in Beta_Space." 2nd Australian Conference on Interactive Entertainment, Sydney, Australia, 2005.

**Cramer, Florian.** "Concepts, Notations, Software, Art." In *Software Art: Thoughts*', edited by Exhibitions, State Center for Museums and. Moscow: Rosizo: Read_me festival 1.2, 2002.

**Dorin, Alan, Jonathan McCabe, Jon McCormack, Gordon Monro, and Mitchell Whitelaw.** "A Framework for Understanding Generative Art." *Digital Creativity 23*, nº. 3-4 (2012): pp. 239-59.doi: 10.1080/14626268.2012.709940.

**Eco, Umberto.** *The Open Work*. Translated by Cancogni, Anna. Harvard University Press, 1989. 1962.

**Edmonds, Ernest.** "The Art of Interaction." *Digital Creativity* 21, nº. 4 (2010): 257-64.doi: 10.1080/14626268.2010.556347.

**Frieling, Rudolf.** "Reality/ Mediality: Hybrid Processes between Art and Life." In, (2003). http://www.medienkunstnetz.de/themes/overview_of_media_art/performance/1/.

**Galanter, Philip.** "What Is Generative Art? Complexity Theory as a Context for Art Theory." GA'03, International Conference on Generative Art, Milan, Italy, 2003

———. "Generative Art and Rules-Based Art." In, *Vague Terrain 03: Generative Art* (2006). http://philipgalanter.com/downloads/vague_terrain_2006.pdf.

**Gardner, Martin.** "Mathematical Games – the Fantastic Combinations of John H. Conway's New Solitaire Game Life." *Scientific American* 223, nº. 4 (1970): pp. 120–23.

**Goffey, Andrew.** "Algorithm." In *Software Studies: A Lexicon*, edited by Fuller, Mathew. pp. 15-20. Cambridge, Massachussets: The MIT Press, 2008.

**Hunicke, Robin , Marc LeBlanc, and Robert Zubek.** "Mda: A Formal Approach to Game Design and Game Research." 19th National Conference of Artificial Intelligence, San Jose, California, 2004.

**Kwastek, Katja.** "Embodiment and Instrumentality." Digital Arts and Culture 2009, California, USA, 2009.

**Miwa, Masahiro.** "About the Name and Concept from 'a Definition of Reverse-Simulation Music Founded on the Three Aspects of Music'." In, *Method* nº. 20 (2003a). http://aloalo.co.jp/nakazawa/method/method020_e.html.

———. "A Definition of Reverse-Simulation Music Founded on the Three Aspects of Music." edited, 2003b. http://www.iamas.ac.jp/~mmiwa/rsmDefinition.html.

———. "Reverse Simulation Music Part 1/2: Reverse Simulation Music as a New Musical Methodology." http://www.youtube.com/watch?v=UX6vXiqpyJQ
**Murray, Janet.** *Hamlet on the Holodeck: The Future of Narrative in Cyberspace*. Cambridge, Massachussets: MIT Press, 1997.
**Reas, Casey.** "Code – the Language of Our Time." Ars Electronica, 2003
**Salen, Katie, and Eric Zimmerman.** *Rules of Play: Game Design Fundamentals*. Cambridge: MIT Press, 2004.
———. "Roger Caillois: The Definition of Play, the Classification of Games." In *The Game Design Reader: A Rules of Play Anthology*. Cambridge, Massachusetts, London, England: MIT Press, 2006.
**Wardrip-Fruin, Noah.** "Expressive Processing: On Process-Intensive Literature and Digital Media." Brown University, 2006.