Art after the Algorithmic Revolution:

A Semiotic Approach to Digital Art

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A thesis submitted to the
University of Applied Sciences Bremerhaven
in fulfillment of the requirements for a
Master of Science degree in Digital Media

Digital Media Master Program
University of Bremen,
University of Applied Sciences Bremen,
University of Applied Sciences Bremerhaven and
University of the Arts Bremen

Bremen, Germany.
April 7th 2011

Declaration

I hereby declare that this thesis entitled "Art after the Algorithmic Revolution: A Semiotic Approach to Digital Art" is the result of my own research except as cited in the references. This thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Acknowledgment

First of all I would like to express my sincere gratitude to my first supervisor Prof. Dr. Frieder Nake for his guidance and advice. His invaluable feedback and suggestions helped me to shape and develop the objective of my research. I will always cherish and keep with me his limitless enthusiasm and his creative vision, which encouraged and inspired throughout this thesis process. I am also grateful to Prof. Dr. Andrea Sick for her support and her crucial advice on the topic of interactive art. In particular, our discussions were fundamental to develop the argumentation presented here on the difference between interaction and interactivity.

This research is the final result of my studies in the master in Digital Media. This international, inter-disciplinary program, offered jointly by the four state universities in Bremen, Germany including the University of fine arts, sciences, and applied sciences, gave me the unique educational opportunity to combine artistic and scientific research. The concepts and ideas that originated this work emerged during the classes and academic discussions with professors and classmates. I am grateful to the Digital Media program and its scholar community for supporting and enabling my intellectual growth, this thesis would not have been possible without them. Specially I would like to thank my classmates and colleagues Jana Wedekind and Dema El-Masri for their commentaries to my first draft.

Most importantly, I am deeply grateful to my sisters Loretta and Marianna Lomanto for proofreading this thesis and being unconditionally there when I needed their help. I also wish to thank my mother for always encouraging me to achieve my full potential, and for her endless support. Last but not least, I would like to thank my partner Guillermo for his understanding love and advice during the whole process of the master.

Abstract

This thesis explores the challenges and changes faced by our culture as a result of the advent of digital technologies. Particularly, the focus is on how artistic practices and aesthetics have been transformed by the algorithmic revolution. The hypothesis, developed and examined throughout this thesis, is that the notion of the algorithmic sign offers crucial insight into the aesthetic and semiotic qualities that characterize digital art. The algorithmic sign is described as the semiotic entity that results from our interaction with computer systems, and as such, the product of a coupled semiosis of human and machine. The idea of a coupled semiosis, or co-semiosis, is introduced to explain how the algorithmic sign has two modes of interpretation —human or true interpretation, and machine or determined interpretation. This double existence of the algorithmic sign is represented, as Frieder Nake maintains, in a visible surface and a computable subface. The distinction between surface and subface, serves as the starting point for discussing how the algorithmic revolution has challenged traditional aesthetic notions, such as medium, image and perception. The main argument is that the notion of the algorithmic sign is fundamental for understanding how the computer and in general digital technologies have become media, especially for artistic creation. Furthermore, this thesis intends to demonstrate that the concept of algorithmic sign best describes the dual ontology of the digital image, and that it reaches its full potential through interactive media. Finally, this theoretical exploration inspired the creation of an interactive installation that addressed the idea that the digital medium is ultimately characterized by its dual existence, by its subface and surface.

Keywords: Digital art, semiotics, aesthetics, algorithmic sign, algorithmic revolution, interactivity

Kurzfassung

Diese Arbeit untersucht die Herausforderungen und Veränderungen, welche unsere Kultur als Folge der Einführung von digitalen Technologien konfrontieren. Insbesondere wird die Frage behandelt, wie künstlerische Praktiken und Ästhetiken durch die algorithmische Revolution verändert werden. Die Hypothese, welche in dieser arbeit entwickelt und untersucht wird, besagt, dass der Begriff der algorithmischen Zeichen entscheidenden Einblick in die ästhetischeN und semiotischen Qualitäten, welche die digitale Kunst charakterisieren, bietet. Die algorithmischen Zeichen werden als semiotische Entität beschrieben, die sich aus unserer Interaktion mit Computersystemen und als solche, das Produkt einer gekoppelten Semiose von Mensch und Maschine. Die Idee einer gekoppelten Semiose oder Co-Semiose wird eingeführt, um zu erklären, wie die algorithmischen Zeichen zwei Modi der Interpretation-Mensch wahre Interpretation und Auslegung Maschine oder bestimmt hat. Diese doppelte Existenz des algorithmischen Zeichens, laut Frieder Nake, hält an einer sichtbaren Oberfläche und einer berechenbaren Unterseite fest. Die Unterscheidung zwischen Oberfläche und Unterseite dient als Ausgangspunkt für die Erörterung, wie die algorithmische Revolution die traditionellen ästhetischen Vorstellungen, wie Medium, Bild und Wahrnehmung in Frage stellt. Daher wird der Begriff des algorithmischen Zeichens der Verbindungsfaden der Untersuchung der digitalen Kunst. Das Hauptargument ist, dass dieser Begriff der Ausgangspunkt für das Verständnis, wie der Computer und digitale Technologien im Allgemeinen, zu Medien geworden sind: eigens für das künstlerische Schaffen. Darüber hinaus will diese These aufweisen, dass das Konzept des algorithmischen Zeichens am besten die doppelte Ontologie des digitalen Bildes beschreibt und dass es durch interaktive Medien sein volles Potenzial erreicht.

Schlagwörter: Digitale Kunst, Semiotik, Ästhetik, algorithmischen Zeichen, algorithmische Revolution, Interaktivität

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Chapter 1

Introduction

> Cybernetics is the alchemy of our age: the computer is the universal solvent into which all difference of media dissolves into a pulsing stream of bits and bytes. It is a curious thing that a calculating machine we forced to become a typewriter [...] now combines the creation, distribution, and spectatorial functions of a vast variety of other media within one box—albeit tied into a network. But this is the present state of affairs, and things are likely to become more complicated before they become less so. (Lunenfeld 1999, 7-8)

It is curious indeed, as Peter Lunenfeld affirms, how the computer has become a "multimedia machine" and how digitality is now the marker that distinguishes our contemporary way of life. This transformation, labeled the "algorithmic revolution"[1] by Peter Weibel has brought

[1]This is the tittle of a renowned exhibition at Zentrum für Kunst und Medientechnologie (ZKM, Center for Art and Media) in Karlsruhe, Germany. *The Algorithmic Revolution: On the History of Interactive Art* (October 30,2004 - January 31, 2008) was curated by Peter Weibel, Dominika Szope, Katrin Kaschadt, Margit Rosen, and Sabine Himmelsbach. This exhibition presented a historical outline, which traced the origins of interactive art to the aesthetic and technological changes that turned the observer into an active participant. In doing so the exhibition connected a broad spectrum of art movements and practices from modern art, OpArt, kinetic art, Arte programmata, Fluxus, and Happenings to modern software art, algorithmic art, NetArt, and the latest explorations of algorithmic literature, architecture, and music.

algorithms to virtually all areas of our social or cultural life. It started in science around 1930s, and in the arts some 30 years later; but it remained widely unnoticed. It was not until the late 1980s and early 1990s when we realized that the world was more or less completely represented by numbers (Weibel 2008, 18). With the invention of the personal computer, and later the arrival of the Internet and the mobile phone, digital technologies evolved exponentially and became more efficient and available, even ubiquitous. However, algorithmic thinking had already silently transformed our way of life.

This thesis intends to explore this complex scenario by discussing the challenges and changes faced by our culture as a result of the advent of digital technologies. Particularly, the focus of this exploration is on how artistic practices and aesthetics have been transformed by the algorithmic revolution. The aim is to examine the notion of the algorithmic sign, defined as the type of semiotic entity that appears in our interaction with computer systems. The hypothesis is that through the study of the algorithmic sign, it is possible to delimit the aesthetic and semiotic qualities that characterize digital art. This characterization will not result in a unique and definite answer. The idea is to raise questions on this subject. Questions that can perhaps help us better understand how artistic practices, perception, and aesthetics have changed (and are still changing) with the emergence of digital technologies.

However, this topic will prove to be broad, and can be tackled from different perspectives. This research will approach this analysis from a philosophic perspective; specifically from a semiotic and an aesthetic point of view. The algorithmic sign will be the connecting thread through this exploration of digital art. I will argue that this concept is the starting point to the understanding of how the computer and in general digital technologies have become media: specially for artistic creation. Furthermore, I intend to demonstrate that the concept of algorithmic sign best describes the dual ontology of the digital image, and that it reaches its full potential through interactive media. But first we need to set the foundation, that is to explain the theoretical background of this research, and to delineate some definitions that we will need ahead.

1.1 Why Semiotics?

The semiotic perspective is a central topic in this research as it is the basis for understanding and delimiting the notion of the algorithmic sign. It probably appears evident to bring in a semiotic approach if we are to discuss something related to signs, and indeed it is. Semiotics has been called by some theoreticians “the science of signs”[2] (Chandler 2007, 4), therefore it is only natural that it comes into question. Additionally, semiotics as the study of meaning production has been used many times to study the symbolic meaning of art and to make more explicit the codes of artistic and aesthetics production (Chandler 2007, 11).

However, what is not so evident is how semiotics is related to algorithms and to computers. This topic will be discussed in Chapter 2, where it will be also explained how computer scientists and semioticians have approached the issue of human-computer interaction (HCI) from the perspective of semiotics. As Mihai Nadin puts it:

> All those involved in human-computer interaction “speak” semiotics, whether they are aware of it or not. In paraphrasing Paul Watzslawick’s famous axiom —One cannot not communicate— I submit (again) to the HCI community that ONE CANNOT NOT INTERACT. And because interaction is based on signs, one cannot not “semiotize”; that is, one cannot avoid semiotics. [...] Indeed, we express ourselves through various signs; we interpret them, and thus become part of the infinite sign process. (Nadin 2001, 437)

Peter Bøgh Andersen calls semiotics “the mathematics of the humanities”, and explains that it “provides an abstract language covering a diversity of special sign-usages” (Andersen 2001, 419). Semiotics, he argues, supports the task of interface design and defines the computer as a medium. Andersen first introduced the notion of the computer-based sign in 1990 and later he worked together with Frieder Nake to further develop Nake’s notion of the algorithmic sign. This notion is based on Peircean semiotics, and has a close relation to Peirce’s idea of the sign as

[2]However, Chandler warns us to call semiotics ‘science’ is misleading. “As yet, semiotics involves no widely agreed theoretical assumptions, models or empirical methodologies.” (Chandler 2007, 4)

a recursive process of interpretation. In the next Chapter this relation will be discussed in detail, it suffices to say here that the algorithmic sign is a sign that results from a double process of interpretation: our interaction with a computing machine (which will be described as a semiotic machine in the next chapter). In this sense, the algorithmic sign is an expanded or extended sign characteristic of the digital age, as Frieder Nake argues:

> "Only today with the advent of the digital technique and the digital media signs themselves have been subjected to a mechanical process. The computer —the digital medium— epitomizes recursivity as an artifact. The recursivity has become mechanized." (Nake 2001, np)

The hypothesis in this research is that the algorithmic sign offers a crucial perspective for studying the specific characteristics of digital art. "The occurrence of art is a relation of departure and arrival, and thus a relation of communication. As such it is semiotically conceivable." (Nake 2001, np). At a time when our signs and ways of perception have been changed and challenged by technology, our understanding of aesthetics and semiotics must allow new concepts —or at least a reconceptualization of old ones. The algorithmic sign is presented here as one of these new concepts.

1.2 Delimiting Digital Art

It is not be evident at first sight, but the first steps towards the algorithmic revolution were made in the first half of the twentieth century[3].

[3] Charlie Gere would even trace it back to the ninetieth century, arguing that digital technology and digital culture development was strongly influenced by the principles of capitalism, such as abstraction, standardization and mechanization, which emerged during the Industrial Revolution (Gere 2008, 23-25). In particular, Gere emphasizes the relation between the growing information needs of industrialization and the invention of the typewriter, and calculating and "automatic" machines. He explains that: "Turing's imaginary device not only invokes the typewriter, one of the paradigmatic information technologies of nineteenth century capitalism, but also, in the tape and writing head assemblage, the very model of the assembly line. Moreover, the algorithmic method which his machine was intended to automate is itself a model of the division of labour, which, as both Adam Smith and, later, Marx realized, lies at the heart of efficient capitalist production." (Gere 2008, 25).

The advent of scientific theories such as mathematical logic, cybernetics, communication and information theory, and system theory laid the basis for the appearance of the computing machine, and powered the algorithmic revolution. Besides influencing our technological development these theories also had an effect on artistic practices. As Edward Shanken explains:

> Radically opposed to the romantic emotionality of expressionism, Abraham Moles and Max Bense's theories of 'information aesthetics,' Roy Ascott's cybernetic art theories, and Jack Burnham's 'systems esthetics' became influential models for more rational approaches to making and understanding art. (Shanken 2009, np)

At the same time traditional concepts in art history —such as the "artists genius", originality, and authenticity— were being confronted and challenged by artists, and art theoreticians. As Walter Benjamin argued in his seminal essay "The Work of Art in the Age of Its Technological Reproducibility", the "new media" of the time (photography and cinema) had already brought a new way of reproduction (and production) of the artworks that made the art lose its uniqueness, its "aura" (Benjamin 2008, 24-27). According to Benjamin, through mechanical procedures art (and the "human apparatus of perception") reached a turning point, and what it lost in "uniqueness", it gained in flexibility. Art movements, before and after Benjamin, are evidence of these changes in art practices. Futurism, Dada, the Bauhaus School, Conceptual art, Constructivism, and later Fluxus are all examples of how art and technology started to cross paths.

As Peter Weibel explains algorithmic thinking did not start with the appearance of the computer. Understood as "instructions to act" algorithms have been used in art for centuries as manuals, rules of play and musical scores. However, in the mid twentieth century artists began to use algorithms not just intuitively but as a rigorous and precise technique. Weibel affirms that algorithmic art was first manual or mechanical. "Images were produced by programs long before the computer came along. The computer as technical interface enhanced and enforced the possibilities of algorithmic art." (Weibel 2008, 21). Indeed, by the mid twentieth century the recursive power of computation introduced a new use of algorithms in the arts.

> Running parallel with advances in computing machines, machine languages and the associated algorithmic procedures and beginning around 1960, intuitive algorithms in the form of instructions for use and action began to play a major role in analog art, with applications in art forms ranging from painting to sculpture, from happening to Fluxus. One might say that sequences of signs (in the form of digits) are also instructions for machines to act. Known as programming languages, artificial languages, or digital codes, they are used in digital art. [...] Accordingly, instructions to act exist for manual and mechanical tools like hands, buttons, keys, and so forth. And instructions to act exist likewise for digital and electronic tools. (Weibel 2008, 20)

A new type of art (or "arts") is born in this context, at a time when the distinctions between human/machine, and art/science became blurred. For the first time in the history of art, the idea behind a work of art took the central stage leaving the material support in the background. Artists distanced themselves from their work and started to develop creative methods that were more similar to scientific experiments than to traditional art practices. Soon artists started experimenting with the digital medium and this meant allowing the machine to produce the artwork, now in a most automatic manner. As the actual task of executing " the steps in generating procedures or decision-making processes that sometimes require hours or days" was now the task of the computing machine (Weibel 2007, 22). These new artistic practices involved an *open* understanding of the notion of authorship, not only because of the role of technology, but also because of the collaboration between artists and scientists, as well as the more active participation of the "observer".

1.2.1 The Beginnings

Although computers were very exclusive artifacts in the 1960s, already by the end of the decade artists (albeit not many) were using them as the tool and medium of their work. The artworks produced then appeared under the label "computer art". A label which many artists and art theoreticians have never really accepted. Frieder Nake affirms of the use the term "computer art" that: "It was a proud name and a bad one. ‘Algorithmic art’ would have been the correct term. The superficial ‘computer art’ disguised the revolutionary fact: the algorithmic principle had entered the world of art.” (Nake 2010, 55). Despite the criticism, what we now call digital art was introduced first in 1965 as “computer art” with three exhibitions. The very first one was organized by German philosopher Max Bense to show the works of Georg Nees. It took place on February 5 - 19 at the Studiengalerie of the Technischen Hochschule Stuttgart. Nees exhibited again later that year along with Frieder Nake at the Galerie Niedlich in Stuttgart on November 5 - 26. In between these two shows in Germany, but totally independently from the two, another computer art exhibition took place. This time works by A. Michael Noll and Bela Julesz were shown at the Howard Wise Gallery in New York on April 6 - 24 (Klütsch 2005; Nake 2005, 111; 55). Although, the use of the computer for artistic creation was not widely accepted, or sometimes even know, just three years after the first computer art exhibition the computer made its official entrance in the world of art.

> In 1968, two exhibitions became the forerunners of the development of digital media. One was called *Cybernetic Serendipity. The Computer and the Arts*, at the Institute of Contemporary Art in London [August 2, 1968]. The other one was *Tendencies 4. Computers and Visual Research* [August 2 - 8, 1968; and May 5 - August 30, 1969], at Galerije Grada Zagreba in Zagreb, Croatia. *Serendipity* established the event component of digital media, and linked to the computing industry. *Tendencies* established the research component of digital media, and linked to the world of art. (Nake 2010, 56)

The shows in the summer of 1968 included a wide variety of works by trained artists, scientists and collaborative groups. The computer-generated drawings that shocked some, and inspired others in 1965 were showed along with works that used the computer —as a tool and medium— for creating many different types of art (e.g. visual art, music, poetry, dance, sculpture, and animation). As Nake explains, the London exhibition was an event that amazed the public with interactive and automated robots and cybernetic sculptures. Cybernetic Serendipity was a fun and exiting show: “A feast for the body as well as for the mind. (...) the announcement of digital media, and the whole new world of entertainment.” (Nake 2005, 59). The Zagreb show was more theoretic and research oriented than Cybernetic Serendipity. It was part of the international art movement New Tendencies, which brought together artists from various schools and styles (e.g. Bauhaus, constructivism, concrete art, op art and kinetic art), as well as scientists and art theoreticians in a series of events between 1961 and 1978. The main interest of the New Tendencies was the development of the idea of "art as visual research" and in this spirit they embraced the idea of the computer as a medium for artistic research (Rosen 2011, 27-30). These two events were heralds of what would later be called digital art, and each one in a different way helped to establish a place for digital technologies in art. In 1968 London and Zagreb were the scenarios for experimentation and tendencies. However, these exhibitions and those in 1965 were not the only sign that computers has entered the domain of art practice.

In 1967 the interdisciplinary art, science and technology journal, *Leonardo,* was created; and in 1969 "the Computer Arts Society was formed in London to 'promote the creative use of computers in the arts'. This society staged Event One and began a lively debate through its bulletin, *Page* which continued into the 1980s." (Candy & Edmonds 2002a, 7). A more significant proof that computer art was entering the "mainstream" was Frieder Nake's article "There Should Be No Computer Art" in Page 18 published in 1971. In this article Nake rejected the idea that computers should be used to produce another "art fashion" (Nake 1971). For Nake the new methods brought with the use of computers should not perpetuate the "market oriented" practices of traditional art. Nake augured that: "Computers can and should be used in art in order to draw attention to new circumstances and connections and to forget 'art"'(Nake 1971). A. Michael Noll also reflected on the quality and value of computer art in an article of the IEEE student journal. He was also critical but not as extreme as Nake. Noll still believed in the "promise of computer":

> "The computer is a unique device for the arts since it can function solely as an obedient tool with vast capabilities for controlling complicated and involved processes, but then again, full exploitation of its unique talents for controlled randomness and detailed algorithms could result in an entirely new medium-a creative artistic medium." (Noll 1970, 10).

However, Noll expressed his concern that the “promise of computer art” was not being accomplished. He was very critical of the quality of the computer art that was being produced at the time, arguing that most of the use of the computer was as a tool or as a way to copy aesthetic effects that could be produced by other media or techniques. Noll also insisted that computers should be more available to artists and that collaboration between art and technology should be more meaningful.

Noll and Nake tried to warn us, but digital technologies have found their own place in art history. By the end of the twentieth century “‘digital art’ had become a established term, and museums and galleries around the world had started to collect and organized major exhibitions of digital work.” (Paul 2008, 7). Digital art started as a subversive challenge to art traditions, but today is hard sometimes to distinguish its “newness”.

1.2.2 Definitions and Categories

The term “digital art” did not appear in the beginning, instead “computer art”, “artificial art” or “system art” were the common names to classify the artworks produced by or with the assistance of computer or digital electronic technologies.

> The terminology for technological art forms has always been extremely fluid and what is now known as digital art has undergone several name changes since it first emerged: once referred to as ‘computer art’ (since the 1970s) and then ‘multimedia art’, digital art now takes its place under the umbrella term ‘new media art’, which in the end of the twentieth century was used mostly for film and video, as well as sound art and other hybrid forms. (Paul 2008, 7)

As Christiane Paul and other critics (Boden & Edmonds 2009; Walker 2006) affirm, the terminology and labels to these new forms of art based on digital electronic technologies are always changing. Margaret Boden and Ernest Edmonds argue that these novel art practices “are still little known or discussed in aesthetics and art theory.” (Boden & Edmonds 2009, 21). James Faure Walker goes even further and affirms that the whole subject has not been just poorly understood, but misunderstood or even “misdescribed”. In his book “Painting the Digital River” he writes:

> The phrase *computer art* suggests that an image is being generated by an electronic box, while someone in white coat stands beside; *digital imagery* suggests neon pixel; virtual or cyberspace suggests some sort of fluorescence hovering in the air, unconnected to the world we live in—that dog on the pavement outside; *interactive* suggests that pre-electronic art is inactive and fails to engage its audience sufficiently; *new media* suggests that there is also old media; for that matter, *new media* has been around long enough to be *old media*. (Walker 2006, 277)

Boden and Edmonds are not really against these particular labels that Walker finds so misleading, what they see as the problem is that there is not a generally accepted taxonomy or clear definitions for these terms. Therefore they propose eleven categories which, instead of being centered on the notion of the "digital", are organized as intersections of different characteristics along the axis of "generative aesthetics" (See Figure 1.2 and Figure 1.1).

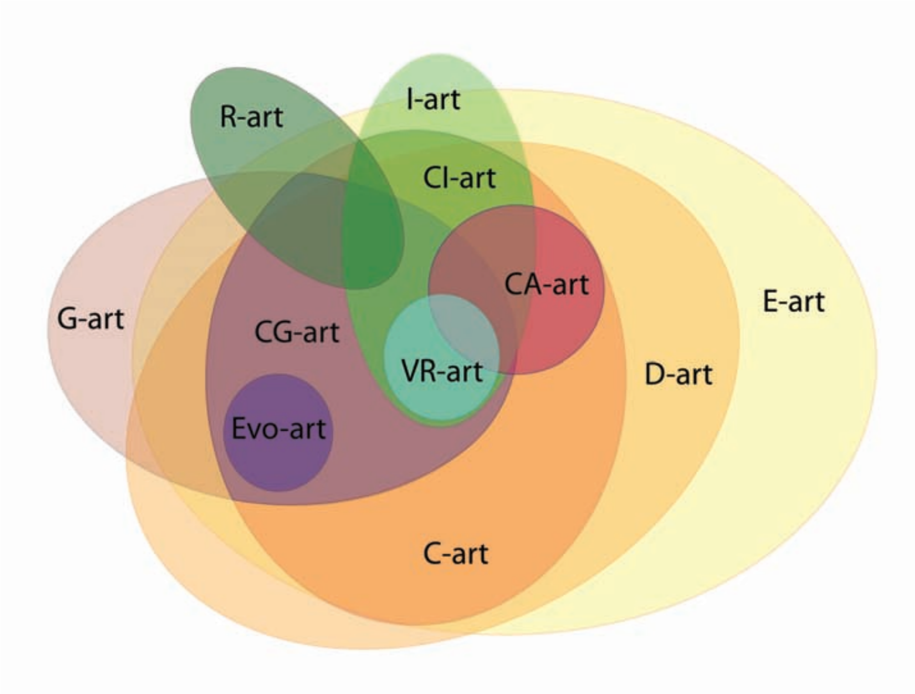


Figure 1.1: A Taxonomy of Digital Art
Content taken from (Boden & Edmonds 2009, 28)

Figure 1.1 shows the Boden and Edmonds' taxonomy[4] and how they define each category. Some of the categories extend beyond electronic and digital art (the two broadest and central categories), such is the case of generative, evolutionary, robotic, and interactive art. All of these can be created without the use of digital electronic technologies and have existed before the appearance of computer systems. This is also the case for digital art, as they explain that it can be considered outside electronic art. Boden and Edmond give the example of nineteenth century Pointillistes which could be classified as digital art because they are produced by a myriad of discrete and discontinuous spots of paint. However, this is rarely the case because the adjective "digital" in digital art is associated to the use of new technologies. That is why they include in their definition of digital art the reference to electronic technology. As in Boden and Edmonds' article, the focus here will be in art that is created through the use of digital technologies as medium or tool.

Figure 1.1, which as Figure 1.2 does not appear in Boden and Edmonds' article, is an attempt to visualize the interrelations and connections between the categories in Boden and Edmonds' taxonomy. The figure illustrates how some of the categories are not limited to digital or electronic art and how others can be (as a whole or partially) related to one or more categories.

For the purpose of this research I will use the term "digital art" as defined by Boden and Edmonds, that is as: art that "uses digital electronic technology of some sort" (Boden & Edmonds 2009, 28). This is probably very broad and it can be argued that when digital is becoming *the* mainstream "format" for artistic creation, the adjective digital will soon become meaningless because it will denote all and nothing in particular. This is a warning to keep in mind; however, the term "digital art" is being used widely by both artists and theoreticians. Additionally as Boden and Edmonds describe it, it allows to cover most (if not all) of its manifestations but still differentiating between previous technologies

[4]Boden and Edmonds call this taxonomy "a taxonomy of generative art" but for the purpose of this research it is more soulful to consider it from the perspective of the "digital" which is more general. Nevertheless, we should keep in mind the notion of the generative quality of digital art which will be discussed in relation to interactive art in Chapter 5.

Category	Description
Electronic Art (Elec-art)	involves electrical engineering and/or electronic technology.
Computer Art (C-art)	uses computers as part of the art making process.
Digital Art (D-art)	uses digital electronic technology of some sort.
Computer Aided Art (CA-art)	uses the computer as an aid (in principle, non-essential) in the art-making process.
Generative Art (G-art)	works are generated, at least in part, by some process that is not under the artist's direct control.
Computer Generated Art (CG-art)	is produced by leaving a computer program to run by itself, with minimal or zero interference from a human being.
Evolutionary Art (Evo-art)	is evolved by processes of random variation and selective reproduction that affect the art-generating program itself.
Robotic Art (R-art)	is the construction of robots for artistic purposes, where robots are physical machines capable of autonomous movement and/or communication.
Interactive Art (I-art)	the form/content of the artwork is significantly affected by the beha-viour of the audience.
Computer Interactive Art (CI-art)	the form/content of some CG-artwork is significantly affected by the behaviour of the audience.
Virtual Reality Art (VR-art)	the observer is immersed in a computer-generated virtual world, experiencing it and responding to it as if it were real.

Figure 1.2: Categories and Descriptions in Digital Art
Content taken from (Boden & Edmonds 2009, 28)

and media. Chapter 3 will offer a critical analysis of the notion of the digital and how it is related to other concepts such as medium, culture, art and image.

Boden and Edmonds' taxonomy distinguishes between digital art, in which the use of the computer or digital technologies is essential to the artwork; and that, in which the computer is *in principle* non essential. This distinction can be related to the broader categorization that Christiane Paul makes of digital art. Paul differentiates two basic categories in digital art: art which uses digital technologies as a tool, and art which uses these technologies as a medium (Paul 2008, 8). For Boden and Edmonds, the distinction between digital as medium or tool would be the same as considering whether or not digital technologies are essential (in principle) for an artwork.

The difference between Paul's and Boden and Edmonds' categorization of digital art is that the latter focuses on the notion of "generative aesthetics". Accordingly, Boden and Edmonds are more interested in generative art rather than the broader category of digital art. They understand generative art[5] as being ruled-based, where the rules or constrains are not followed in a step-by-step manner but in a more indirect approach that ultimately leaves some decision to be taken by the computer system.

The inclusion of the concept of generative processes is crucial for understanding the importance of the notion of the algorithmic sign in relation to digital art and in particular to interactive art. This relation will be addressed in Chapter 5. However the limits of this research would not allow me to discuss in detail all the categories in Boden and Edmonds' taxonomy. Therefore I will focus on the visual dimension of digital art, its early origins in computer graphics and how it has evolved into generative interactive art. Concretely, I will study the works of Manfred Mohr and Vera Molnar in order to examine the concept of algorithmic sign in relation to digital art (See Chapter 4). The idea is to analyze how these two artists came to utilize computers for artistic creation, and compare how the two approach the use of computers. My thesis is that this analysis can offer some insight into the characterization of digital art. In this sense Boden and Edmonds' taxonomy serves for setting the ground of this discussion, but it will not be the central point since the main goal of this research is to describe and analyze what could be the characteristics of digital art, and not to categorize it or to establish hierarchies.

1.3 Getting Inspired

Lastly, I will study the notion of interactivity and its relation to the algorithmic sign. From this exploration I will draw inspiration to create an experimental interactive installation. The objective of this practical

[5]It is important to note that although Boden and Edmond acknowledge the connection between generative art and biology, they focus their notion of generative art on the mathematical and computational sense. "Even so, the formal mathematical sense remains a core aspect of the label's meaning." (Boden & Edmonds 2009, 25)

work is to question the assumptions we have when interacting with computer systems, and to challenge the HCI idea that we are the *users* of computer systems, and that computers are intelligent machines. On one hand the installation intends to question the concept of the user and the perception we have of human computer interaction. This will be done by asking the participant to be *used* by the machine as part of the process of interacting with the machine. In other words a sort of play of slave/-master role play. On the other hand the idea is to offer a space where one can experience the double interpretation process that occurs when humans and machines interact. Chapter 6 will be dedicated to the conceptualization and production of this interactive experimentation with the algorithmic sign.

Chapter 2

The Semiotic Approach

2.1 Semiotic Background: The Peircean Model

> ...[S]emiotics is in principle the discipline studying everything which can be used in order to lie. (Eco 1976, 7)

The question of the algorithmic sign belongs to the field of semiotics and as mentioned in Chapter 1, it is strongly related to Peirce's theory of signs. However, before considering the notion of the algorithmic sign I would like to set the semiotic background of this research and introduce some important concepts.

The semiotic road is not an easy one. It is risky and hard to navigate, mostly because as Umberto Eco affirms "semiotics is concerned with everything that can be taken as a sign" (Eco 1976, 7). A sign for Eco is everything that can significantly stand for something else. Although, according to Chandler (Chandler 2007, 2), Eco's definition of semiotics is one of the broadest, the fact is that the object of semiotics is indeed very broad. Furthermore, the study of semiotics involves many different theoretical perspectives and methodologies. However, as diverse as it may be, one can recognize two distinct origins of what we can identify today as semiotics. On the one hand, we have the structural linguistics of Swiss linguistic Ferdinand de Saussure, and on the other hand, the phenomenological pragmatics of American philosopher Charles Sanders Peirce (Chandler 2007; O'Neill 2008, 3; 2). Around the same time (the end of the nineteenth century) but working independently of each other, Saussure and Peirce developed two different models of the sign that are the basis of contemporary semiotics.

While studying language as a sign system Saussure introduced a new general science called semiology (from the Greek sēmeîon 'sign'). He defined it as the "science that studies the life of signs within society [...] [it] would show what constitutes signs, what laws govern them." (Saussure 1966, 16). According to Saussure, semiology belongs to social psychology and linguistics is only a part of it. Saussure's model of sign is based on the dyadic tradition that describes the sign as an abstract entity composed of two parts, a signifier and a signified, which are linked together as a whole (see Figure 2.1). To support this dyadic description of the linguistic sign Saussure established a distinction between the formal rules of language (*langue*) and its use in actual situations (*parole*). He focused on the langue, giving importance to the internal structure of semiotic systems rather than to the specific use of signs (Chandler 2007, 9). This structuralist dichotomy of system and usage laid the basis for the structuralist theory, and it is one of the major points of critics of Saussure's semiology.

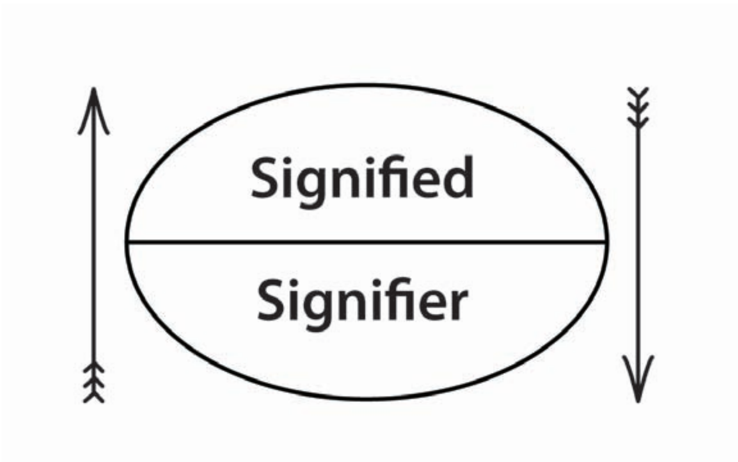


Figure 2.1: Saussure's Model of the Sign
Source: (Saussure 1966, 114)

Meanwhile on the other side of the Atlantic, Peirce developed a theory of signs that is strongly related to logic, he named it 'semeiotic' (or semiotics). On the relation of semiotics and logic Peirce wrote: "Logic, in its general sense, is [...] only another name for semiotic (σημειωτικη), the quasi-necessary, or formal, doctrine of signs." (Peirce 1955, 98). Peirce's semiotics is based on an epistemological perspective also related to phenomenology, and it is deeply concerned with the processes of perception, representation, and interpretation. In contrast to Saussure who is more interested in the sign's relation to language, Peirce is more interested with the process of sense-making and with describing the different categories or classes of the sign[1]. In this sense Peirce's semiotics is a theory of signs that extends beyond linguistics.

In Peirce's terms a sign is something that stands for something else and that is correlated to a mental process (of interpretation) (Peirce 1955, 99). His sign model is a triadic one consisting of three essential elements: the object (what is represented), the representamen (how it is represented), and the interpretant (how it is interpreted) (Chandler 2007, 29) It is normally referred as Peirce's semiotic triangle as described in Figure 2.2, however Chandler notes that Peirce himself did not offer this illustration. Peirce calls the interaction between these three elements 'semeiosis' or semiosis, and describes it as a "tri-relative influence" by no means "resolvable into actions between pairs" (Peirce 1955, 282).

> A Sign, or Representamen, is a First which stands in such a genuine triadic relation to a Second, called its Object, as to be capable of determining a Third, called its Interpretant, to assume the same triadic relation to its Object in which it stands itself to the same Object. The triadic relation is genuine, that is its three members are bound together by it in a way that does not consist in any complexus of dyadic relations. (Peirce 1955, 99-100)

Peirce based this triadic relation in his empirical phenomenology, which describes all experience as being of three basic kinds: firstness, secondness, and thirdness (Peirce 1955, xiii). Shaleph O'Neil (O'Neill 2008, 68-69) gives a general definition of these three categories, or as Peirce called it, modes of being (Peirce 1955, 75-77). As O'Neil explains

[1]Perhaps the most known of Peirce's sign classification is according to the "modes of relationship" between the sign vehicle and what is interpreted, which results in the three modes of the sign: icon, index and symbol.

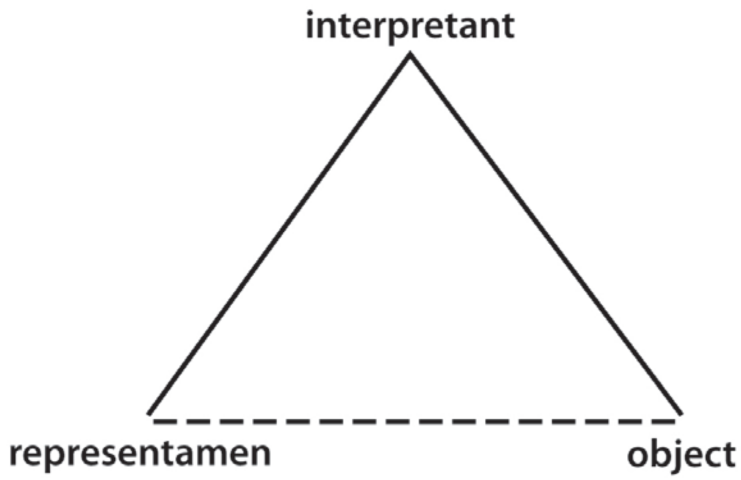


Figure 2.2: Peirce's Model of the Sign
Source: (Chandler 2007, 30)

it, firstness is an undifferentiated qualitative experience that we cannot identify or name. Secondness is the experience of a phenomenon that we cannot recognize in itself but that we can correlate to something else, a sort of mapping between a sensation and its cause. And thirdness is the experience of a representational object standing in for the experience of a real object. Thirdness is then the process of standing for something else, in other words semiosis or the domain of signification. Peirce defines this third category or mode of being as: "the medium or connecting bond between the absolute first and last" (Peirce 1955, 80).

Although Saussure might be considered by some as the founder of semiotics (Chandler 2007; Winfried 1990, 10; 63), Saussure's and Peirce's theories have both set the ground for semiotics as a field of study. Contemporary thinkers (such us Roland Barthes, Umberto Eco, Louis Hjelmslev, and Roman Jakobson, to name a few) have revisited and expanded semiotic theory offering different perspectives and new insight to the study of sign systems. However different and diverse semiotics may have grown, authors keep going back to Saussure's or Perice's model of the sign (or both) to analyze a great variety of phenomena: arts, social behavior, biology, cognition, etc. Despite the different approaches "it is safe to say that signs are relational entities: *a sign is something that stands for something else*." (Andersen 2003, 166).

Discussing in more detail the characteristics of each model of the sign goes beyond the range of this research. Nevertheless, I would like to point out the main differences that influence why the concept of algorithmic sign is based on Peirce's triadic concept. The fact that Peirce's model is a triadic one might seem as an evident distinction from the dyadic Saussurean model; however, this reflects more than quantity. The triadic model of the sign comes from Peirce's three modes of being, particularly from the concept of thirdness, which he identifies with the process of semiosis and the idea of a medium (Peirce 1955, 80). The triadic model is then a more suitable one to study the process of mediation, and even of interaction.

Peirce's model includes the idea of a referent "something beyond the sign to which the sign vehicle refers (though not necessarily a material thing)" (Chandler 2007, 63). This inclusion not only makes the model more complex and less abstract, but it also recognizes the social or cultural context in which a sign is immersed, and the role of this context in the process of sense-making in semiosis. Frieder Nake argues that "this general or public component of the meaning of the sign is the object of the sign." (Nake 2008, 106). The idea of a referent or object is crucial when semiotics is used in media studies, because it already acknowledges the material dimension of the sign (albeit it may not be distinct materiality), whereas the dyadic model leaves this dimension aside.

Last but not least, it is crucial to mention that the interpretant in the Peircean model allows for what Chandler calls "an 'infinite series' of signs" (Chandler 2007, 63). This is possible because the interpretant is not just the meaning of the sign but the process by which the meaning is produced, hence it can be said that it is another 'sign' in itself (Bolter 1991, 197). "The interpretant, the definition of the sign, may in turn be treated as a sign requiring definition. The process continues in theory as long as we like, because each new interpretant allows for a further interpretation." (Bolter 1991, 203). Saussure also talks about the importance of understanding that the value of a sign does not stand alone but in relation to other signs. However, this does not imply the same radical potential for dynamic interpretation that can be found in the Peircean sign (Chandler 2007, 63). Fixed in a more static structure, the Saussurean model lacks the 'generative' quality needed to support the concept of the algorithmic sign.

This last distinction between the dyadic and the triadic models of the sign is perhaps the most important one to have in mind for the task of delimiting the notion of the algorithmic sign. As Nake affirms, “this introduces the sign as a recursive concept, as a process without end. Only the pragmatics of a given situation forces us to interrupt the infinite sign process of interpretation.” (Nake 2008, 106). However, the algorithmic sign is not explained by this recursive concept alone. Another important notion is needed, that of the semiotic machine. Let’s take another turn on the semiotic road, so we can find the intersection between semiotics and the computer, but let’s keep with us the idea of the recursiveness of the sign, later we will need it.

2.2 Semiotics and Computer Science: An Intersection

There is a fairly long tradition of using semiotics to support the work and research in computer sciences[2], and more specifically in HCI. However, the intersection between semiotics and informatics is not as recognized as a part of the mainstream computer science. Mihai Nadin affirms in most of the cases that the association of semiotics and HCI is only elementary and superficial, or at best not acknowledged (Nadin 2001, 437). This leaves us with only a short list of theoreticians who in the last 20 years have come up with interesting and relevant approaches relating computing and semiotics. Peter Børg Andersen, Clarisse Sieckenius de Souza, Mihai Nadin, Winfred Nöth and Frieder Nake are among this list, and perhaps are the most relevant to mention for this investigation. I will very briefly describe the main semiotic approaches of these authors, highlighting the important aspects for understanding the notion of the algorithmic sign.

[2]Already in 1966 Heinz Zemanek published an article in the Communications of the ACM journal titled *Semiotics and Computer Languages* (Zemanek 1966). In this article, Zemanek analyzes how programming languages can be understood from the perspective of a general theory of languages, and introduces the semiotics and pragmatics of programming languages.

2.2.1 Computer Semiotics

Peter Bøgh Andersen is considered by some as a pioneer in seriously bringing together computer science and semiotics. In 1990 he presented a theory of computer semiotics in his doctoral dissertation, which was also published in a book by the same name (Andersen 1997). The goal of computer semiotics is to offer a theoretical background to understand and design computer systems. Andersen defines computer semiotics as a "discipline that analyzes computer systems and their context of use under a specific perspective, namely as signs that users interpret to mean something." (Andersen 1992, 4). According to this new discipline, Andersen affirms that computer systems are not ordinary machines but symbolic ones that can be understood as sign-vehicles. He explains that computer systems as symbolic machines are constructed and controlled by signs (Andersen 1992, 6). These signs, he argues, form a complex network where semiosis occurs in different levels from the graphical interface down to the machine code.

Andersen introduces the concept of a computer-based sign, in order to explain these processes of sign-creation and sign-interpretation inside the symbolic machine. He defines this new type of sign as "a sign whose expression plane is manifested in the processes changing the substance of the input and output media of the computer" (Andersen 1997, 129). He then describes the computer-based sign as having three classes of features: handling, permanent, and transient. The handling feature is produced by the user's actions or input to the system; the permanent feature is generated by the computer as an identifying and constant property of the sign; and the transient feature is also generated by the computer but it changes as the sign is used inside the system (Andersen 1997, 176-177). Andersen takes this characterization of the computer-based sign and incorporates the notion of action to create a detailed classification of computer-based signs[3]. This typology takes in consideration three criteria, namely what features a computer-based sign possesses, how it affects other signs or how it is affected by others, and

[3]Andersen will later include action as one of the features of computer-based signs (Andersen 2003, 173).

		+action		-action
		+handling	- handling	
+permanent	+transsient	Interactive	Actor	Object
	-transsient	Button	Controller	Layout
permanent		Ghost		

Figure 2.3: Typology of Computer Based Signs
Source: (Andersen 2003, 172)

what is its range of meaning (Andersen 1992, 14). Concretely Andersen's sign typology describes six classes of computer-based signs (interactive signs, actor signs, controller signs, object signs, layout signs, and ghost signs) and how they relate to the three features of computer-based signs and the notion of action. The result of this classification is explained in Figure Figure 2.3.

As seen in Figure 2.3 Andersen's classification of computer-based signs involves many aspects of HCI and aims to show how computer-based signs are similar to and distinct from traditional types of signs (Andersen 2003, 173). A detailed analysis of Andersen's sign taxonomy would exceed the limits of this investigation. Nevertheless, it is important to mention the role that the notion of action plays in Andersen's typology, as well as his analysis of the computer-based sign as a two-dimensional object that is involved in two types of chains of expression: concurrent or sequential chains.

Andersen's computer semiotics is mainly based on structuralist linguistics, and he takes a rather technical perspective to develop his notion of computer-based sign. Nevertheless, his approach is broad as he analyzes computer systems as media. His concept of the computer-based sign is not limited to the sign processes that occur at the interface level. He stresses the importance of understanding that computer-based signs, are also those signs that exist "underneath" the interface. These signs are "invisible" from the point of view of the interface; however, they are meaningful for the programmer and ultimately for the computer.

Andersen affirms that the computer program is in itself a text, more specifically an executable text that is also itself a sign that is interpreted by the computer system.

> The system itself is specified by a program text (that is a sign since it stands for the set of possible program executions to the programmer). The actual execution involves a compiler or interpreter that controls the computer by means of the program text, and since the compiler is a text standing for the set of permissible program texts, the compiler is also a sign—in fact it is a meta-sign that—in some versions—very much resembles an ordinary grammar. (Andersen 1992, 6)

Andersen's computer-based sign incorporates the notion that there is a particular interpretation process that occurs inside the computer system. However, the computer system's (program and compiler) interpretation is not true interpretation, since it is determined by the program text written by the programmer. In his early works, Andersen does not focus on the differences between human and computer interpretation of signs, as he is more interested in applying his computer semiotics to actual interface design.

Nevertheless, in 1997 together with Per Hasle and Per Aage Brandt, Andersen wrote an article on machine semiosis (Andersen *et al.* 1997). In this article Andersen et al. describe a history of computer based-signs, and the particular qualities of the computer as a medium that does not only physically transform signal but also produces semantic transformations. Andersen et al. argue that the computer is a semiotic machine because it is built and used only by means of signs (Andersen *et al.* 1997, 552). In fact they maintain that automated machines, in particular computers, are the only type of machines that can produce genuine machine semiosis. To explain this argument Andersen et al. introduce the notion of a "causal interpretant", which is a determined interpretant that only appears in automated machines. In the computer the causal interpretant would be the compiler and run-time system, that must process textual code (which can be considered as a sign) in order to process an input and produce an output. The causal interpretant is characteristic of computer-based signs, and is opposed to the intentional interpretant that can only be produced by humans, since machines lack self-awareness and intentionality.

Overall, Andersen sees the computer as a special machine, one that is not just an automaton. He affirms that computer systems are media, and as such are a natural subject of semiotics (Andersen 2003, 169). More recently in collaboration with Frieder Nake, Andersen links the notion of action in computer-based signs with Nake's concept of algorithmic sign (Andersen 2003; Andersen & Nake Forthcoming, 173). This collaboration between Nake and Andersen, and the notion of a causal interpretant are fundamental for delimiting the concept of algorithmic sign in this research.

2.2.2 Semiotic Engineering

Clarisse Sieckenius de Souza and her research group, Semiotic Engineering Research Group (SERG), have developed a theory called semiotic engineering that they claim brings new perspectives and design possibilities in HCI (de Souza 2005, 318). De Souza defines semiotic engineering as "a semiotic theory of HCI that brings together under the same communicative context the three sources of interpretation and communication involved in the design of interactive computer artifacts: designers, users and computer systems." (de Souza 2005, 334). The semiotic research of the SERG group is directed towards the practices of interface and software design, as well as user evaluation methodologies. They view HCI as a twofold computer-mediated communication, and the user interface as a one-shot message sent by the designer to the user.

This perspective however, falls outside of the spectrum of this research. It is of interest here the analysis that de Souza and her group make of the process of interpretation in HCI by splitting the concept of meaning production into two categories (de Souza 2005, 337). On one side semiotic engineering sees that there is a human process of interpretation (semiosis), and on the other there is the computer's way to process signs. "Human meanings (that of designers' and users') are produced and interpreted in accordance with the unlimited semiosis principle. Computer meanings (human meanings encoded in programs), however, cannot be so produced and interpreted." (de Souza 2005, 337). For de Souza this distinction reveals an ontological challenge for semiotic engineering, since it always has to deal with two meaning processes: the non-determined or human, and the algorithmic which is constrained and does not allow for unlimited semiosis (de Souza 2005, 338). But, as I will discuss ahead, other authors do not see this as a challenge to the use of semiotics in HCI. Instead some found in this distinction the key for understanding human use and design of computer artifacts.

2.2.3 Semiotics and HCI: Computational Design

Mihai Nadin was perhaps one of the first to apply Peircean semiotics to develop and design computer interfaces. "The premise for considering a computer's interface from a semiotic viewpoint is that it represents a *complex sign system*, a *language*" (Nadin 1988, 275). In 1994 Nadin created the first university program dedicated to the design of computer systems, called Computational Design, however he had been working in this topic since 1985. The aim of this study was to develop a theoretical background to support the design of digital products. "A computational theory of design is implicitly a semiotic theory. It has to address the components of design in a way similar to the one in which communication theory deals with communication [...]" (Nadin 1990).

With a strong theoretical background in both semiotics and computer science, Nadin succeeded in bringing an aesthetic perspective to computer design. Influenced by Max Bense's semiotic theories, Nadin acknowledged the creative qualities of programming what he called the art of computing, which could be found in elegant, balanced and optimized codes. He affirmed that programming should allow for creative algorithms and creative interpretations of algorithms (Nadin 1988, 273). Already in mid 1980s Nadin recognized the computer as a "semiotic engine". A special kind of machine that besides being a tool to extend the human mind, operates as a medium, an intermediary for human activity.

> The computer is a semiotic engine. After all, it is not electrons that users are interested in, but the information processed and the new interpretations made possible. This is why the computer accelerated the semiotization of human life, including the semiotization of the interaction between humans and machines as well as among individuals involved in distributed activities. (Nadin 2001, 437)

Nadin's understanding of the computer as a semiotic machine is of great importance for the delimiting the concept of the algorithmic sign, in particular for understanding how the computer as a machine engage in processes of interpretation.

2.2.4 Semiotics of Media

German semiotician Winfred Nöth has written extensively on how semiotics can be applied to the study of different media, a study which he calls semiotics of media. From this perspective Nöth approaches the notion of the computer as a sign processing machine. As Nadin, he understands the computer not only as a tool but as a medium, a medium to extend not only physical but also intellectual work. Nöth analyzes the characterization of the computer as a semiotic machine. From a semiotic perspective, he finds that this characterization involves a paradox. He argues that there are some limitations for calling the computer a semiotic machine, since the computer interprets signs in a determined way it can not produce an unlimited semiosis as described in Peircean terms. To explain how, despite these limitations, the computer could be considered a semiotic machine Nöth introduces the idea of a quasi-sign and quasi-semiosis. This distinction between a "full" semiosis and a quasi-semiosis, proposed by Nöth can help in the understanding of the two sign processes that are involved in notion of the algorithmic sign. I will come back to Nöth's and Nadin's analysis of the computer as a semiotic machine in Section 2.3.

2.2.5 Semiotics, Aesthetics, and Algorithmics

Frieder Nake is considered a pioneer of computer art. A mathematician who was influenced by Max Bense's information aesthetics started using the computer as a medium for aesthetics research. Nake has focused his work and research in the field of interactive graphics, and he has made important contributions to the aesthetic and theoretical development of computer art (Andersen 2003, 172). One of his most important "theoretical contributions has been to incorporate the mechanical aspects of computers in a semiotic framework" (Andersen 2003, 172). By introducing the notion of the algorithmic sign Nake has acknowledged the difference between human and machine interpretation of signs. As well as Nöth, Nake affirms that the machine can not really interpret signs but only process signals. However, he argues that these two processes —human interpretation and machine signal processing— occur as a coupling creating the “illusion” of HCI.

> Human–computer interaction may semiotically be characterized as the coupling of two independent, yet related, processes: one of these is a full-fledged sign process that humans are involved in. It takes place in concurrency with a restricted signal process inside the computer. [...] These two independent processes are coupled. Cultural and interpersonal aspects influence the sign process, which is a process of open, unlimited interpretation. Technical and algorithmic aspects influence the signal process, which is a process of a prescribed determination of meaning without any leeway. (Nake & Grabowski 2001, 442)

I will return to Nake’s notion of the algorithmic sign in Section 2.4. I would like to only mention here that Nake’s semiotic approach goes beyond the technical aspects. The concept of the algorithmic sign, can be taken as the starting point to understand how the computer has become a medium in its own right and not just a remediation[4] of existing media. In particular the algorithmic sign can help us characterize the dual being of digital art: being interpreted by the human and executed (computed) by the machine. According to Nake, the algorithmic sign is the sign that characterizes algorithmic art —by extension also digital art. The breeding ground for this new and special type of sign is the semiotic engine (or machine) (Nake 2009, 89).

2.3 Understanding the Semiotic Machine

As mentioned in Section 2.2 many semioticians, and especially computer semioticians, affirm that the computer is a semiotic machine[5]; but, how

[4]The notion of remediation mentioned here comes from (Bolter & Grusin 2000) and refers to “the representation of one medium into another” (Bolter & Grusin 2000, 45).

[5]Some authors, like Nadin and Nake, use the term engine instead of machine. However, I will use both interchangeably because for the purpose of this research there is not a strong distinction between these two terms.

can we talk of machine semiosis if computers can only produce a determined (automated) interpretation of signs? It can be argued that semiosis, as sign production is only a human process, and that even if machines can extend mental activities, they are incapable of true thinking. However, even if we agree that the computer is a semiotic machine because it processes signs, as Winfried Nöth questions, can a typewriter also be called a semiotic machine? (Nöth 2003, 81).

How can we talk of semiotic machines without stating that there is a paradox or a contradiction? To approach this question we need to take another detour and rethink our relation to technology. We cannot enter in the territory of the semiotic machines from a dualistic perspective, we need a dialectic approach.

2.3.1 Questioning Technology

Our relation to technology has become a problematic one for contemporary thinking. It is a common ground for discussion on science, politics, ethics, aesthetics and even metaphysics. Perhaps one of the most influential approaches to consider the relation between humans and machines is Donna Haraway's cyborg theory, which is best known for her Cyborg Manifesto. Haraway's ironic and utopian myth of the cyborg aims to undermine the Cartesian dualism that characterizes the modern notion of subjectivity, and which is the basis of modern science. She argues against the strong philosophic tradition that establishes an opposition between mind and body as well as between natural and artificial, and even culture and technology.

Her cyborg proposes a responsible relation to technology that cannot be defined as anti or pro. It is complex and in a way conflicting, but it recognizes (without fear or love) that we are hybrids of machine and organism. "The machine is not an it to be animated, worshiped, and dominated. The machine is us, our processes, an aspect of our embodiment." (Haraway 1991, 180). However, Haraway makes a clear distinction between what she calls pre-cybernetic and cybernetic machines. For her the former still hold a *spectrum* or *ghost* of the hand that should animate them, while the cybernetic machines seem to operate on their own blurring the frontiers between natural and artificial.

> High-tech culture challenges these dualisms in intriguing ways. It is not clear who makes and who is made in the relation between human and machine. It is not clear what is mind and what body in machines that resolve into coding practices. [...] Biological organisms have become biotic systems, communications devices like others. There is no fundamental, ontological separation in our formal knowledge of machine and organism, of technical and organic. (Haraway 1991, 177-178)

Through her cyborg theory Haraway proposes a different approach to technology as well as to the western notions of identity and subjectivity. With the cyborg "myth" she suggests "a way out of the maze of dualisms in which we have explained our bodies and our tools to ourselves." (Haraway 1991, 181). Although her theories involve a strong feminist background, her arguments can be well applied to the question of human-computer interaction without entering in a gender discussion.

One important point in Haraway's cyborg theory is the reconfiguration of our relation to technology, as mentioned before her position is not against or in favor of technology. For her, any attempt to understand technology from a dualistic reasoning would result in a reduced perspective or a technological determinism. The cyborg imagery makes more evident the fact that technology is part of us being human. We are our machines and the machines are us as Haraway affirmed.

The question of technology is not a new one for contemporary philosophy, already from Heidegger's essay *The Question Concerning Technology* there is the recognition of the complexity of our relation to technology. Heidegger's approach is to confront the essence of technology in order to establish a *freer* relation to it, which extends beyond an instrumentalist perspective. Heidegger traces the essence of technology back to the Greek understanding of it. In particular to the concept of *technē* and how it is related to the one of *poiēsis* as a *producing*. For Heidegger there is no one answer to the problem of the essence of technology, it seems to be a diffuse notion. However, he explains it as a *Stellen* [to set upon] or *Ge-stell* [enframing], in other words a human disposition to produce, to bring in to presence (Heidegger 1977, 302). Although it is Heidegger intention to think technology from a non-instrumentalist perspective there are some aspects of his analysis that can still fall into a deterministic and even negative understanding of technology. For him still there is some threat in modern technology that we should try to confront. Nevertheless, his analysis is a quintessential reference when questioning technology. What is, perhaps, more interesting in his analysis is the connection he makes between *technē* and *poiēsis*, which he finally extends to art.

> The arts were not derived from the artistic. Art works were not enjoyed aesthetically. Art was not a sector of cultural activity. What was art perhaps only for that brief but magnificent age? Why did art bear the modest name technē? Because it was a revealing that brought forth and made present, and therefore belonged within poiēsis. It was finally that revealing which holds complete sway in all the fine arts, in poetry, and in everything poetical that obtained poiēsis as its proper name. (Heidegger 1977, 316)

The French philosopher Bernard Stiegler takes a similar approach to technology or better in his own terms "technics". He understands technics as the exteriorization of the human, a notion that involves every human production from the primitive tools to the complex systems of informatics. Ben Roberts explains how for Stiegler technics is the condition of culture and it would be absurd to oppose one another. Roberts goes on and affirms that for Stiegler "technics is the 'prosthesis of the human': the human is constituted not by some interior capacity (e.g. consciousness) but by a new prosthetic relationship with matter." (Roberts 2007, 26). Stiegler's notion of technics aims to encompass more than the human relation to technology itself. What Stiegler strives for is to use the notion of technics to challenge philosophy and its technological condition.

Stiegler's arguments bring back the questioning to what Jacques Derrida calls "an impossible thinking", which is a different way of thinking that would allow to understand in a non-reductionist way the paradoxical relation of the organic (as a living singularity of the event) and the inorganic (as the dead universality of mechanical repetition). In The Stanford Encyclopedia of Philosophy (Lawlor 2010) it is explained how for Derrida in the relation between event and mechanical reproduction it is not possible to subordinate or reduce one term to the other. Instead what he proposes is a relation in which each part would be internal to the other while remaining heterogeneous. "Derrida's famous term 'différance' refers to this relation in which machine-like repeatability is internal to irreplaceable singularity and yet the two remain heterogeneous to one another." (Lawlor 2010).

I believe that we need to place the concept of semiotic machine along this contemporary questioning of technology, if we want to avoid reducing this concept to a contradiction. This is a connection that I make as an extension to the semiotic background, but is one that comes here as a parenthesis (or a very long marginal note) since this is not the place to go into detail in a philosophical discussion of technology. Of importance on the topic of the semiotic machine —and the algorithmic sign— is the introduction of a dialectic thinking that allows for a non-reductionist and non-dualistic understanding of the relation human/machine or organic/inorganic. The computer belongs to the kind of machines that Donna Haraway calls cybernetic machines, which are considered as systems that can produce automatic responses to human actions. As a cybernetic machine the computer is understood as automaton, and is given the capacity of agency. This type of thinking is needed to explain how computing processes can be understood as semiosis, and how we talk about human computer interaction.

2.3.2 The Computer as a Semiotic Machine

Unlike human or natural languages, machine languages are based on strict mathematical formalisms. In its most reduced form computer language is expressed in only two letters or values —zeros and ones, or true and false— however, as reduced as it may be this language is enough to support the processes of the first immaterial machine, one that does not processes things but signs (Nadin 2007, 64). Nevertheless to say that computers are semiotic machines because they process signs is not enough. As Nöth argues there are many machines involved in sign processes but cannot be called semiotic machines. He mentions as examples typewriters, cameras, copy machines, and tape recorders, which he claims are machines that produce signs but not through a process of semiosis (or sign interpretation) (Nöth 2003, 84). A camera does not interpret signs to produce a picture, whereas the computer must interpret a text (in the form of a program) in order to execute an operation (be it mathematical, verbal or pictorial). This distinction between machines that reproduce signs and those, like the computer, that process signs beyond representation seems to be evident. However, the question is to which extent can computers engage in sign production as semiosis —in Peirce's terms. Is it true interpretation what goes on inside the computer? If not, can we still describe the computer as a semiotic machine? As mentioned before, Nöth argues that the answer to these questions might come in a distinction of degree, that is the kind of semiosis that occurs in the computer is not of the same complexity as Peirce's triadic semiosis.

Nöth affirms that the computer does not actually interpret signs, since computer semiosis is determined and can only produce a limited interpretant. However, he goes back to Peircean sign theory and brings the notion of the quasi-sign that Peirce uses to explain the logical processes performed by the calculating machines of his time. Peirce affirms that this calculating machines (like the Jacquard loom) are capable of some reasoning but incapable of "the triadic production of the interpretant", they can only produce a quasi-sign (Nöth 2003, 84).

> The term quasi-sign suggests an answer to the question whether there can be semiosis in a machine of the kind which Peirce knew. A quasi-sign is only in certain respects like a sign, but it does not fulfill all criteria of semiosis. While some criteria of semiosis may be present in machines, others are missing. The concept of quasi-sign thus suggests degrees of semioticity. Quasi-semiosis does not only begin with calculating machines. It can be found in processes in which much simpler instruments are involved. (Nöth 2003, 84)

This distinction proposed by Nöth recognizes that the computer produces something like semiosis. A sign process that is not genuine or full semiosis because it does not allow for unlimited interpretation, but semiosis to some degree. The argument that computers do not process signs, but quasi-signs can be also understood as Nake's thesis that computers do not process signs but signals. Nake and Andersen maintain in (Andersen & Nake Forthcoming) that signs are only produced and interpreted by humans and as they enter the computer, these signs are reduced to signals that the computer system can only pseudo-interpret.

> A sign enters the computer through an interface. Whatever is left of the sign after this passage, we call signal. The signal

> becomes subject matter of computation, i.e. manipulation by software on the computer. After the computation is finished, the transformed signal passes back into the open, through some other, or the same, interface. (Andersen & Nake Forthcoming)

Computers have become more than calculating machines, they have turned into a medium. From Andersen and Nake's quote we can infer that the computer system is working as a medium for a semiotic process, namely the transformation of a sign into a signal and back into a sign. Nöth goes further and affirms that: "Whereas the sign processes within machines considered so far are quasi-semiotic processes, processes in which machines serve as mediators in human semiosis are certainly processes of genuine semiosis." (Nöth 2003, 86). Genuine semiotic machines do not exist as autopoietic systems[6], machines like computers that are considered automatons[7] are in fact allopoietic systems that need to be produced and maintained by humans. Computers seem to operate automatically and are perceived (and understood) as having human characteristics, such us agency, mind, or consciousness; yet this liveliness of the computer is determined by human action. The relation between human and machine is what seems to be the key for understanding the computer as a semiotic machine. In other words, it can be said that the genuine semiotic machines exist in relation to human semiosis.

Andersen, Hasle, and Brandt, in their article of 1997, describe machine semiosis as "the semiotic processes that take place inside ma-

[6]The term autopoietic system comes from the work of Chilean biologists Humberto Maturana and Francisco Varela, who in 1973 introduced the notion of autopoiesis in their book "Autopoiesis and Cognition: The Realization of the Living". According to Maturana and Varela the term autopoiesis describes the capacity of living systems to create, maintain and develop themselves. An autopoietic system is a system that must be capable of self-creation, self-control and self-reproduction. "Autopoiesis in living systems means that the system is not only capable of self-reference and autonomy in relation to its environment, but also of self-maintenance and finally self-reproduction. Machines are not autopoietic, but allopoietic, systems in so far as they are produced and maintained by humans." (Nöth 2003, 93)

[7]Automatons or automata are systems capable of performing tasks by themselves or automatically, they have some levels of self-awareness, and are perceived as autonomous agents. However, this "autonomy" of automata is limited since machines are not capable of autopoiesis (self-reproduction and self-reference), their mode of production and agency is determined by human agency.

chines, between machines, and between them and their human users." (Andersen *et al.* 1997, 548). As well as Nöth, Andersen et. al affirm that the notion of autopoiesis could bring some insight to the difference between machine and human semiosis (Andersen *et al.* 1997, 569). However, they focus not on the difference in nature of these two processes of semiosis, but on the idea that human semiosis is needed in order for the machine semiosis to appear. "(...) the difference between human and machine semiosis may not reside in the particular nature of any one of them. Rather, it may consist in the condition that machine semiosis presupposes human semiosis and the genesis of the former can be explained by the latter." (Andersen *et al.* 1997, 569). Andersen et al. do not refer to computer semiosis as quasi-semiosis, instead they introduce the notion of causual interpretant to explain that semiosis in machines is a determined process that lacks intentionality. Nevertheless, they see that this should not make computer semiosis less semiosis, because as it emerges from human semiosis it does not need to be morpho-genetic.

Andersen and Nake (Andersen & Nake Forthcoming, Forthcoming) take up this distinction between human and machine semiosis proposed by Andersen et al., and affirm that computer semiosis is independent but "coupled semiosis" as it occurs after and with human semiosis. Andersen and Nake use Max Bense's term co-reality (Mit-Realität)[8] to explain this ontological difference of human and machine sign production.

> Computer semioses can only come after and with semioses we are originators, participants, and witnesses of. Without those first, natural, original, genuine, proper semioses (how ever we want to identify them), there would and will not be computer semioses. But since we have come on a large scale and permanently to involve computers, as interactive media, in our semioses, co-semioses have started to appear. (Andersen & Nake Forthcoming)

In addition to Nöth's, and Andersen and Nake's arguments, we have Nadin's broad understating of the computer as a semiotic machine. Nadin

[8]Bense uses the term co-reality to explain the ontological modality of art and technology, and in particular aesthetic objects. Bense's argument is that aesthetic objects "requires some real thing in order to appear: aesthetic objects are 'co-real"' (Schaper 1956, 303)

affirms that computation is not just technological, but it can also be understood as a "semiotic process unifying the algorithmic and the interactive." (Nadin 2007, 68). Nadin argues that although electronics have made possible the existence of the computer, computation as a cognitive process does not occur in the circuits of the machine. It is a mental process and in the same way as we can do calculations using a piece of paper or an abacus, we could write an algorithm or program and execute it mentally or on paper. It would take time and the outcome might not be as precise, but in principle and theoretically it can be done.

From this perspective Nadin affirms that computation as a cognitive process is as well a semiotic process (Nadin 2007, 67). The question that comes from the line of thinking proposed by Nadin is what kind or type of semiotic entities are involved in computational processes. He argues that they must be signs, but does not analyze what are the characteristics of these signs compared to signs produced by other cognitive or semiotic processes different to computation. Nevertheless Nadin does make a differentiation between the semiotic processes performed by humans or a semiotic machine, in particular those that require creativity and open interpretation.

The question now is not whether or not the computer is a semiotic machine, but what kind of signs are those produced by machine semiosis. Nöth has introduced the term quasi-sign to name those signs produced by a machine. However, this term seems to reduce the notion of machine semiosis to only signal processing and excludes the possibility of considering the computer as a medium. I argue, as Andersen and Nake suggest, that in order to talk of the computer as a semiotic machine —and to consider HCI form a semiotic perspective— we need to introduce the concept of the algorithmic sign as an extension to Peirce's concept of sign that allows interactive treatment of software as signs (Andersen & Nake Forthcoming).

2.4 The Algorithmic Sign

The semiotic road has finally taken us to our destination: the algorithmic sign, or the computer artefact viewed as a sign. This concept was introduced by Frieder Nake[9], in order to explain the semiotic processes that occur when we interact with computer systems. "Algorithms and programs remain what they were as physical entities. But in the semiotic dimension they change when we take their interactive use into account." (Nake & Grabowski 2001, 445). From this change a new kind of sign emerges: the algorithmic sign.

The algorithmic sign can be described as the sign that is produced through machine semiosis (or co-semiosis). This new kind of sign is based on Peirce's model of the sign, and as the Peircean sign it is not a thing but a relational process of meaning production. The algorithmic sign possesses the same elements as other signs (representamen, object, interpretant), however, it presents a special and additional characteristic. It is interpreted twice, through computer and human semiosis (Nake 2009, 89). The algorithmic sign is then a sign that operates as a double. As product of a coupled semiosis, the sign is interpreted by the human and processed (executed) by the machine. It is a double-faced sign that, on one hand, is a triadic sign that is the product of a recursive process of interpretation as described by Peirce, and on the other hand is a sign that is a maximally reduced to a signal that can be manipulated and executed by the computer.

> The algorithmic sign thus is an object of computer manipulation and human interpretation alike. Open interpretation by humans (the sign as sign) and fixed determination by a computer (the sign as signal) together characterize the algorithmic sign in its dual nature. This nature reveals the algorithmic sign as a new category of signs. It becomes (or, rather, should be) the most important object of study in computer semiotics. (Nake & Grabowski 2001, 442)

According to Nake and Grabowski's description of the algorithmic sign, it is a sign both based on intentionality, and on a mechanical process of causes and effects. In this double process of co-semiosis the algorithmic sign appears as a new semiotic phenomenon, since it is not just something standing for something else, but it also becomes active. Through the mechanical signal processing of the computer, the algorithmic sign

[9]Nake has worked together with Peter Bøgh Andersen and Susanne Grabowski to develop this concept.

is executed, it *runs* and from a static textual description it becomes a dynamic process (Andersen 2003, 173). This capacity of producing a sign that can be active is what makes computer semiosis more than a process of linear causality. Formally, the computer semiosis is a sign process reduced to a determination. Since program code is a text with one and only meaning, computer semiosis is a limit case of interpretation (Nake 2008, 107). However, program code is not meant to be read or executed only once. "Every programming language from Plankalkül on has included some method of repeating the execution of segments of code." (Sebesta 2006, 4). The power of computation is based on this repetition of algorithmic processes using recursive and iterative functions. As different results can appear each time a program (or part of its code) is executed, recursiveness allows the algorithmic sign to produce different, albeit limited, meanings or interpretations.

Nake's understanding of the algorithmic sign as a double —that incorporates both sign and signal processes— calls for an extension of the traditional Peircean model of sign. This extension implies that semiotics develops "an understanding of the technical aspects of computer systems, in so far they are relevant to semiosis." (Andersen 2003, 176). The result is a sign with an extra interpretant called causal interpretant as suggested by Andersen. As explained before the causal interpretant is characteristic of computer semiosis, and in contrast to the interpretant produced by human semiosis, it is determined and lacks intentionality.

> The double nature of the algorithmic sign can be captured in a Peircean semiotics by claiming that a program text is a Representation that denotes the I/O-functions and the execution sequence of a machine, but has two different Interpretations, an intentional and a causal one. The intentional one is written by the language designer in the form of a formal semantics of the language, e.g. an operational semantics specifying which actions some virtual machine should take when running the program; the causal one is given by the compiler and runtime system that implements the language and actually runs the program. (Andersen 2003, 176)

The extra interpretant in the algorithmic sign extends Peirce's triadic relation. Having a fourth component the algorithmic sign is represented in quadrilateral model as described in Figure 2.4. This quadrilateral model

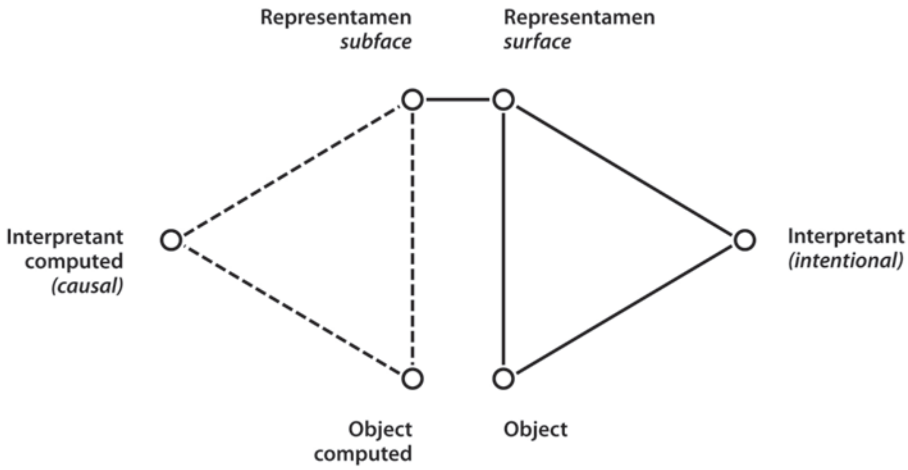


Figure 2.4: Quadrilateral Model of the Algorithmic Sign
Adapted from (Andersen & Nake Forthcoming)

offers an instrumental and a semiotic view of the algorithmic sign, and covers the tool and media aspects of computer systems (Andersen 2003, 183-184).

Following this model the algorithmic sign "can be determined as a representamen (with its surface and *subface*), an object and an interpretant, where object and interpretant appear twice: each of them in a computable (and computed) version, and an intentional version." (Andersen & Nake Forthcoming). It is important to clarify that even though the object appears twice in the model it is not understood as an additional fifth element, but as a different representation of the same object: one in the surface and one in the *subface*.

Nake introduces the term subface to name the semiotic processes produced by the computer that are hidden from the human as a user. He argues that the screen is the surface and the display buffer is the subface, the first one is visible and the second is computable. The subface becomes somehow visible for us when we interact with the computer at the level of programming code; however, the subface as computation is immaterial and as such it is never fully visible or accessible to us.

This distinction proposed by Nake of subface and surface is crucial for thinking of the computer as media, and as I will argue in the next chapter, it is key for understanding the specific aesthetic and semiotic qualities that characterize digital art. As Nake affirms "(i)t does not make sense to talk about the computer image without keeping in mind its visibility and computability. i.e. its computable visibility and its visible computability." (Nake 2008, 105).

Chapter 3

Subface and Surface

> In the digital world, things always exist double: at the computer periphery, they are accessible by our senses; in the computer memory, they are accessible by the processor. (Nake 2001, np)

In the previous chapter we looked at the theoretical background behind the notion of the algorithmic sign. The aim of this analysis was to rethink our interaction with (and through) computer systems as users and producers, but most importantly to consider the computer as a medium and a semiotic machine. From this semiotic perspective, the computer is understood as a machine capable of some level of interpretation, albeit a determined one. The term co-semiosis is created to explain the relation between machine and human semiosis, and how machine semiosis occurs after and with the human one. The algorithmic sign, as a product of this co-semiosis, is described as a doubled[1] process of semiosis; and in result as having two modes of existence or what Frieder Nake calls *surface* and *subface*. I will argue in this chapter, that we need to look into

[1]Doubled not in the sense of duplicate, this term refers to the description by (Andersen & Nake Forthcoming) of the algorithmic sign as having two interpretants, a causal one involved in computer semiosis and an intentional one that occurs in human semiosis.

these two expressions of the algorithmic sign (subface and surface) to understand the specific aesthetic and semiotic qualities that characterize digital media, and in particular digital art.

> The surface of any object on the computer corresponds to the intentional interpretant of the computer sign. The subface corresponds to the causal interpretant. I am not saying that the subface is the causal interpretant. For my intention here is to point at a correspondence between two perspectives. (Nake 2008, 107)

Following Nake's argument, the surface is the visible or perceptible[2] expression of the algorithmic sign, and the subface is its computable one. Signs in the computer are then both visible and computable at the same time. The relation between surface and subface is not explained by a one to one identity, nor by a direct or linear causality. One cannot translate surface into subface, or the other way around, as we do with a negative to a photograph. Surface and subface occur as a coupling (we could also say as a co-reality) they cannot be separated since they are in fact two expressions of the same process: the algorithmic process.

That being said, it is important to note also that the relation between subface and surface is not the same as the relation of content and form, where the subface would be the content and the surface the form. There is content and meaning in both surface and subface. The surface is not just a material form, it also carries content. We interpret computer signs at the surface or "screen level". We produce meaning out of this perceptible expression of the algorithmic sign in the same manner as we would do with other signs. However, the content in the subface *means* something different viewed from the human or from the computer perspective. The subface as the computable expression of the algorithmic sign, refers to the process of computation in which the algorithm as programming code is interpreted and executed by the machine. This is an immaterial process, not because it lacks form but because it is invisible for us. Although determined, the subface occurs as an automatic process inside the machine. At the level of the programming code we have some

[2] Although I talk about visibility and later about the image. However, as suggested by Mark B. Hansen (Hansen 2004) these arguments could be applied to hearing and touch as well.

kind of access to the subface. We can create, change or alter it but this is only an indirect access, because the subface really appears when the program is *running,* in the process of computation.

Surface and subface represent the dual ontology of the computer *thing* “insofar as it is not only visible, nor is it only computable. It is visible in a new meaning of the word, and it is computable in a new meaning.” (Nake 2008, 105). It is from this perspective that we can think and talk about the computer or digital image. But before discussing the digital image it is imperative to clarify the notion of digital, and what it means as an adjective.

3.1 Grasping the Immateriality of the Digital

The Oxford English dictionary ("digital" 2010) offers three definitions for the adjective digital. Firstly it describes it as that of or related to information represented as digits by using particular values of a physical quantity; only the last definition for digital refers to it in relation to the finger or fingers. This probably comes as no surprise as perhaps the most common use of the word digital nowadays is related to the use or description of electronic media.

Charlie Gere in his book “Digital Culture” explains how the adjective digital can describe a much broader range of systems, but how since the appearance of the computer it has been reduced to describe this particular technology.

> In technical terms it is used to refer to data in the form of discrete elements. Though it could refer to almost any system, numerical, linguistic or otherwise, used to describe phenomena in discrete terms over the last 60 or so years, the word has become synonymous with the technology which has made much of the aforementioned possible, electronic digital binary computers. (Gere 2008, 15)

The problem of this limited notion of digital, is that it is subordinated to a specific technology. For instance, when paired to the term culture it may seem that our digital culture is a product of our technological advances; that it has appeared as a result of the widespread use of computers or digital machines. However, as Gere affirms this is an inverse reasoning and the relation between digital culture and digital technologies should be understood the other way around (Gere 2008, 17). Gere's argument is that there needs to be a social and cultural background in order to set the conditions for a new technology or a new technological paradigm to appear. He traces the idea of digital back to human developed abilities and systems to express or to understand the world by using discrete elements. The path he traces goes back to writing —since writing and language deal with discrete units— and makes it clear that the idea of digital goes beyond a particular technology. According to Gere:

> Digital refers not just to the effects and possibilities of a particular technology. It defines and encompasses the ways of thinking and doing that are embodied within that technology, and which make its development possible. These include abstraction, codification, self-regulation, virtualization and programming. (Gere 2008, 17)

Gere is talking from a cultural point of view, nevertheless, his arguments on the "digital" can be applied to other uses of this adjective[3]. In particular, Gere's definition of the "digital" offers some insight to the terms "digital media", "digital art", and "digital image" because it allows for a conceptualization of these terms that goes beyond a technological determination. By recognizing how our ways of thinking have shaped our technological development, we can better understand how these artifacts affect our systems of signification.

Following this approach, the idea of a digital image does not necessarily mean that an image is produced by or represented on a computer or a particular technology. What the digital adjective should imply here is that it is an image expressed in a discrete manner (as a sum of discrete elements) although it is perceived as a whole. Visually the digital image appears as a fixed composition of light and color. However, the fact is that the image on the screen is a dynamic arrangement of discrete units. Both perspectives are right and this is what the digital adjective denotes. The digital image is both a discrete or numerical representation and a "the whole" graphic representation that we perceive.

[3]However, Gere's definition of the "digital" might not be adequate when we commonly refer to an specific technology or device such as a "digital camera" or "digital television", in these cases *digital* refers in fact to a particular technology.

Lev Manovich argues that the digital or computer image[4] and all new media in general are made of two layers, a cultural and a computational.

> On the level of representation, it belongs on the side of human culture, automatically entering in dialog with other images, other cultural "semes" and "mythemes." But on another level, it is a computer file that consists of a machine-readable header, followed by numbers representing color values of its pixels. On this level it enters into a dialog with other computer files. (Manovich 2002, 45-46)

However, these two layers are more than levels of representation. The digital image is a sign that is interpreted by both humans and computer systems; it is a sign that has a subface and a surface. The digital or discrete representation of an image has made it computable, and this is a fundamental change in our systems of signification.

3.2 The Double Life of the Digital Image

The digital image is an algorithmic sign that we see on the screen and at the same time it is being processed by the computer as a set of pixels or as a mathematical equation. This new type of image is in continuous change, and it allows us and invites us to intervene in this change. The result is something that is no longer an image in the traditional sense.

> [i]t is only by habit that we still refer to what we see on the real-time screen as "images." It is only because the scanning is fast enough and because, sometimes, the referent remains static, that we see what looks like a static image. Yet, such an image is no longer the norm, but the exception of a more general, new kind of representation for which we do not yet have a term. (Manovich 2002, 100)

As Manovich explains we still call it an image. However, we add the adjective digital to be precise and to differentiate these new kind of rep-

[4]Manovich uses the term "digital image" interchangeably with "computer image", I prefer to talk about digital image only. My argument is that the adjective digital is more general and covers all those images presented on digital and electronic devices including all sort of screens and projections.

resentations from other kind of images that are produced as a whole and that cannot be altered without reproducing them.

New media theorist Mark Hansen, agrees with Manovich that "new media can and must be distinguished from old media by their different ontological status, and indeed, their total material fluidity: rather than being anchored to a specific material support, new media are fully manipulable, digital data." (Hansen 2004, 32). The digital image is produced by the manipulation of discrete information and, as data it can then be perceived and expressed in many different forms. However, Hansen criticizes Manovich's theorization of the digital image based on the idea of "cinematic framing". For Hansen the digital image "explodes the frame" and cannot be understood as a fixed and objective cut in the flux of reality. Instead, the digital image should be defined now by its almost complete flexibility and addressibility, its numerical basis, and its constitutive 'virtuality."' (Hansen 2004, 8). Hansen adds that Manovich's description of new media is ironically limited because it reduces the potential of the digital by ascribing its form to the image-frame of cinema.

Hansen's description of the digital image is not inherently different from Manovich's. What Hansen does not agree with is Manovich's use of the cinematic metaphor to theorize the digital image. As explained above, Hansen argues that the cinematic framing is antithetical to the almost limitless framing potential of the digital image (Hansen 2004, 35). However, Hansen's major problem with this metaphor is that it implies a passive or static perception.

> As I see it, digitization requires us to reconceive the correlation between the user's body and the image in an even more profound manner. It is not simply that the image provides a tool for the user to control the "infoscape" of contemporary material culture, as Manovich suggests, but rather that the "image" has itself become a process and, as such, has become irreducibly bound up with the activity of the body. [...] In sum, the image can no longer be restricted to the level of surface appearance, but must be extended to encompass the entire process by which information is made perceivable through embodied experience. This is what I propose to call the digital image. (Hansen 2004, 10)

Hansen explains how the digital image is produced with a sort of second surface (or what we call here the subface). The image in the digital age, he states, cannot be restricted to its superficial appearance. Hansen bases this description of the digital image[5] on the theories of philosophers Gilles Deleuze and Bernard Stiegler, and media theorists Edmond Couchot and Friedrich Kittler. Hansen affirms that Couchot, Deleuze, and Kittler have all recognized the extreme flexibility and total addressibility of the digital image, but that these critics have focused on the effect of these qualities on the optical properties of the image (Hansen 2004, 203-204). For Hansen this mainly optical or visual perspective is not enough to describe the image in the digital age. He argues that what characterizes the digital image is not just its technical or material qualities, but the changes in perception that digital has brought.

The thesis introduced by Hansen is that the "digital image demarcates an embodied processing of information" (Hansen 2004, 12). This means a shift in the idea of passive perception to a more embodied one, where the body would act as a processor of information instead of a passive mediator. To test and explore this thesis, Hansen takes on Henri Bergson's theories on visual perception and follows (and extends) Bergson's notion of bodily affection. Although he concentrates on the visual, Hansen argues that his theory would also apply to other sensorial perception or registers of aesthetic experience, such as hearing or touch.

> As a processural and necessarily embodied entity, the digital image lays bare the Bergsonist foundation of all image technology, that is, the origin of the perceivable image in the selective function of the body as a center of indetermination. No matter how "black-boxed" an image technology (or technical frame) may seem, there will always have been embodied perception at/as its origin. In relation to today's electronic technosphere, however, Bergson's theorization of this process of embodied selection must be updated in at least one important respect: rather than selecting preexistent *images*, the body now operates by filtering *information* directly and, through this process, *creating* images. (Hansen 2004, 10-11)

[5] But also on the notion of the digital in general and applied to media and aesthetics.

For Hansen contemporary media art can produce a paradigmatic shift "from a dominant ocularcentrist aesthetic to a haptic aesthetic rooted in embodied affectivity." (Hansen 2004, 12). He bases his claims in the new dimension that the digital has brought to aesthetics, in particular to the image. To illustrate his theory of how with digitization the body has become an active processor of information —and the center of image production or "embodied framing"— Hansen analyzes the work of new media artists like Jeffrey Shaw, Robert Lazzarin, Douglas Gordon, and Bill Viola. According to Hansen, these artists (amongst others) have followed in their work a "Bergsonist vocation" by "placing the embodied viewer-participant into a circuit with information, the installations and environments they create function as laboratories for the conversion of information into corporeally apprehensible images." (Hansen 2004, 11). With a concrete analysis of the oeuvre of these artists Hansen explores how contemporary art, in particular digital art, has introduced a more embodied aesthetics.

It is from this perspective that Hansen argues that the interactivity of the new media (and the digital image) is just not defined by the change from viewers into users. Instead, interactivity should be also considered from the notion of *virtualization.* Hansen affirms that:

> Carried over to the domain of the aesthetic, virtualization opens a recursive interaction between body and artwork: by actualizing the virtual dimensions of the artwork, the viewer-participant simultaneously triggers a virtualization of her body, an opening onto her own "virtual dimension." In the case of new media art, such a recursive interaction opens a circuit between the body and an informational *process.* (Hansen 2004, 144)

Virtualization[6] can be said to be a vehicle of the "Bergsonist vocation of new media art" by which the image appears as a product of an "em-

[6]In developing his notion of virtualization and its correlation with the digital, Hansen follows the notion of the virtual from the French philosophical tradition that comes from Bergson and that was later taken up by Gilles Deleuze and Felix Guattari. However, Hansen's virtualization is also based on the works of media philosopher Pierre Lévy and of cultural critic Timothy Murray, authors who break from philosophical tradition and develop their own appropriation of Deleuze's aesthetics of the virtual.

bodied framing". Hansen affirms that digital interactivity in new media artworks operates through a recursive process of virtualization that places the user-participant in correlation with "two distinctive virtualities": the actualization of the virtual in the aesthetic experience, and a virtualization of the body (Hansen 2004, 146). In doing so "such works not only extend perception (i.e., the body's virtual action); more important still, they catalyze the production of new affects—or better, new affective *relations*—that *virtualize* contracted habits and rhythms of the body." (Hansen 2004, 146). Hansen's theories on the digital image —beyond its superficial appearance— provides insight into how our modes of perception have changed due to the appearance of digital technologies. Hansen argues that digitization have displaced "the framing function of medial interfaces back onto the body" (Hansen 2004, 22) and that this displacement is what characterizes the "newness" of the digital as an adjective. It is not just the dematerialization of the image what makes the new media art "new", according to Hansen, what is specific to new media art is the change in perception that comes with it, as the body takes on the framing function and *creates* images by processing information. "New media art calls on the body to inform the concept of 'medium' and also to furnish the potential for action within the 'space-time' of information" (Hansen 2004, 23). Hansen's approach complements the conceptualization of the digital image as an algorithmic sign because it analyzes how we perceive this new type of signs that are not static and stable, but that exist as a process.

3.3 The Digital as Medium

We have discussed how the *surface* and *subface* represent the two modes of existence of the algorithmic sign and how the digital image can be theorized from this perspective, as both a technical and a perceptual process. Let's now focus on how the conceptualization of the algorithmic sign, as subface and surface, affects the notion of medium. For instance, media theorist Lev Manovich affirms that the appearance of "new media" calls for a swift from media theory to software theory. This new approach proposed by Manovich incorporates the idea of programmability as one of the main characteristics of new media, and suggests that we use concepts from computer science to enrich new media theory (Manovich 2002, 48).

Without going so far as Manovich's software theory, notions like the algorithmic sign or computer semiosis not only bring together semiotics and computer science, but also establish an intersection between these two disciplines and media theory. However, before we explore what this intersection means to digital art, we need to clarify what does it mean to talk about media or medium in the digital age.

One of the first and most influential theories on the medium, and its plural media, is the one of Marshall McLuhan. His ideas are commonly reduced to his statement "the medium is the message[7]", by which he meant that "the "content" of any media is always another medium" (McLuhan 1994, 8). This statement shows McLuhan's interest on making us aware of the effects of media, to which we are blind because we only *see* the actual content, or the specific content of the actual message. According to this theory, media are described as the "extension of man", the extension of our senses and even of our consciousness by means of technology. For McLuhan these extensions had consequences in a personal and social level, on our ways of perception and interpretation.

McLuhan's approach has been criticized for being too centered on the effect of technology, for which it is associated to technological determinism. The most relevant criticism of McLuhan's perspective on media (at least for our discussion here) is that his conceptualization of the medium as an extension of our senses reduces the notion of mediation, in particular because it does not address the difference between tool and medium. What is interesting for us is the idea that the process of mediation is not isolated, but it has cultural and social effects.

The French writer and philosopher Régis Debray is a strong critic of McLuhan's media theory. On the one hand, Debray questions the scientific rigor of what he calls the "McLuhanites" and affirms that the Canadian has become a cliché. On the other hand, Debray argues that McLuhan "mixes together under the same label of *medium* the *channel* or material vehicle of information, the *code* or internal structure of a language, and the *message* or content of a concrete act of communication."

[7] And the massage.

(Debray 1996, 71). Debray insists that McLuhan conceptualization of the medium, as the message or an extension of man, is too simplistic because the notion of medium includes four non-contradictory but exclusive senses, namely a general procedure of symbolizing, a social code of communication, a supporting material, and a recording device (*dispositif de diffusion*) (Debray 1996, 13). That being said, Debray defines the *medium* "in the strong sense" as "the system of *apparatus-support-procedure*, that which a mediological revolution would unsettle and disturb organically." (Debray 1996, 13).

Debray, however, focuses on the notion of mediation rather than on the medium. Thereby he introduces the discipline of mediology, which aims to study how the technical structures of transmission are interrelated with cultural systems or higher social functions. In doing so, mediology brings new light into the relation of culture and technology, and explains how this relation is not one of opposition, nor it is one of a one-way determination. Cultural and technological systems, Debray argues, influence each other in a dynamic relation that, does not always have the same pace.

> In the word "*mediology*," "*medio*" says not media nor medium but mediations, namely the dynamic combination of intermediary procedures and bodies that interpose themselves between a producing of signs and a producing of events. These intermediates are allied with "hybrids" (Bruno Latour's term), mediations at once technological, cultural and social. (Debray 1996, 17)

Mediation, for Debray, is more than that "that is in the middle", because it elaborates (it affects) what it mediates (Debray 2001, 164). As a process mediation is not transparent or sterile, it does not function as a "tunnel". The notion of mediation is fundamental to the mediological study the processes of technological transmission[8] of culture. Debray's

[8] It is important to mention that Debray differentiates between communication and transmission. He does not define them as opposing terms but, he explains that the two cannot be equated, they must be understood as a dialectic relation. Communication is a necessary condition of transmission, however not sufficient. (Debray 2001, 29) "Communication is a transmission that has cooled, that is stable and calm" (Debray 1996, 48). Communication has a shorter temporal reach and is expected to occur as a two way relation, while transmission happens over time

mediology offers an important theoretical background for conceptualizing digital media, however, it is too general and centered on the idea of cultural transmission. Thereby it is not enough for understanding the changes and challenges of the digitization of media.

Jay David Bolter and Richard Grusin introduce the notion of remediation, in a book by the same name, as the representation of a medium in another. They affirm that although remediation is not exclusive to new or digital media, it is a defining characteristic of these media (Bolter & Grusin 2000, 45). Remediation is based on the idea that new technology can only "define itself in relationship to earlier technologies of representation." (Bolter & Grusin 2000, 28). Bolter and Grusin add that remediation can work in both directions, since older media can also refashion newer ones. In this sense, the two authors argue that all mediation is remediation in the same way that McLuhan affirmed that "the content of any media is another media".

> It would seem, then, that *all* mediation is remediation. We are not claiming this as an a priori truth, but rather arguing that at this extended historical moment, all current media function as remediators and that remediation offers us a means of interpreting the work of earlier media as well. (Bolter & Grusin 2000, 55)

Bolter and Grusin explain that remediation operates within a double logic, that of immediacy (or transparency) and hypermediacy. This double logic is established by our culture and it aims to multiply and erase media. "Both new and old media are invoking the twin logic of immediacy and hypermediacy in their efforts to remake themselves and each other." (Bolter & Grusin 2000, 5). Therefore, is not immediacy or hypermedia what defines the new in new media. Bolter and Grusin affirm that what characterizes new media are "the particular ways in which they refashion older media and the ways in which older media refashion themselves to answer the challenges of new media." (Bolter & Grusin 2000, 15). Mark B. Hansen, however, does not agree with characterizing new media from the perspective of remediation. He argues that the notion of remediation does not provide much insight into the characteristics of new

and has to do with the process and practice of memory.

media. Instead, he says, it makes it harder to conceptualize new media because from the perspective of remediation digitization has made media thoroughly and bidirectionally interchangeable (Hansen 2004, 1).

However, Hansen is more interested in analyzing the more radically position that suggests that with the appearance of digital technologies media have become obsolete. For Hansen, this position is mainly represented in Friedrich Kittler's argument that digitization has erased all differences between individual media, and that in fact with a total digital base the very concept of media would disappear.

> Inside the computers themselves everything becomes a number: quantity without image, sound, or voice. And once optical fiber networks turn formerly distinct data flows into a standardized series of digitized numbers, any medium can be translated into any other. (Kittler 1999, 1-2)

As Hansen sees it, Kittler's approach to the digital makes human perception (and the image itself) obsolete and it also strips aesthetics away from the human perception experience. This is the fundamental point in Hansen's critique of Kittler, the obsolescence of human perception. Hansen affirms that for Kittler "the digital revolution marks the endgame in the long-standing war of technology and art; with digitization, the perceptual-aesthetic dimension of media becomes mere 'eyewash,' a hangover of a bygone, humanist epoch" (Hansen 2004, 71). What Hansen proposes instead —as discussed in the previous section— is a (new) media theory based on a new phenomenology, which emphasizes the role of the body as an active framer of the image.

In order to elaborate his theory of new media, Hansen draws on the works of Walter Benjamin, Henri Bergson and Gilles Deleuze. Bergson and Delueze are fundamental for Hansen's understanding of notions of perception, image and framing in relation to the digital; while Benjamin informs Hansen's conceptualization of media. In particular, Hansen sees in Benjamin's essay the "Work of Art"[9] a beacon of hope for the notion of medium in the face of theories like Kittler's, which declares the obsolesce of media and of the aesthetic qualities of the digital image.

[9] Benjamin's essay "The Work of Art in the Age of Its Technological Reproducibility", which Hansen refers to as the "Work of Art".

Hansen affirms that the correlation “between the formalist aspect of the aesthetic act and the physiological shockeffect of modernist art” (Hansen 2004, 2) that Benjamin establishes in his essay the “Work of Art” is of great importance for the concept of media in the digital age.

> Indeed, this correlation lends a newfound specificity to the oft-celebrated redemptive dimension of Benjamin’s aesthetics, for if the hypostatization of the formal act of framing reality vacates the artwork of its Romantic trappings (specifically, its autonomy and its objective status as the bearer of truth or the idea), and if the shock-effect relocates the impact of the work squarely in the domain of experience, this is all in the service of a redemption of embodied experience: a renewed investment of the body as a kind of *convertor* of the general form of framing into a rich, singular experience. One might even characterize this properly creative role accorded the body as the source for a new, more or less ubiquitous form of aura: the aura that belongs indelibly to *this* singular actualization of data in embodied experience. (Hansen 2004, 2-3)

Accordingly with this reading of Benjamin, Hansen proposes a theory of new media that is based on the correlation of new media aesthetics with a strong theory of embodiment[10]. Hansen’s approach to new media and its aesthetics is fundamental for the purpose of this research, because it provides a theoretical basis to rethink digital art avoiding an instrumentalist perspective, and the common places of the digital.

[10]Hansen uses the term embodiment in the sense that “it has been lent by recent work in neuroscience: as inseparable from the cognitive activity of the brain”. (Hansen 2004, 3)

Chapter 4

Towards an Aesthetics of Digital Art

4.1 The Computer: Tool and Medium for Art

In Chapter 3 the notion of medium in the digital age was introduced as a problematic one. From the point of view of remediation, digital media are mainly characterized by the particular manner in with they refashion older media (Bolter & Grusin 2000, 15). As Friedrich Kittler sees it the "general digitization of channels and information erases the differences among individual media" (Kittler 1999, 1) which makes obsolete the very notion of medium. Through the notion of post-medium, Rosalind Krauss, explains how new media have been reinvented by digitization (Krauss 1999, 296). Mark B. Hansen characterizes the medium in the digital age by the shift in the correlation between media and body; "[t]his means that with the flexibility brought by digitization, *there occurs a displacement of the framing function of medial interfaces back onto the body from which they themselves originally sprang.*" (Hansen 2004, 22). As diverse as these perspectives may be, what seems to be a common denominator is the fact that digital (or new[1]) media lack the material specificity of traditional media.

Concretely, I concur with Hansen's theory which defines the "newness" of digital media as shift to "embodied perception". He agrees that the notion of medium has become in some ways obsolete as Kittler affirms, however Hansen still believes that this notion can continue to matter in the digital age (Hansen 2004, 1). For Hansen it is not the media per se what has been erased, but the epoch of media differentiation (Hansen 2004, 274). Accordingly the term medium becomes relative and is only pertinent in reference to a plurality of media.

From this perspective it seems problematic, indeed, to talk about the computer as a medium. Mostly because the computer alone cannot cover the full notion of digital media. On the one hand, the computer did not start as a medium (Bolter & Gromala 2003, 15), it became one through many technological advances (e.g. the personal computer, the graphic user interfaces, the world wide web; to name a few). On the other hand, the computer does not have a unique form. The computing machine has evolved in time from an automaton to the now ubiquitous mobile devices, this results in many different machines that can be called computers and many others that perform similar tasks and have similar features but are not called computers.

In this sense, and specially in relation to art, it would be better to talk of digital technologies[2] — particularly, because it was not the computer alone what produced the "algorithmic revolution". It was also the *digital* as binary structures of 0s and 1s what allowed the mechanization of mental labor and the discrete expression of almost all human symbolic production. Images (still and moving), sound, text and speech can then be stored, transferred, or manipulated mathematically, or better algorithmically, at the level of numbers. This is the true basis of the

[1] I prefer to use the adjective digital, instead of new, because it is more precise in the sense that new only describes a temporal aspect.

[2] Rosalind Krauss talks of the "technical support", which she affirms "has the virtue of acknowledging the recent obsolescence of most traditional aesthetic mediums (such as oil on canvas, fresco, and many sculptural materials, including cast bronze or welded metal), while it also welcomes the layered mechanisms of new technologies that make a simple, unitary identification of the work's physical support impossible" (Krauss 2006, 56).

so called "multimedia revolution" (Lunenfeld 1999, xvi).

We will however continue talking about the computer as a medium, but in a more restricted sense, and specially to denote that its characteristic of being a machine that as a semiotic engine has become more than a tool. That being said, the next two sections will be dedicated to the study of how artists started using the computer as a tool and a medium for aesthetic research. The aim of this analysis is to show that from the early computer drawings one can appreciate the qualities of digital art (albeit not all of them). In particular I will consider the works of Manfred Mohr and Vera Molnar, two of the first trained artists who turned to the computer for artistic creation, from the perspective of the algorithmic sign.

4.2 The Case of Molnar and Mohr

In the mid 1960s engineers and mathematicians[3] with an interest in aesthetics started using computers for visual research, soon trained artists followed, collaborations appeared and the distinction between artists and technologists was blurred. The semiotic machine became a tool for artistic creation marking the beginning of computer art. With the background of both conceptual and constructivist art, the creative experiments with the computer introduced the algorithmic principle to art. As Frieder Nake affirms: "If photography liberated art from representing visible aspects of reality, algorithmics liberates art from carrying out the work. It is now enough to describe it. Once described, entire series can be generated." (Nake 2009, 82). Traditional notions in art history such as originality, aura or artist geniality, which have been first challenged in the beginnings of the twentieth century, became obsolete with the rise of computer art.

Computer art, or better algorithmic art[4], brought a new type of sign into the world of art: the algorithmic sign. With it new creative languages appeared, both as generative aesthetics and actual programming

[3]The three most prominent computer artists, and often recognized as pioneers of computer art, are Georg Nees, A. Michael Noll, and Frieder Nake.

[4]On why better *algorithmic* or *generative* art see the Chapter 1.

languages as artists had to learn how to interact with the machine. This interaction was not just physical but also symbolical, it meant learning the logic and the potential of the new tool and medium.

> The computer artist must learn, when she wants to become a master, how the machine would interpret the sign, although that machine lacks the capability of genuine interpretation. All the semiotic engine can produce is a determination. Determination is interpretation as the extreme case, where free interpretation is not allowed. The revolution in aesthetic thinking that algorithmic art started around 1965 is the attempt to think like that engine that cannot think: the semiotic engine. (Nake 2009, 89)

For some computer artists this learning process meant experimentation and exploration of new techniques. For others it meant collaborating with engineers and programmers, but for a few the algorithmic logic was already familiar. This is the case of Vera Molnar, who was already working with her "machine imaginaire" before she started using the computer. She knew exactly what she wanted from the computer: precise variations (Guderian 2006, 25). Molnar wanted to systematically investigate an aesthetic problem that required simple geometric forms to be altered in specific and precise (mathematical) ways, the computer was to her the tool that would transform her method into a new picture language.

4.2.1 From the Machine Imaginaire to the Machine Réel

Vera Molnar was one of the first female trained artists (Nierhoff 2006, 11, 12) to start using the computer as a medium or as a tool for artistic creation. This Hungarian artist decided she would be a painter at the age of 12 and started painting scenes of the woods and nymphs. However, soon she abandoned the traditional image hierarchies and replaced figurative matter for simple geometrical forms. She described herself as "a painter, an image-maker, in particular, of images of a non-figurative kind. I 'create' visual forms in the sense that they consist of combinations of shapes that cannot be found in nature." (Molnar 1975, 185). Since 1946 she began creating pictures experimenting with mathematical or rather constructive composition rules (Nierhoff 2006, 14), such as *Décomposition d'un Mondrian* (Figure 4.1). From these experiments she developed a method that she called the "machine imaginaire". This was a "procedure in which initial simple geometrical elements and their combination were successively altered in specific ways" (Molnar 1975, 185). She started with an idea that was then modified systematically, step by step, until *all* the aesthetic possibilities were explored. In other words she imagined she had a computer for which she designed a program, a set of instructions that she then followed so that she would not exclude a single combination of the forms (Molnar 2006, 31).

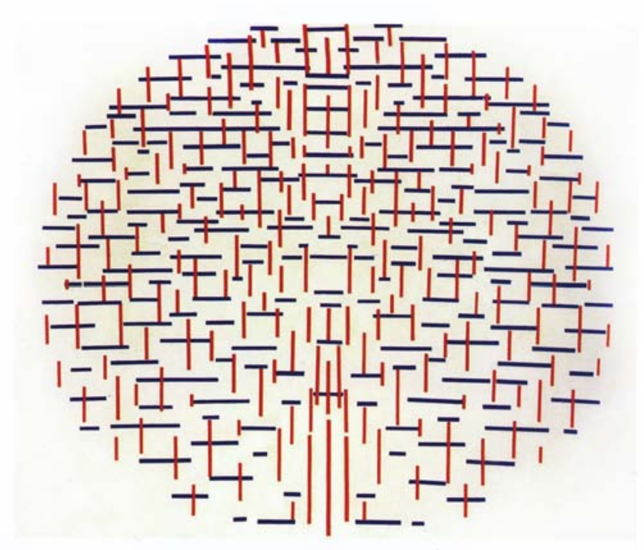


Figure 4.1: Vera Molnar, *Décomposition d'un Mondrian* (Decomposition of a Mondrian) Collage, 85 x 110 cm. 1954
Source: (Nierhoff 2006, 12)

> When I have an idea for a new picture, I make the first version of it rather quickly. Usually I am more or less dissatisfied with it and I modify it. I alter in a stepwise manner the dimensions, proportions and arrangement of the shapes. When simple geometrical shapes are used, such modifications are relatively easy to make. By comparing the successive pictures resulting from a series of modifications, I can decide whether the trend is toward the result that I desire. What is so thrilling to experience is not only the stepwise approach toward the envisioned goal but also sometimes the transformation of an indifferent version into one that I find aesthetically appealing. (Molnar 1975, 186)

Molnar's machine imaginaire method was based on her understanding of art as a continuous creative research. The machine imaginaire was a breakthrough for the artist mostly because it offered a systematic way to put some distance between the artist and the inevitable cultural influence. However, the machine imaginaire was still performed by the artist and it was not enough to produce the kind of "inconceivable images" (Molnar 2006, 31) that Molnar aimed for. Even while using the machine imaginaire Molnar was still influenced by her *being-human* and it was impossible for her to act truly haphazardly. The principle of hazard was essential for Molnar's aesthetic research, as it was for many artists since Hans Arp's image series *Sorted according to the laws of hazard* (Figure 4.2). For artists in the fifties, such as John Cage, the principle of hazard should be transferred into an algorithmic or mathematical one, which would allow the artist to *control* the hazard without influencing it (Nierhoff 2006, 18).

Figure 4.2: Hans Arp. *Untitled (Squares Arranged according to the Laws of Chance)*
Cut-and-pasted colored paper on colored paper, 33.2 x 25.9 cm. 1917
Source: (MoMA 2010, np)

That was Molnar's idea when she put together her machine imaginaire, to enable series of changes in order to discover new visual compositions, see Figure 4.3. However, this procedure soon proved to be a very tedious and time consuming task, and also as a technique it did not entirely satisfy Molnar because it was not precise enough. No matter how systematic her method was, her own 'hazard' was not as innovative as she wanted it to be (Nierhoff 2006, 18).

This stepwise procedure has, however, two important disad-

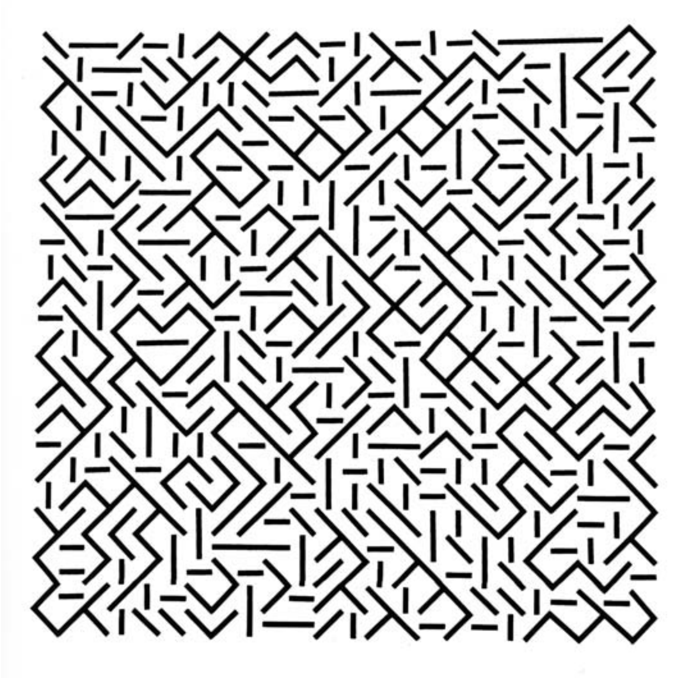


Figure 4.3: Vera Molnar, *Distribution Alèatoire de 4 Éléments* (Aleatoric Distribution of 4 Elements) Collage/carton, 75 x 75 cm. 1959 Source: (Hollinger 1999, 139)

> vantages if carried out by hand. Above all, it is tedious and slow. In order to make the necessary comparisons in a developing series of pictures, I must make many similar ones of the same size and with the same technique and precision. Another disadvantage is that, since time is limited, I can consider only a few of many possible modifications. Furthermore, these choices are influenced by disparate factors such as personal whim, cultural and educational background and ease of execution. (Molnar 1975, 186)

As soon as possible Molnar traded her machine imaginaire for the machine réel, the computer. It was the year of 1968, when she gained access to a digital computer at the Centre de Calcul of the University of Paris–Sorbonne in Orsay. She learned the programming language Fortran[5] before she started working with an IBM 370 computer and a Benson plotter. This change to the real machine helped Molnar minimize the dif-

[5]Later on she worked with the programming languages Basic and C, however of the two she only learned Basic and when she decided to use C she turned over the programming to professionals. Since 1996 she has been working with Erwin Steller.

ficulty and tediousness of her method, and at the same time increase the complexity of her results. She could work using parameters in a more effective way by reducing the time and effort needed to produce each picture, but also by gaining precision (Figure 4.4). Sometimes she would modify the parameters of her programm and then wait for the results after the picture was printed. At other times she would not even wait to print it, since the computer allowed her to view on a CRT[6] screen how the modifications to the parameters affected a picture, or a whole series of pictures, and from there make a selection (Molnar 1995, 187). In this way she could keep control over the machine as she could still select and even go back to repeat drawings that had appeared before.

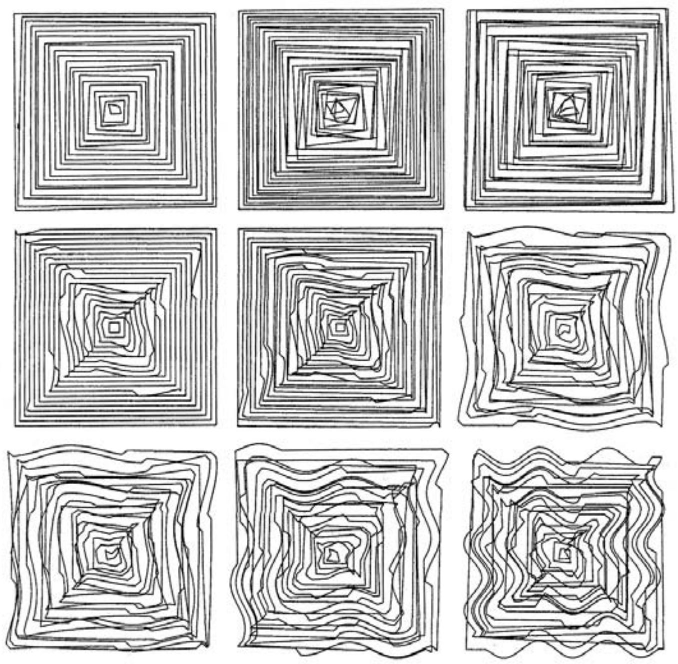


Figure 4.4: Vera Molnar, *Transformation series*
Ink on paper, 48 x 36 cm each. 1974-76
Source: (Hollinger 1999, 247)

Patric D. Prince affirms that "Molnar's early recognition of the computer's ability to save and rework artistic research is crucial to the history of digital art and one of the important elements of contemporary graphics." (Prince 2003, 8). Molnar used this "conversational method"

[6]CRT stands for cathode ray tube.

with a program called RESEAU-TO to produce several series of images which explored the algorithmic transformation of quadrilateral figures[7] (Molnar 1975, 188). She produced these series of explorations between 1970 and 1976, and they were part of her first single exhibition "Transformations" at the gallery of the Polytechnic of Central London, in 1976 (Herzogenrath & Nierhoff 2006, 79). Figure 4.4 is an example of these images produced with the RESEAU-TO program, which Molnar described as:

> This program permits the production of drawings starting from an initial square array of like sets of concentric squares. The available variables are: (1) the number of sets, (2) the number of concentric squares within a set, (3) the displacement of individual squares, (4) the deformation of squares by changing angles and lengths of sides, (5) the elimination of lines or entire figures and (6) the replacement of straight lines by segments of circles, parabolas, hyperbolas and sine curves. Thus from the initial grid a great variety of different images can be obtained. (Molnar 1975, 188)

Despite of all the advantages of the computer she sees it only as an aid, an "automatization" of her machine imaginaire. Computers, she believes, are "no more than other simpler tools, do not guarantee that a work of art of good quality will result, for it is an artist's skill that is the decisive factor" (Molnar 1995, 188). The computer helps, she says, "but it does not 'do', does not 'design' or 'invent' anything" (Molnar 2006, 31). It is not responsible for these inconceivable images that she creates. As she describes it, the computer is a tool that has indeed allowed her to achieve her goal but only because of its algorithmic power.

Molnar's use of the computer is clear, for her the semiotic engine is just an instrument for drawing and painting: a very powerful one but a tool nonetheless. She knew what she wanted from the computer, inconceivable variations that were very difficult, if not impossible, for her to achieve by hand (Figure 4.5). Dietmar Guderian affirms that: "She forces her own stamp onto the computer —a process that we could refer

[7] The theme of the "metamorphosis of the square"(Nierhoff 2006, 17) continued to be one of the main topics of Molnar's œuvre, although later she approached it in different ways.

to as true artistic freedom in handling of the machine" (Guderian 2006, 28). That is why she is never fully surprised by the results, because her visual experiments with the computer are intellectually controlled.

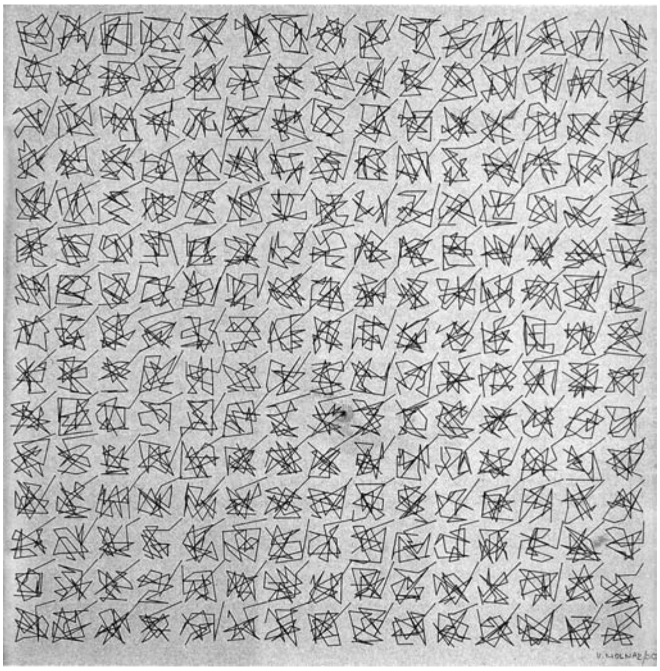


Figure 4.5: Vera Molnar, *Hommage à Dürer, 225 variations aléatoires* (Homage to Dürer, 225 aleatory variations) Direction chaos plotter drawing, open series +/- 30 x 30 cm. 1990. Source: (Nierhoff 2006, 20)

4.2.2 The Êtres Graphiques as Algorithmic Signs

The work of Vera Molnar and Manfred Mohr has many similarities. They are both trained artists who traded traditional tools to work with the computer. Around the same time, both living and working in Paris, they turned to programming languages to express algorithmically what their hands and brushes could not do. They both used random number generators[8] —as did the pioneers of early computer art Georg Nees, Frieder Nake and A. Michael Noll— but more importantly both were already working in a systematic manner before they started using computers.

However, the main focus here is not so much in the similarities between these two artists but in what sets them apart. It is a slight

[8]"Mohr attaches importance to the fact that his random parameters, as mathematical chance, only disturb the algorithmic process in places where they cannot cause any fundamental structural alterations." (von Mengden 2007, 28-29).

but crucial difference: their relation to the machine. For Molnar the computer is nothing more than a tool, whereas for Mohr it is not just a tool but also a medium for his work. As Frieder Nake affirms:

> For Manfred Mohr, the computer is not a casual instrument. It is rather the necessary medium making possible the narration that the artist initiates with the algorithm. The artist as algorithmic man, as narrator of a new kind, delivers news from a world much familiar to mathematicians but totally alien and unfamiliar to the rest of us. (Nake 2001, np)

Although Mohr started painting influenced by Art Informel and Tachisme (Lähnemann 2007, 12), already in the mid 1960s he rejected this style for being too subjective (Figure 4.6). Influenced by Max Bense's information aesthetics Mohr started exploring different techniques that allowed him to gain a more rational understanding and production of art (Kurtz 1994; von Mengden 2007, 18; 25). This study of Bense's aesthetics started a close relation to semiotics that would persist throughout his career and that would be central theme of his work and thinking. Marion Keiner affirms that semiotics "provided him with a new artistic goal: 'A rational construction of art!' or a rational creation of signs."[9] (Keiner 1994, 138).

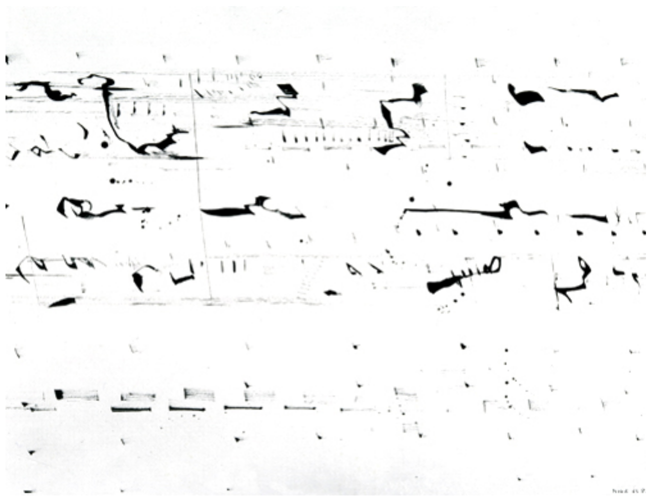


Figure 4.6: Manfred Mohr, *Hommage à K. R. H. Sonderborg* (Homage to K. R. H. Sonderborg). Drawing, ink on paper, 49 x 63 cm. 1963. Source: (von Mengden 2007, 25)

[9]"A rational construction of art!" is a quote from Manfred Mohr, in the catalog of the exhibition "Algorithmus und Kunst: Die präzisen Vergnügen", Hamburg 1993.

After his early years of spontaneous emotions, Mohr started to paint only abstract geometrical forms with logic and precision. His works showed architectural order and geometric elements systematically arranged "developed signs into 'carriers of aesthetic information'." (von Mengden 2007, 29). But before he moved away from the automatic painting Mohr had already left the use of color in his painting, working only with black and white, and also rarely with gray. Thomas Kurtz argues that this radical break with color was Mohr's first step towards the use of the computer; because, the decision of simplifying some aspects of his work helped him focus on more complex composition possibilities. Kurtz affirms that: "The radical nature of the supposed minimization of the painter's possibilities is reflected in the choice of a rigorously operating binary system with which other complex systems can be constructed." (Kurtz 1994, 18). However, Kurtz's stress on the "binary" and its relation to the use of color in Mohr's work is not so relevant, and perhaps even misleading. What was the turning point in Mohr's career was Mohr's change in style for a more rational aesthetics, which to Kurtz is the artist's second step on the way to computer art. After this radical and definite change, Mohr developed a particular sign vocabulary of circles, squares and lines which he would put together to form new aesthetically charged complex signs. In his book, Artificiata I[10], Mohr explained his goal for creating these new signs that seem to borrow from existing ones, but that could not really be easily interpreted in their new context. "The viewer will have to learn to observe small changes in signs and their parameters so as to attain to a new sensitization of his visual field." (Kurtz 1994, 20). This can be seen in Mohr's *777MHz* (Figure 4.7) where geometrical elements might be taken as wiring diagrams.

Precisely the year that Mohr wrote Artificiata I, he watched a TV show about how researchers at a meteorological institute in Paris were using an automatic plotter to print computer graphics. Mohr contacted the institute and was granted access to both the computer and the plotter to develop his algorithmic visual research. He worked at the Meteorological Institute only until 1981, but he has never again returned

[10]Compiled in 1968 and published a year later by Editions Agentzia in Paris.

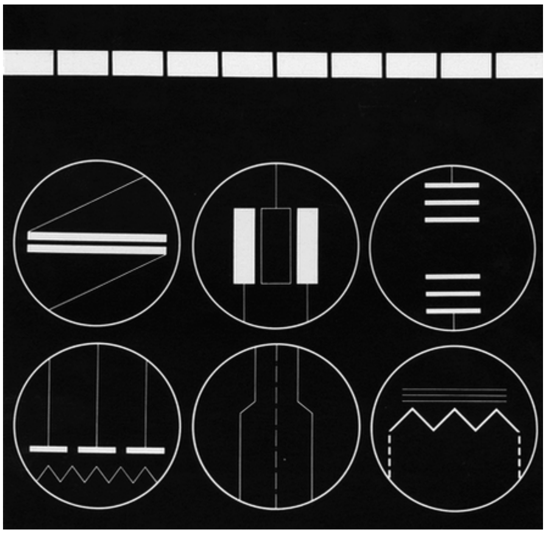


Figure 4.7: Manfred Mohr, *777MHz.*
Tempera on canvas, 130 x 130 cm. 1967
Source: (Mohr 1997-2011a, np)

to traditional painting.

With the computer, Mohr was able to generate images that were not the product of a unique process but instead were the result of a class of images. The generative use of computer algorithms allowed the artist to create series of images that were all instances from one *original* idea (or class). The unique and original work of art disappeared in the strict sense and was replaced by the algorithm. Mohr called his computer generated pictures: *êtres graphiques,* which were indeed algorithmically generated signs, in other words algorithmic signs (Figure 4.8)[11].

> Those algorithms determine the entire class of the pictures of one work phase. This artist creates works as classes. His series are not variation as finger exercise, but combination as mind effort. The individual picture is part of a compound unity, implicitly or explicitly. The compound unity is a mental string which exists in the algorithm in crystal clear form —a precise enjoyment, in Max Bense's words. (Nake 2001, np)

[11]Manfred Mohr wrote on his website about the algorithm used for creating this series: "The elements are horizontal, vertical, 45 degree lines, square waves, zigzags, and probabilities for line widths and lengths. The algorithm places elements in a horizontal direction and has a high probability to move from left to right and a limited probability to backtrack. Thus an abstract text is created." (Mohr 1997-2011a, np)

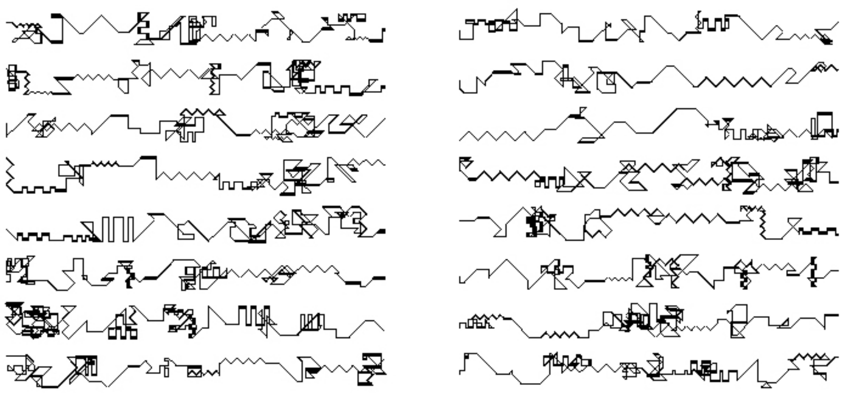


Figure 4.8: Manfred Mohr, *P-021/A + B, "band-structure"* (P-021/A, right; P-021/ B, left) Ink on paper, 50 x 50 cm. 1969 Source: (Mohr 1997-2011a, np)

Nake argues that Mohr's êtres graphiques are inconceivable but yet computable. He affirms that Mohr's work exists in a double way. "It is an individual perceivable, corporeal materialization in its own right. At the same time, it is an instance of an algorithmically (i.e. computable) defined class." (Nake 2001, np). We can see here the clear relation to the algorithmic sign, even more if we think of Mohr's study of the cube[12]. In his studies of the cube Mohr experiments with the two-dimensional image of a multidimensional space (Lähnemann 2007, 16), and in doing so he confronts the observer with what is inconceivable to our senses, placing in front of us a space that can only exist in our minds, see Figure 4.9.

> These spaces of higher dimensions are postulates, thought products, inventions, gedanken experiments for computations. This total precision of thought corresponds to total estrangement from sensual experience. Neither the eye, nor any other sense, can comprehend anything. Inconceivable for our senses, but computable for our mind: such are the conditions of higher dimensions, be they four, six, or even more. (Nake 2001, np)

Mohr's êtres graphiques are an example of Bense's artificial art and gen-

[12]Mohr's aesthetic research on the cube, which resulted in the hypercube series, started in 1973. Since then it has been the main topic of Mohr's œuvre, and due to the high level of complexity that it has reached, in 1999 it required Mohr to returned to the use of color.

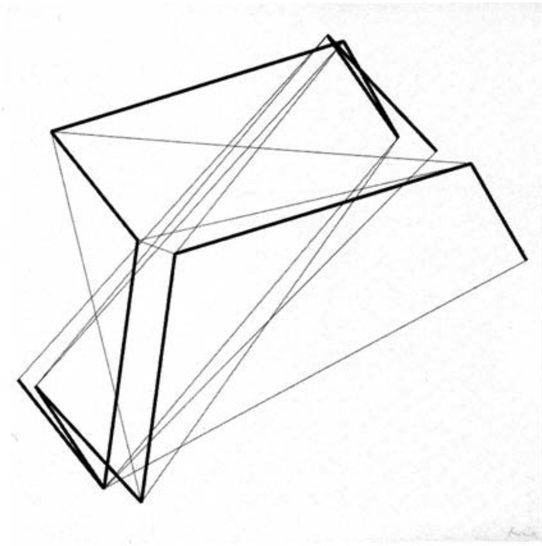


Figure 4.9: Manfred Mohr, *Half Planes series, P-503 a*
Plotter drawing, ink on paper, 80 x 80 cm. 1997
Source: (Herzogenrath *et al.* 2007, 76)

erative aesthetics, “since the signs are produced by the rational structure of the programs and by generative processes” (Keiner 1994, 140). However, Mohr describes his work not as cold mathematical art, but as the expression of a vital philosophy (Keiner 1994, 154). Mohr does not agree with the term computer art as a definition of his art (Nake 2001, np), but as much as he despises the term he has come to accept it as it has become prevalent. In an interview with Barbara Niedorff (Herzogenrath *et al.* 2007, 35), Mohr affirms that computer art is a misleading term, and that he prefers programmed aesthetics, generative art, or even algorithmic art instead[13]. However, he explained that when he has tried to use one of these terms instead of computer art, not many people really understood the terms. If we consider Mohr’s œuvre from the perspective of the algorithmic sign, this misunderstanding disappears and it becomes evident what Mohr is trying to point out, that the computer although necessary is not the protagonist.

> [W]hile looking at Manfred Mohr’s compositions, the viewer will not see programs, computers, random number generators, or algorithms. Manfred Mohr does not illustrate the

[13]For more about on this distinction between computer art and generative art see Section 1.2.2 and Chapter 5.

Figure 4.10: Manfred Mohr, *parallel Resonance series P-1414_874*
Pigment-ink on canvas, 80 x 80 cm. 2010
Source: (Mohr 1997-2011a, np)

> technology of computer graphics or even the functioning of random number generators. [...] the artist uses a very powerful instrument the computer able to perform an enormous number of operations and to generate huge amounts of visual representations. But all this is part of the aesthetic search, not the result. (Nadin 1994, 60-62)

The computer for Mohr is a means to an end, however it is more than an instrument as it is for Molnar. Mohr's êtres graphiques are not just computer-aided pictures. His œuvre could hardly come to existence without the computational power of the semiotic machine. Morh's "style —the unmistakable, innovative quality of his art— is an inevitable product of the medium computer." (von Mengden 2007, 32). His êtres graphiques bring us closer to the notion of the algorithmic sign, they aesthetically present us with the dual existence of this new type of sign that is both perceivable and computable (Figure 4.10).

That being said, it is not that Molnar's works do not confront us with the algorithmic sign, they do. However, Mohr's works, specially his hypercubes, express the computational aspect of the algorithmic sign in a different way. Nake explains that in the surface Mohr's works "show lines and areas and colors, and don't reveal anything at first sight unless a context is established. Only context enables us to make sense out of our sensory perceptions." (Nake 2001, np). Accordingly, it can be said that

Mohr's works extend their reach beyond the surface and, that placed in context, they highlight the subface of the algorithmic sign.

4.3 Characterizing Digital Art

The study of the work of Mohr and Molnar can help us identify some of the qualities that characterize computer art. Despite the differences between these two artists their work is both based on generative processes that resulted in series of drawings that were part of the same artwork. What Molnar and Mohr are interested in is *recursiveness*, the computational principle that would allow for precision and variation. As a consequence the idea of the *original* in their artworks was blurred, if not erased (Nierhoff 2006, 12, 22). The original became a section of a process, an instance of a class of images. The idea of reproducibility[14] in computer art becomes irrelevant, because the only original there is, is the idea. That is the algorithm which is intrinsically meant to be *executed* or *re-produced* more than once.

This challenge to the notion of the original in art was not new, it comes from the background of constructivist art and in particular of conceptual art. However, already in the beginning of the twentieth century artists like Marcel Duchamp or Lázló Moholy-Nagy[15] had questioned the idea of originality and had proved that the artist is more important as the creator of an idea than as the doer of a piece. What is different is that the use of the computer in arts introduced the algorithmic principle, which fully liberated the artist from executing the work. As Frieder Nake argues: "The art of the work of art, in the case of computer art, is the class of works the algorithm stands for. Looking for the masterpiece becomes looking for the master algorithm." (Nake 2009, 88). Algorithmics is the first principle that Nake affirms characterizes not just computer art, but also digital art. The other three are randomness, semiotics and interactivity (Nake 2009, 81). These principles are by extension characteristic of digital media but here we focus on what these four principles

[14] The subject of Walter Benjamin's seminal essay on the work of art in the age of mechanical reproduction.

[15] His famous telephone pictures are an early example of an artwork produced at a distance following a set of instructions by the artist.

mean to digital art.

Although Nake's four principles are not definitive (since digital art is still evolving) and they do not necessarily manifest all in one artwork, authors like Lev Manovich and Christiane Paul agree with them as a way to describe digital art and differentiate it from other art forms. These authors might not use the same terms to name these principle but in other words they refer to the same characteristics. Lev Manovich describes digital media (and by extension digital art) using the principles of numerical representation, modularity, automation, variability and transcoding (Manovich 2002, 27-58). Manovich's five principles of new media, are related to Nake's principles but somehow limited. The problem with these principles, which Manovich affirms that summarize the differences between old and new media, is that they focus on a computational perspective and in this respect they could be contained in the principles of algorithmics and randomness proposed by Nake.

Christiane Paul in her book Digital Art does not talk of principles, instead she emphasizes the difference between the use of digital technologies as a tool or as medium. She argues that digital art truly differentiates itself from traditional art when digital technologies are used as an artistic medium, nevertheless, she recognizes that digital art in general is already set apart by the importance it gives to the notion of randomness, its potential for manipulation and recontextualization, and the challenge it poses to the concepts of authenticity and originality (Paul 2008, 27-29). Paul then points up the distinction of digital art she finds crucial the use of the *digital* as a creative medium, and affirms that: "The digital medium's distinguishing features certainly constitute a distinct form of aesthetics: it is interactive, participatory, dynamic, and customizable." (Paul 2008, 67). However, Paul's features of the digital medium are described mostly from the perspective of the "user", they refer to how the digital medium can be used by artists and "spectators". In contrast, Nake's principles are more general and describe both the qualities of the digital medium and its use. For this reason, the characterization of digital art presented here is based on Nake's principles: algorithmics, randomness, semiotics and interactivity.

The principle of algorithmics is intrinsic to computation, in fact it is in the roots of it. There would be no computation without algorithmics. Nevertheless, algorithmics as a principle of digital aesthetics is not restricted to computers. An algorithm is basically a very precise explanation on how to do something (Reas *et al.* 2010, 13). According to this description recipes or driving directions could be considered algorithms. The difference is that with computation the algorithm has reached a greater potential, because the instructions described for the computer must have one and only one way of interpretation. In this way, what algorithms lose semantically they gain in recursiveness and this is how they can produce new results following the same instructions. The algorithmic principle extends from a simple step-by-step approaches to rule based systems, which allow the artists to work with generative processes that give more "autonomy" to the computer program (Boden & Edmonds 2009, 24).

This is why algorithmics have freed the artist from carrying out the work, because one description of a set of instructions can generate an entire class of works. "We are not so much occupied with a particular and unique work that we see in front of us as a material substrate as we are interested in the abstract description of all possible members of a class of objects." (Nake 2009, 82). The principle of algorithmics turns the digital work of art into the domain of notations, which is not new to performative art but is new indeed for visual arts. As in music "[t]he score freezes the music by taking away the sound, which effectively is the dimension of time" (Andersen & Nake Forthcoming), the algorithmic sign becomes both instruction for action and interface for interaction.

The second principle proposed by Nake is randomness, which is closely related to algorithmics. As we learned in the case of Mohr and Molnar, they did not turn to algorithmics to repeat more of the same. What they, and most of the early computer artists, wanted were variations, controlled changes based on probability principles. "When computers first attracted attention through their potential use for art, the consensus was that while programs can describe the algorithmic component of art, intuition could only be modeled by randomness." (Nadin 1994, 60). Artists in the early twentieth century had already tried to act randomly. However, in the hand of the artists hazard is always determined in the end. In Molnar's words, it is not possible for the artist to escape the ready-mades. The computer offered the chance for artists to free their hands and approach hazard mathematically. Although the computer can only produce pseudo[16] randomness, its number crunching power made it seem like if it was real randomness. As Nake affirms: “The principle of randomness says that the artist is free to introduce into the algorithmic description of a class of works any number of random decisions. Within a class of works, each individual work is identified by a set of parameters.” (Nake 2009, 82). These parameters are not fixed values, instead they can be probabilistically altered. For this reason the principle of randomness has complemented algorithmics and allowed artists, such as Mohr and Molnar to create inconceivable images.

Nake identifies the third principle, the principle of semiotics, as the most general because it refers to the idea that a work of art is a sign. A sign in the sense of Peircean semiotics: that is, an entity which does not merely exist in its materiality but as a relation of interpretation (Nake 2009, 82). Accordingly the work of art only appears as a semiotic process. This does not mean a denial of the materiality of the artwork, instead it is a recognition that the work of art exists beyond its form. As Nake argues: “such statements are, of course, true for all of art, but in the case of digital art, the sign turns out to be of a special kind” (Nake 2009, 83), of the algorithmic kind. In other words the semiotics principle proposed by Nake characterizes digital art as one that deals with algorithmic signs[17].

Finally, Nake introduces the principle of interactivity which refers to both the participatory and the transformational qualities of digital art (Nake 2009, 83). As in the case of Molnar and Mohr the digital work of art is experimental in nature, not only for the artists but also for the viewers. Early computer artists believed in art as a continuous aesthetic research, but the investigation did not stop once the work was finished. Even if the observers of Mohr hypercubes are not supposed to physically interact with the artwork, they are pressed to interact mentally (Figure 4.11). Viewers are confronted with inconceivable yet computable

[16]Pseudo because it is always determined by the limits of a program, it can never be truly infinite randomness.

[17]This realization has deeper implications for the art work in the digital age, which will be discussed in more detail in the next chapter.

images, and they need to engage in a mental process more than an emotional one in order to interpret these images.

Figure 4.11: Manfred Mohr *space.color.motion*
Exhibition, Mueller-Roth Gallery at Art Cologne 2003
Source: (Mohr 1997-2011a, np)

For Nake the principle of interactivity is perhaps the most important one in characterizing digital art. However, it is affected by the other three principles as we have seen that the four of them are related. Interactivity is at the core of the idea of the algorithmic sign as it is a sign in action and for action. Interactivity here is meant in a wider sense than just pressing or clicking buttons on the screen. As Nake affirms:

> Interaction between members of the audience and the code is what the transformation of the work into its class is calling for. In interactive use of algorithms we exploit the peculiar features of computer programs. As long as the feature of interactivity does not become central, the computer is used more as a tool, or as an automaton, than as a medium. (Nake 2009, 88)

The next chapter will be dedicated to an exploration of the principle of interactivity and its implications for digital art, and in particular for interactive art. As it has become a recurring topic in new media literature and computational design, the notion of interactivity has turned into a commonplace that means all and nothing. I agree with Nake's argument of the importance of this principle for digital art, but it needs to be reworked, rethought in order to revitalize it.

Chapter 5

Rethinking Interactivity

> [T]he creative act is not performed by the artist alone; the spectator brings the work in contact with the external world by deciphering and interpreting its inner qualification and thus adds his contribution to the creative act. (Duchamp 1957, np)

Marcel Duchamp's statement refers to art in general, but in the case of digital art and in particular interactive art they become more significant, if not mandatory. As discussed in Chapter 3, Mark B. Hansen affirms that digitization has transformed the correlation between media and body. Through this change perception has become a more *embodied* act, where the body ceases to be a passive mediator and becomes a sort of information processor. This is true for all digital art (and all digital media), however it becomes patent in an almost tangible way in interactive art.

Duchamp's and Hansen's sentences reach another level when applied to interactive art. This type of art has decisively broken the boundaries between spectator and artwork. A rupture that began with the works of the Dada artists, but that achieved new meaning with digitization and the use of computer algorithms. In interactive art the "spectator" literally plays an active role in the creative act, not just by perceiving and interpreting the artwork, but by giving it life. In this sense the interactive artwork emerges as it is experienced by the audience. This chapter will focus on how the notion of interactivity has found its place in art history and how it has become a defining aspect of digital art. I will argue that approaching the notion of interactivity from the perspective of the algorithmic sign can help us better understand how we can talk about interaction between humans and computers in an aesthetic way.

5.1 From Interaction to Interactivity

In the previous chapter the importance of the principle of interactivity in digital art was emphasized by introducing Frieder Nake's argument that the computer becomes an artistic medium only when the feature of interactivity becomes central (Nake 2009, 88). However, a detailed differentiation between the terms *interaction* and *interactivity* has not been addressed. Although the terms are closely related, and are often used interchangeably, it is necessary to contextualize their dennotations and interpretations in both art and science. The German music and HCI researcher, Uwe Seifert, explains that both terms refer to the concept of "action", which can be understood differently in social or in natural sciences. He affirms that:

> There are two fields of meanings concerning "agency", "agent", "action", "interaction" and "to act upon". One semantic field concerns the social sciences, and strongly relates to the idea of an intentional being, a human. The other concerns the natural sciences and refers to the idea of effect. (Seifert 2008, 9)

Seifert's explanation is still somewhat general, but it points us in the right direction. Art historian and media theorist, Katja Kwastek, goes deeper and sources the roots of interactivity to the early twentieth century. She affirms that as a concept *interaction* precedes *interactivity.* Interaction, according to Kwastek, started out as a general notion equated to reciprocity, that "conventionally denoted 'mutual or reciprocal action or influence"' (Kwastek 2008, 16). In the early 1900s, the idea of interaction was adopted by sociology to study social processes. Already at the time, interaction was a controversial term that was understood as a stimulus-response theory, as well as an interpersonal communicative process.

While the sociological approach to interaction remained, Kwastek notes that a different perspective to the term originated in the middle of the twentieth century. Cybernetics theorists took in the notion of interaction, but Kwastek affirms that they were "less interested in the interactions between human beings than in analogies between the self-organization of the human organism and cybernetics." (Kwastek 2008, 16). With cybernetics interaction entered in the domain of natural sciences. From there it was only one small step for it to become part of the computer science vocabulary, as "man-machine communication" was replaced by human-computer interaction (HCI).

The term interactivity came from the use of interaction in computer science. While interaction still keeps a social or ideological tone, interactivity emerged a as technically charged term. As German media art curator Inke Arns argues:

> Interaction encompasses both the theory of interrelated social action, as well as the primarily technological category of human-machine communication generally termed interactivity. From the 1960s to the 1990s, the social notion of interaction was replaced by a more technologically and media-based definition of interactivity (human-machine interaction). (Arns 2004, np)

These broad and different approaches to interaction, from which interactivity emerged, evidence the difficulty of delimiting the notion of interaction in relation to interactive. However, media art theorist Dieter Daniels argues that there are two main usages of interaction are: as reciprocal actions by humans, and as a technological category of human-machine communication —the later is also commonly referred to as interactivity. He affirms that in media society these two usages cannot avoid to overlap. For this reason he proposes an extension to the concept of interactivity so that it would "stand for all forms of media-based communication and interaction that occur between human and machine as well as between humans." (Daniels 2008, 30). Daniels' extension of *interactivity*, to encompass a social dimension, offers a more comprehensive view. This extension is necessary to understand how the notions of interaction and interactivity developed into interactive art. In particular, because interactive art has an important social and political component that cannot be acknowledged if the concept of interactivity is restricted to a technological perspective.

5.2 A Brief History on Interactive Art

The term “interactive” is no less controversial than interaction or interactivity, especially because it has become so widely used that it is on the verge of becoming meaningless (Paul 2008; Sommerer *et al.* 2008, 67; 2). When defining interactive art it is important to recognize the limitations of this term. The main obstacle in the adoption of this term in art is its usefulness as an adjective. Principally, because it is widely agreed that from a broad psychological perspective all artistic experiences are interactive (Boden & Edmonds 2009; Manovich 2002; Paul 2008, 35; 56; 67). For this reason it is commonly questioned if the term interactive can efficiently address the unique qualities of this new art form. Christiane Paul recognizes this psychological understanding of interaction in the Arts, but argues that interaction in traditional art remains a mental event in the spectator’s mind since it is evident that the “physicality” of the artwork does not change. She continues to explain that:

> With regard to digital art, however, interactivity allows different forms of navigation, assembling, or contributing to an artwork that go beyond this purely mental event. While the user’s or participant’s involvement with a work has been explored in performance art, happenings, and video art, we are now confronted with complex possibilities of remote and immediate intervention that are unique to the digital medium. (Paul 2008, 67)

As Paul explains through the use of digital technologies the “generic” interactive quality of every artwork is transformed into an embodied experience that is fundamentally different. However, before discussing the characteristics of interactive art it is necessary to understand how interactivity became part of art history.

5.2.1 The Roots

The history of interactive art is inevitably entangled with the history of digital art.[1] The roots of interactive art can then be found in the early twentieth century with the influence of artistic movements, such as Futurism, Surrealism, Dada and kinetic art, which broke aesthetic paradigms and subverted traditional art canons. These art movements followed the ideals of Modernism, specially, the conviction that the artwork was not finished by the artist but through the reception of the viewer. Marcel Duchamp is probably the best representative of this Modernist leitmotiv; his sculpture *Rotary Glass Plat*es *(Precision Optics [in motion])* is considered an early example of interactive art (see Figure 5.1). Authors as Peter Weibel and Dieter Daniels affirm that these art movements of the early 1900s laid the basis for the emergence of interactive art, in particular because they were the precursors of the idea of audience participation. In this sense, Daniels mantains that: "The attack on the ideal of everlasting, unchangeable beauty carried out under the colors of Modernism therefore had a centuries-old history before it was ultimately conferred with a new technological basis within the concept of interactive media art." (Daniels 2008, 27). However, it was not until the 1960s that the role of the spectator developed into a more active one.

In the 1960s two parallel developments occurred, which started to decisively give shape to interactive art. On one hand, the emergence of art forms, such as OpArt, performances, happenings, and closed-circuits installations, introduced the idea of *participation* as a dialogue between the artwork and the viewer, who became a fundamental part of the work (Manovich 2002; Dinkla 1996, 56-57; 281). On the other hand, technological developments, in particular in cybernetics and robotics, inspired artists as well as scientists to create "responsive" artworks[2] that would

[1] *The Algorithmic Revolution: On the History of Interactive Art* exhibition at the Zentrum für Kunst und Medientechnologie (ZKM) presented the historical connections between the developement of interactive art and the introduction of the algorithmic principle in art —both as intuitive directions, and as precise executable program.

[2] Notable examples are the cybernetic sculptures of Nicholas Schoeffer in the 1950s and James Seawright, Edward Ihnatowicz and Tony Martin in the 1960s. It is also crucial to mention the cybernetics and telematics artworks of Roy Ascott, and the conceptualization of "cyborg art" by Jack Burnham.

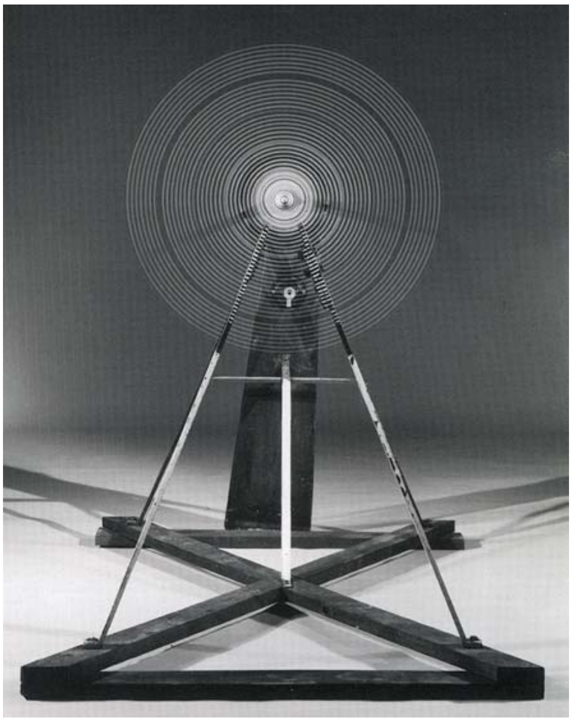


Figure 5.1: Marcel Duchamp, *Rotary Glass Plates (Precision Optics [in motion])* Duchamp's motorized sculpture from 1920 requires the viewer to turn on the machine and stand at a distance of one meter. Source: (Paul 2008, 11)

react to the viewers actions. Daniels emphasizes the influence of the "participational" art forms of the 1960s in the development of interactive art. He argues that these art forms, in which the participation of the audience was a defining aesthetic element, are better described by the term "intermedia".

> The origins of intermedia art as inspired by John Cage and molded by Fluxus and Happening lie in the decision to replace an autonomous, finished work with an invitation to the audience to essentially self-determine how they experience the artwork and in doing so, lift the boundaries between artists and audience and those separating the genres. (Daniels 2008, 33)

However, he also affirms that interactive art emerges in the "interference of social theory and mass-media technologies." (Daniels 2008, 34). In this sense participation in art represent the ideological background of interactive art, while the cybernetic or responsive art is related to the technologically driven or instrumental aspects of interactive art. In any case, it is important to note that the term interactive was not used to describe these art forms in the 1960s. Nevertheless, they laid the basis for what we came to know as interactive art.

5.2.2 Myron Krueger

The cybernetic art of the 1960s already started using computers to implement feedback systems between the artworks and the spectators, however very few of these systems were based on algorithmic processes (Kwastek 2008, 18). It took almost a decade until the developments in HCI were used in the arts. In 1969 an installation called “Glowflow” broke new ground in both art and HCI. Set up by a group of artists and scientists in the Union Main Gallery of the University of Wisconsin, Glowflow was described in its exhibition catalog as:

> Glowflow is not an exhibit in the traditional sense, but a continuous experimentation in interactive art. Its basic elements —lights, sounds and viewers— interact through control devices which are programmed by the artist-researcher to explore a variety of relationships. While many exhibits in the past have established predetermined relationships of viewer to environment, Glowflow is capable of going beyond fixed interactions. With a computer as a control device, it is possible to explore much more dynamic viewer environment relationships. (Exhibition flyer cited in: Kwastek 2008, 19)

Katja Kwastek affirms that it was in this text that the notion of interactive art was introduced first “and at the same time related to the implementation of the computer as control device.” (Kwastek 2008, 19). Amongst the co-creators of Glowflow was Myron Kruger, whose work became now known as the starting point for interactive art (Nake 2009, 89 footnote 15). Myron Krueger, a computer scientist by training, started in computer art by assisting artists interested in working with digital technologies. However, soon he realized that he had his own personal vision of what computer art “should be like”. Krueger decided to become an artist guided by the principle that “interaction was the s*ine qua non* of computer art.” (Krueger 1985, 146). He had the firm conviction that computer art would only be a new art form through interaction.

> The term ‘computer art’ implies a novel artform based on the computer. However, most works of computer art fit into

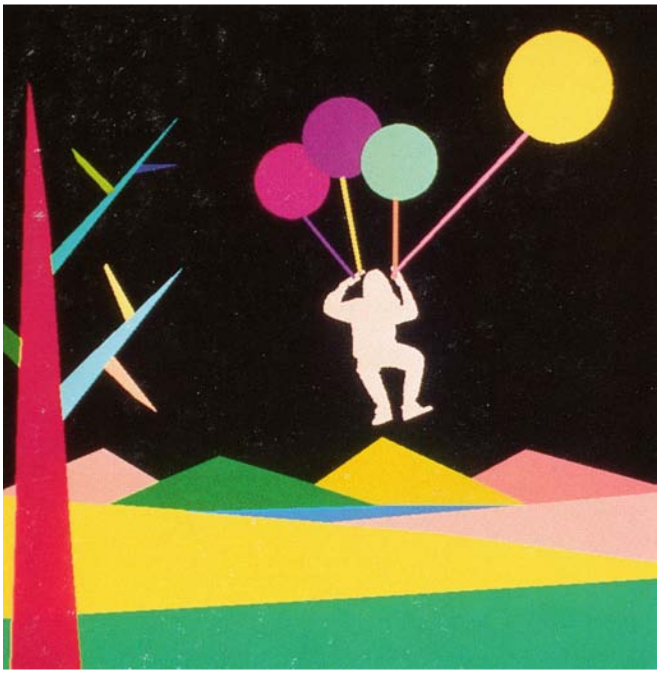


Figure 5.2: Myron Krueger, *Videoplace Parachute Scene*
Ungoverned by immutable physical laws, a participant's image can float freely about the screen. Source: (Krueger 1991, np)

> the existing tradition. They can be viewed hanging on walls, standing on pedestals or projected as film. They fail to exploit the computer's most unique feature: its ability to respond in real-time. It could be argued that computer art which ignores responsiveness is using the computer only for visual design automation, rather than as the basis for a new medium. (Krueger 1985, 145)

After Glowflow, Krueger continued working in what he later called "artificial reality". Already in 1970 he developed a "Responsive Environment, called Metaplay, which combined live video and computer graphic images and projected them in front of the viewer." (Krueger 1985, 147). Metaplay, was the predecessor of his famous Videoplace, which he first conceived in the mid-1970s but, was only functional a decade later, see Figure 5.2.

Krueger described Videoplace as the "marriage" of two cultural forces, television and the computer, "to produce an expressive medium for communicating playfulness and inviting active participation." (Krueger 1985, 147). For Krueger Videoplace is more than an artwork, it is as an experimental art form that would challenge our sense of reality by offering an augmented sensorial experience. Videoplace was an exceptional exploration of the interactive medium. However, it did not receive so much attention as the artworks of the communication arts[3] did (Kwastek 2008, 19). Perhaps it was too revolutionary for the time, or considered only as a playful display of the possibilities of new technologies, or even as just as "unfinished" work because even today it has not "still not achieved its ultimate aim of developing a program capable of learning independently." (MediaArtNet 2005, np). The fact is that Krueger's work has had a great influence in interactive art. This was recognized in 1990, when he became the first recipient of the main award of the Prix Ars Electronica in the then new category of interactive art.

5.2.3 Between Ideology and Technology

Although the origin of interactive art can be traced to 1969 with Glowflow, it was not until the end of the 1980s that the term interactive art "became the catchword of new media art" (Kwastek 2008, 19). During the 1970s and 1980s, the works on interactive art that were most notorious were focused on the ideas of telematics and telepresence and were mostly based on analog technologies (Arns 2004, np). However, by the end of the 1980s the personal computer had appeared in the market and by early-1990s the Internet was becoming available. These changes in technologies helped popularize and consolidate interactive art.

Interactive art entered the "mainstream" and with this came a shift in the tension between its ideological and its instrumental nature. Dieter Daniels affirms that this was a paradigmatic shift that was produced or at least supported by the forces of capitalism.

> By combining ideological strategies with technological means, the movements of the 1960s aimed to link the influence of art with that of the media. The social and cultural utopias supplied the objective of a hoped-for role of media in the future triggering a macro-change in society. This relation was turned on its head in the 1990s: media technology is now often seen as the leitmotif from which all social, cultural, and economic changes emanate. Today, for instance, the meaning

[3] Some of the artists working in communication arts projects during 1970s and 1980s were: Robert Adrian X, Kit Galloway and Sherrie Rabinowitz, and Douglas Davis.

> of 'interactivity' is essentially defined through the electronic media. (Daniels 2008, 34)

Söke Dinkla explains this shift as the transformation of the motto "art and life" into "art and technology", which she argues has "reached a peak today with the terms 'life' and 'technology' becoming increasingly congruent." (Dinkla 1996, 289). It could be said that technically the "dream" of interactivity is fulfilled, but ideologically the "utopia" of interactivity is dead. Perhaps we should ask if "there should be no (more) interactive art?" as Frieder Nake did about computer art in 1971 (Nake 1971). Katja Kwastek quotes German scholar Wolfgang Kemp, to highlight an additional criticism of interactive art, which refers to another aspect of the illusion of freedom of choice inherent to interactivity.

> The suspicion already expressed in 1984 that 'interactivity aims more to optimize the human-machine relationship than to place technology in the service of communication between people' has not yet been dispelled.[. . .] In other words, the first bond of this art that seeks to liberate the viewer is the bond to the program. I think that even expert systems, which [...] explicitly seek to promote dialogue and communication cannot simply delete the fact with one key that freedom of choice can only be simulated, not programmed. What is programmed is the illusion of alternatives. (Kemp 1996, 19; cited in: Kwastek 2008, 15)

The challenge for interactive art is to scape the logic of consumerism and offer more meaningful forms of interaction. Interactive art must bring some balance between ideology and technology, so that it can retain its aesthetic value.

5.3 Interactive Art: a Work in Progress

Despite the criticism and the challenges of interactive art artists and theoreticians have kept the discussion open, and have not stopped producing artworks. Frieder Nake, for instance affirms that interactive art highlights the importance of interactivity as a feature of digital media. As he affirms that: "Even though remarkable results were achieved in the early days, interactivity was still lurking behind the scenes and had not yet gained an important status. It took the separate movement of interactive art to show that." (Nake 2009, 89) Ernest Edmonds is one of those who still invests in interactive art. Together with Margaret Boden, he defines interactive art as the kind of art in which "the form/content of the artwork is significantly affected by the behaviour of the audience." (Boden & Edmonds 2009, 35). Boden and Edmonds make an important addition to this definition, by differentiating between interactive art as a general category that extends beyond digital and electronic art[4], and computer-interactive art. CI-art, as they shorten it, refers to the computer-based varieties of interactive art.

Boden and Edmonds further describe computer-interactive art as being generative by definition. However, not in the restrictive sense that they refer to generative art, and specially to computer-generated art. They describe these two categories as being based on processes that require minimal or zero human intervention. In this sense they affirm that computer-interactive art cannot be completely generative, "[f]or although the artist can go to lunch and leave the program to do its own thing, the audience cannot." (Boden & Edmonds 2009, 35). Despite differentiating between computer-interactive art and interactive art in general, these two authors argue that interactive art has become "overwhelmingly computer-based" (Boden & Edmonds 2009, 35). For this reason when we talk about interactive art, our main focus is on computer-interactive art. The predominance of computer-interactive art becomes evident in Söke Dinkla's definition of interactive art.

> The artistic material of interactive art is the automatized dialogue between program and user. Interactive artworks provide a critical analysis of the automatized communication that is replacing interhuman relationships in more and more social fields. Thus the distribution of power between user and system is not just a technological issue but a social and political one as well. (Dinkla 1996, 289-290)

Dinkla's definition, although insightful, does sound a bit outdated in particular in the light of the criticism discussed in the previous section of this chapter. It is interesting to note how she emphasizes the idea that

[4] Boden and Edmonds note that early interactive artworks did not even use electronic technologies, such is the case of Ascott's first interactive works.

interactive art addresses both technological and social issues. However, it is the notion that interactive art involves a *dialogue,* what is more relevant in this definition. Particularly, because one of the more significant characteristics of interactive art is its openness.

Although interactivity can be expressed as a very closed programmed "illusion" of the freedom of choice, interactive art embraces what Peter Lunefled would call the "aesthetics of the unfinished", or in Umberto Eco's terms the *opera aperta.* This quality of interactive art as being always a work in progress represents one of the most important challenges of digital art: the impossibility of *authentically* reproducing the artwork. Boden and Edmonds recognize this challenge but see in it an opportunity for reconceiving various aesthetic notions.

> With regard to CI-art, then, perhaps we should speak not of the 'artwork' but of the 'art system'—where this comprises the artist, the program, the technological installation (and its observable results), and the behaviour of the human audience? [...] Or maybe we should think of each occurrence of CI-art as a performance and the program/installation as the score? If so, the 'performance' is more like a jazz improvisation than the playing of classical music, for it can vary considerably from one occasion to another. (Boden & Edmonds 2009, 40-41)

In this sense the notion of algorithmic sign can serve as a basis for understating how meaning can be produced dynamically, in the same way as Boden and Edmonds suggest to consider interactive art as more similar to a musical score. As described in Chapter 2, the notion of the algorithmic sign is closely related to Peter Bøgh Anderesen's concept of computer-based signs. When Andersen introduced this concept in 1990, he already distinguished the action and handling features as the highest level of complexity of this new type of signs. He understood then, that what made computer-based signs different from other signs was that —even though they were based in a static description— they could become active. This distinction accounts for the dynamism of the digital medium in being both manipulable and interactive.

It is this semiotic perspective what allows us to conceptualize interactivity as a dialogue that extends beyond its technological dimension. As Nake warns us *interaction* between humans and machines is not so in the true sense of interaction, but an illusion that becomes real because we understand it in such way.

> The miracle of human-computer interaction is that it is impossible as interaction in a true sense of the word. It is happening nevertheless. This is possible because human acts of interpretation correspond in a rich (but computable) way to machine operations of determination. The miracle is that humans were bold and intelligent enough to establish this. The miracle is not that machines were so intelligent to do it. (Nake 2008, 107)

The algorithmic sign, as a way to explain in detail the process of meaning production between human and machine, is a key notion to approach this *miracle* of interaction. In particular, for understating how an interactive artwork is always in the process of "becoming"[5]. As Boden and Edmonds suggest, the interactive artwork is not one "artwork" but an art system which, as the algorithmic sign, emerges in the process of interaction.

It can be argued that interactive art, as a general category, is essentially algorithmic since it can be described as a set of instructions to act (Weibel 2007, 24). However in computer-interactive art the algorithmic sign emerges, and the set of instructions becomes executable in itself. In this sense, the algorithmic sign becomes a relatively autonomous notation —autonomous as a machine can be (Andersen & Nake Forthcoming). This characteristic of being both instruction and interface for action is what distinguishes computer-interactive art from other art forms.

Boden and Edmonds emphasize how this level of autonomy of computer-interactive art challenges traditional art notions, such us authorship and authenticity. However, the two are more concerned with the problem of aesthetic evaluation in interactive art. They recognize that computer-interactive art, is not judged by the traditional artistic criteria that are even still applied to some interactive installations. Boden and Edmonds affirm that there is a general agreement that the criteria to evaluate computer-interactive art should be focused "not the nature of the resulting 'artwork' (the beauty of the image projected on the wall,

[5]From the perspective of art history it is important to consider this characteristic of interactive art as it presents a challenge to the preservation and documentation of interactive artworks.

for example, or the harmoniousness of the accompanying sounds), but the nature of the interaction itself." (Boden & Edmonds 2009, 41). Nevertheless, they warn us that there is "significant disagreement" on the kind of interaction that is most "aesthetically" valuable. Questions as: How to measure or assess the experience of the participant? or, To what extent should the participant be aware of how he or she influences the artwork? remain unanswered. These questions, as well as the tension between technology and ideology, should be an imperative discussion for artists and theoreticians, specially if "there should be *more* interactive art".

Chapter 6

An Attempt to Grasp the Subface

6.1 Motivation

> An art work is only a starting point, a principle of order, an artist's guidelines, intended to provoke the viewer to continue the investigation. (Mohr 1997-2011b, np)

With digitization the notions of image, perception, and media have become unstable and are now under question. Authors as Friedrich Kittler affirm that digitization erases all differences between individual media, making the very notions of medium and image disappear, and the perceptual-aesthetic dimension of media become mere eyewash (Hansen 2004, 71). Other authors still invest in these notions, but agree that a reconceptualization is needed to explain the changes brought by digitization. Such is the case of Mark B. Hansen, who proposes a new media theory based on a new phenomenology, which emphasizes the role of the body as an active framer of the digital information.

It is from Hansen's perspective that I have approached the notion of the algorithmic sign[1], which is a new type of sign, that emerges from our interactions with and through computing systems. It is the result of a doubled process of semiosis, and as such it has two modes of existence: a visible surface, and a computable *subface*. This dual ontology of the algorithmic sign is what characterizes the digital medium. In order to perceive and interpret these new type of signs our bodies have become, as Hansen affirms, "selective processors of information"[2]. This is how we can see a collection of discrete points on a screen as the whole image they represent. Additionally, this more prominent framing function of the body allows us to engage in the illusion of interactivity.

The exploration of these new media theories have motivated me to create an experimental interactive installation that addresses the idea that the digital medium is ultimately characterized by its dual existence, by its subface and surface. As the computable expression of the algorithmic sign, the subface is invisible to us. Not only because of its *immateriality,* but also because it is hidden by the immediacy of the fast processing power of digital technology. The ubiquitous graphical user interface (GUI)'s mode of interaction makes it further difficult to be aware of the relation between surface and subface in the digital. In this way the "myth of transparency"[3], as perpetuated by HCI design, converts us in users and encourages us to ignore what is beyond the surface.

The point is not to dismiss the usefulness of software and GUIs. They have a practical use, and they have become necessary part of our lives. However, it is because of the relevance of digital technologies in our society, that it is crucial that we confront the subface. We must become more aware of the processes in which meaning is produced by digital technologies. This is fundamental for digital artists and designers. In this sense, Casey Reas and Ben Fry, creators of the programming environment Processing, affirm that: "Understanding software and its

[1]Section 2.4 discusses the notion of the algorithmic sign as proposed by Frieder Nake in collaboration with Peter Bøgh Andersen and Susanne Grabowski.

[2]See Chapter 3 for a detail discussion, based on the arguments developed by Mark B. Hansen, on how digitization have changed our ways of perception.

[3]The myth of transparency refers here to the design ideal that media interfaces (and media itself) should be as *natural* and close to real experiences as possible, ultimately aiming to become transparent (Bolter & Gromala 2003, 48-50).

impact on culture is a basis for understanding and contributing to contemporary society." (Reas & Fry 2006, 526). If artists and designers limit themselves to *use* digital technologies as tools, specially without a critical approach, they are at risk of creating works that are just a naive exaltation of the advances in digital technologies.

Dieter Daniels addresses this issue when discussing interactive art in the 1990s, and how some of the interactive artworks produced in this decade are entirely dependent on technological specifications (Daniels 2008, 35). He agrees with Friedrich Kittler's argument that it is our ignorance what "makes us confuse the products of media with art". According to Kittler it is only possible to:

> [C]ontinue mistaking for art the output of media because the design and nuts and bolts of technical devices ensure they remain black boxes. [...] as the warning signs make very clear, for qualified specialists. What goes on beneath the covers, in the actual circuitry, is not art but the end of the same in data processing that takes its leave of humanity. (Kittler 1989, 57; cited in: Daniels 2008, 35)

Being able to "open the black boxes" and being knowledgeable in data processing and programming does not make one an artist. Programming is a form of expression, as much as writing or drawing can be, and this knowledge is fundamental in digital art, as learning the use of color or perspective is in painting. Linda Candy and Ernest Edmonds also affirm that artists must be able to "access digital environments that are adaptable to their evolving needs", but recognize that in many cases this can be a very difficult task for artists. They suggest that: "the creation of more software tools that allow the artist access to deeper levels of the computer's programming system, rather than software applications that have been developed for specific tasks such as image manipulation" can be a solution to this problematic (Candy & Edmonds 2002b, np). Such software tools have started to emerge, such is the case of programming environments such as vvvv[4], Processing[5], Arduino[6], or OpenFrameworks[7].

[4]http://vvvv.org/
[5]http://processing.org/
[6]www.arduino.cc/
[7]http://www.openframeworks.cc/

These systems are developed with artists and designers in mind, specifically for facilitating the creation of images, animations, and interactions. Additionally, they have a strong didactic orientation[8]. Reas et al. maintain that learning to program and working more directly with computer code: “opens the possibility of not only creating tools, but also systems, environments, and entirely new modes of expression. It is here that the computer ceases to be a tool and instead becomes a medium.” (Reas *et al.* 2010, 25). This was my initial motivation to start experimenting with an interactive installation, to have the opportunity to learn more about programming and get more in touch with the expressive and aesthetic qualities of the computer as a medium.

6.1.1 Inspiration

For developing the concept of the experimental interactive installation I found inspiration in the work of Myron Krueger. His legendary Videoplace encouraged me to explore the use of computer vision in interactive art. Videoplace was a pioneer work for the use of computer vision technologies in art, as well as for being one of the first interactive artworks. Krueger’s early understanding of interactivity as an artistic medium was ahead of his time, but today it is taken for granted. One of the objectives of the experimental interactive installation I aim to develop, is to challenge some of our assumptions and expectations of interacting with computer systems. I will revisit one basic interaction mode used in Videoplace: a participant drawing on a projected screen by moving his or her finger through the air (see Figure 6.1). My approach to this mode of interaction is to question the direct relation between our actions and the systems reactions, as well as forcing a break in the computer ability to respond in real-time.

Another influence on my experimentation is the topic of control and surveillance through video technologies. Video surveillance systems have been around for decades, however, computer vision technologies are only recently becoming more accessible and accurate. The increasing use of computer vision and image recognition technologies by public and

[8] As a novice programmer, this is was a decisive factor for choosing Processing for developing the experimental interactive installation described here.

Figure 6.1: Myron Krueger, *Videoplace Digital Drawing Interaction*
In Digital Drawing, the Videoplace participant uses her finger to draw; opening her hand erases the drawing. Source: (Krueger 1991, np)

private institutions, challenges our personal assumptions (and rights) of privacy and autonomy. Interactive installations, such us Cheese (2003) by Christian Möller, and the Suicide Box (1996) by the Bureau of Inverse Technology (Natalie Jeremijenko and Kate Rich), use motion tracking and image recognition techniques to addressed the issue of surveillance and control by means of technology. These two projects are notable examples of computer vision and live image recognition[9]. Although, their use of computer vision is not interactive they confront us with the fact that computer systems are silently observing us and even controlling our actions, for instance as traffic cameras do.

The BIT Suicide Box was: "a motion detection video system designed to capture vertical activity." It consisted of a concealed video system positioned in the range of the San Francisco's Golden Gate Bridge. "In standard operation any vertical motion in frame will trigger the camera to record to disk." (BIT nd, np). The objective was to supply "frame-accurate data of a social phenomenon not previously accurately quantified. Box placement was determined to exploit cultural climate and BIT

[9]Cheese, in particular, used a very sophisticated emotion recognition system (Levin 2006, 468).

agent proximity; San Francisco is gateway to the Silicon Valley and both Information capital and Suicide capital of the USA." (BIT nd, np). According to Golan Levin, with Suicide Box the artists wanted to address the "hidden politics of technology" (Levin 2006, 467).

Christian Möller's Cheese installation was developed in collaboration with the Machine Perception Laboratories of the University of California, San Diego. In this project six actresses "try to hold a smile for as long as they could, up to one and half hours. Each ongoing smile is scrutinized by a emotion recognition system and whenever the display of happiness fell below a certain threshold, an alarm alerted them to show more sincerity." (Möller nd, np). The installation displayed in six flat panel monitors, the video recordings of the actresses with the respective fluctuating graphic level-meter indicating the strength of each actress' smile (see Figure 6.2). This piece focused on the difficulty of performing forced sincerity. Moreover, the videos show how "friendliness" can be measured and enforced by a machine.

Figure 6.2: Christian Möller, *Cheese*
Source: (Möller nd, np)

Different from the projects discussed here, the quality of my project will be essentially experimental. However, the aim is to address one question that is forever tied with technology: Do we *use* technology or does technology *uses* us? The issue is not if we should embrace tech-

Figure 6.3: Norman White, *The Helpless Robot*
Plywood, steel, sensors, computers, software, electronics, 193 x 180 x 104 cm.
1987–2002. Source: (DAM 1999-2009, np)

nology or reject it. The goal is to effect a pause in the expected speed of computer systems, in order to adopt a critical perspective towards technology. In this aspect of the user/tool, or master/slave, relation we have with technology, I am also influenced by the work of Norman White. Specifically, I am interested in his "Helpless Robot" (see Figure 6.3), which he describes as "an interactive work that unlike most robots is essentially passive. It rotates on a large industrial 'lazy susan', and it can do so only by enlisting the help of human beings, using its electronic voice." (YZO n.d., nd, np). With this project, White is most interested in developing an "artificial personality". That is not my intention. However, I find that the idea of *helpless* machines is crucial for the final goal of my project, which is to challenge the HCI idea that we are the *users* of computer systems, and that computers are intelligent machines.

6.2 Implementation

6.2.1 Concept

"Drawing at a Distance" is the working title of the experimental interactive installation described here. It illustrates the idea that the digital medium is ultimately characterized by its dual existence, by its subface and surface. The algorithmic sign is the semiotic expression of our interaction with both the surface and subface. However, we tend to ignore the dual existence of digital objects. We perceive the visible surface, but do not acknowledge the computable subface. But how could we? Digital media are designed to be transparent and natural; we, the *users*, are not supposed to be bothered by the *unfriendly* computational processes going on behind the surface. Why should we? We want machines to be smart, and we even believe they have become so. They recognize our voice and movements. They record our past, direct our present, and predict our future. Or so we think. We forget this is an illusion and believe that we are in charge, when most of the time we must adapt ourselves to the machines.

The objective of this installation is to question the assumptions we have when interacting with computer systems, and to challenge the HCI idea that we are the *users* of computer systems, and that computers are intelligent machines. This project is a performance of the slave/master role that we play when interacting with digital media. By asking the participants to be *used* by the machine as part of the process of using the machine, they are confronted by the double interpretation process that occurs when humans and machines interact: determined interpretation and intentional interpretation.

6.2.2 Description

The participant enters the installation space and hears a series of recorded instructions, which gives him or her directions to draw a geometric figure in the air (see Figure 6.4). These instructions are of the kind: "Come in. Stand in front of the camera, facing the white screen. Raise your right arm. Point your index finger at the camera. Very slowly move it down from right to left in a 45 degree angle. Stop right in front your face. Then

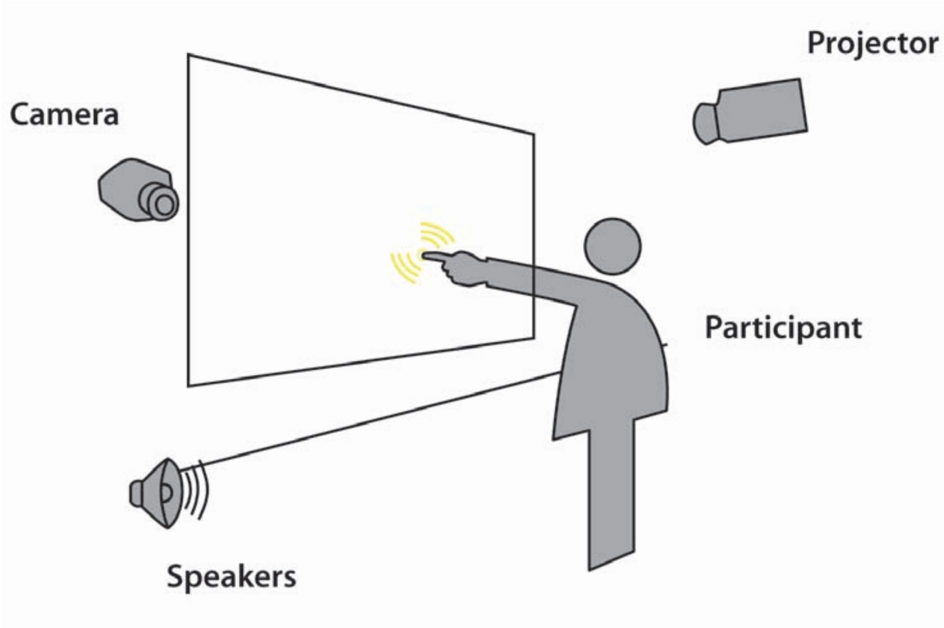


Figure 6.4: Envisioned Interactive Setup
The sketch shows the participant drawing in the air
while following the instructions given by the system.

move your finger from side to side in zigzag four times. Stop. Point at the red dot on the screen. Lower your arm. Observe." After the set of instructions are finished a projection will show a computer drawing that is produced from the interpretation of the human movements. The only way to complete the task and observe the drawing is to follow closely the directions given by the machine.

The set up of the installation consists of a video camera, a computer, a projector, a speaker set, and screen. The video camera is used a sensor to track the participant's movements. The video signal is processed by a Processing application based on Golan. Levin's algorithm for simple object tracking (Levin 2006, 480), explained in the next section. The recorded coordinates of the participant's movements are then reproduced as a drawing projected on the screen (see Figure 6.5).

6.2.3 Computer Vision

To develop my experimental interactive project I have chosen to use computer vision techniques in order to capture and *interpret* the participants movements. "Computer vision is the science and technology of making machines that see." (Cipolla *et al.* 2010, vii). Concretely, it refers to the

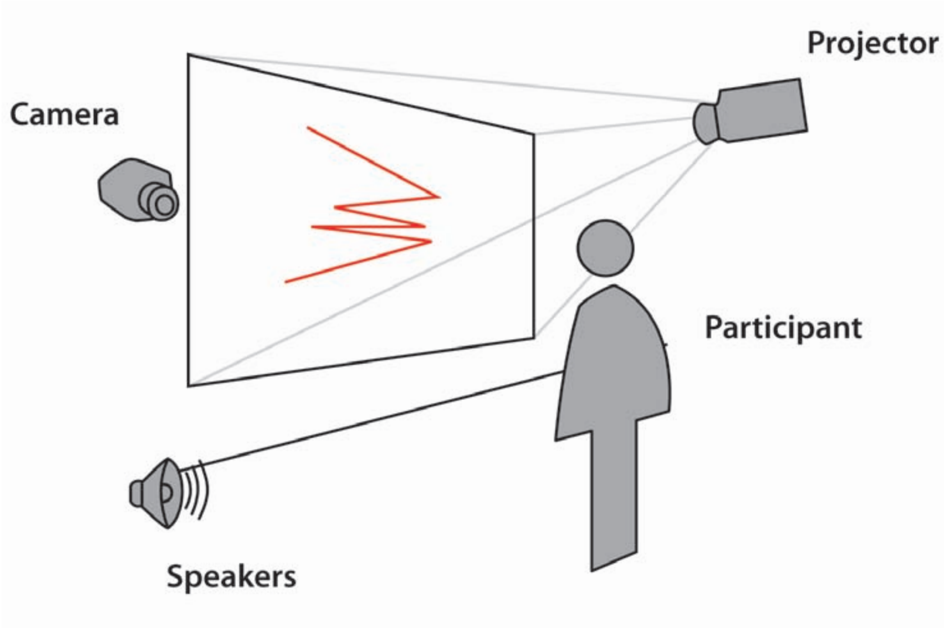


Figure 6.5: Envisioned Final Stage
The sketch shows the final stage of the interaction, when the participant observes the results of his or her drawing as interpreted by the system.

theory, design and implementation of algorithms the allow computer system to process digital images and video in order to make automatic and *intelligent* assertions, such as object or person recognition, and movement tracking (Cipolla *et al.* 2010; Levin 2006, vii, 462). Computer vision used to be a very exclusive domain reserved for expert researchers and engineers. The place of computer vision was restricted to research labs, and a few art exhibitions, however, in recent years this situation has changed. Technological developments have made computer vision more available, even for mass consumption. Computer vision systems have become another home appliance, used in surveillance systems and video games alike. These developments, combined with the rapid growth of open-source software applications and code-sharing communities[10], have made possible broad artistic experimentation.

Despite the great advances in technology, computer vision is never truly *vision*, a machine cannot see in the same way the human

[10]This is the case of Processing, Arduino, or openFrameworks, which are open-source, and are developed and supported by a strong community of programmers, designers, and artists.

eye and brain can. As Golan Levin explains:

> [N]o computer vision algorithm is completely "general", which is to say, able to perform its intended function given any possible video input. Instead, each software tracking or detection algorithm is critically dependent on certain unique assumptions about the real-world video scene it is expected to analyze. If any of these expectations is not met, then the algorithm can produce poor or ambiguous results, or even fail altogether. (Levin 2006, 471)

For this is reason, choosing the appropriate computer vision technique is as essential as designing the physical conditions in which computer vision will be performed. The most elementary, and accessible low-level computer vision techniques, use algorithms that allow pixel differentiation in three basic ways:

> "*frame differencing*, which attempts to locate features by detecting their movements; *background subtraction*, which locates visitor pixels according to their difference from a known background scene; and *brightness thresholding*, which uses hoped-for differences in luminosity between foreground people and their background environment." (Levin 2006, 469).

For my experimental interactive project I chose to use an elementary object tracking technique, which uses brightness thresholding to find the location of the single brightest pixel in every fresh frame. Concretely I will base my program in Golan Levin's "Brightness Tracking" Processing sketch explained in (Levin 2006, 470) and included in the Processing built-in examples.

Golan Levin's "Brightness Tracking" sketch is based on a simple object tracking algorithm, which tracks the location of a single illuminated point by extracting its coordinates from the pixel array of every fresh video frame. This algorithm works by comparing the brightness value of each pixel in the incoming video to the brightest value yet encountered in that frame; if the analyzed pixel is brighter then its location is stored (Levin 2006, 470). The result of this process can be expressed as a two-dimensional array, which contains the x and y coordinates of the tracked location of the brightest pixel. Levin's algorithm can be easily adapted for color tracking, as Daniel Shiffman explains in his book Learning Processing (Shiffman 2008, 291). In both cases, tracking brightness or an specific color, requires that there is only one object of interest. This means that the setup of the installation should be carefully conditioned in such manner that there is only one “brightest” point to be tracked.

6.2.4 Processing

The computer vision techniques discussed above are fairly easy to implement using open-source programming environments that allow direct read-access to the video data obtained by the computer’s frame-grabber. Processing is one of such programming environments, which is specifically designed to support the work of visual artists and media designers. Processing was created “to teach fundamentals of computer programming within a visual context, to serve as a software sketchbook, and to be used as a production tool for specific contexts.” (Reas & Fry 2006, 527). As an educational tool it allows artists and designers to learn programming concepts, while it introduces aesthetic concepts to programmers and computer scientists. Moreover, its sketchbook structure makes it easy to run and test projects, which simplifies the processes of reviewing and refining.

Processing does not introduce an entirely new programming language, instead it is based in common and established syntax. “The core language and additional libraries make use of Java, which also has elements identical to the C programming language.” (Reas & Fry 2006, 538). This gives Processing a strong and familiar background, and allows people to use and extend previous programming knowledge, and start working right away without much difficulty. Processing “traditional” syntax is also and advantage for novice or non-programmers, because it serve as a starting point for learning and getting familiar with software concepts that could later be used in more advance or specialized programming environments.

Processing sketches can be easily exported as Web applications, and as part of the Processing “philosophy” people are highly encouraged to publish and share their works. This has resulted in a strong collaborative network, where newcomers can find help in solving problems and advance programmers can contribute to debugging and extending the programming environment. In this manner, Processing is continuously developed and supported by an active community. Reas and Fry, defend the openness of Processing, and maintain that being open-source is what has allowed its success.

> Opening the Processing source code allows people to learn from its construction and to learn through extending it with their own code. People are encouraged to publish the code for their programs written in Processing. The same way the "view source" function in web browsers encouraged the rapid expansion of the Web, access to other peoples' Processing code enables members of the community to learn from each other and the skills of community raise as a whole. (Reas & Fry 2006, 531)

One of the ways in which Processing is extended is by the implementation of specialized libraries. Up to now there are already a broad variety of libraries that target specific features, such us video, typography, animation, or sound, to name a few. For computer vision, there are more than a dozen libraries listed in the Processing website in addition to the one that comes with the Processing environment. In the development of my interactive project I have experimented with libraries: the Processing video library, JMyron[11] and OpenCV[12]. JMyron is Joshua Nimoy's project (named in honor of Myron Krueger), which started as a plug-in for macromedia director called WebCamXtra. It is freeware and open source, and compared to others it "provides more detailed data about the tracked objects in the scene, such as their bounding quads and contour pixels" (Levin 2006, 474). OpenCV is also freeware and open source under the a Berkeley Software Distribution (BSD) license. It was originally developed by Intel and is now supported by Willow Garage, which is a robotic research lab. OpenCV is widely used with C++, openFrameworks, Java and Processing. This library offers great functionally for gesture and movement recognition in an image, and allows to use this data as input for an application (Noble 2009, 517). However, the OpenCV library for Processing is not as well developed as the one of OpenFrameworks. This causes unexpected difficulties, specially in the video capture. For this reason I have chosen to work with JMyron and

[11]http://webcamxtra.sourceforge.net/index.shtml
[12]http://opencv.willowgarage.com/wiki/ and http://ubaa.net/shared/processing/opencv/

the Processing video library in the final version of my interactive project.

Conclusions

Throughout this thesis I have developed and examined the hypothesis that the notion of the algorithmic sign offers crucial insight into the characterization of digital art. First, I presented an exploration of the theoretical background that supports this research. Accordingly, the algorithmic sign was described as the semiotic entity that results from our interaction with computer systems, and as such, the product of a coupled semiosis of human and machine. The idea of a coupled semiosis, or co-semiosis, was introduced to explain how the algorithmic sign has two modes of interpretation —human or true interpretation, and machine or determined interpretation. This double existence of the algorithmic sign is represented, as Frieder Nake maintains, in a visible *surface* and a computable *subface*.

The distinction between surface and subface, served as the starting point for discussing how the "algorithmic revolution" has challenged traditional aesthetic notions, such as medium, image and perception. Mark B. Hansen's new media theory was used to explain how these notions can be reconceptualized in the digital age. According to Hansen, what characterizes the digital medium is a shift in the correlation between media and body. A change by which perception has become a more *embodied* act, where the body ceases to be a passive mediator and becomes a sort of information processor. Hansen argues that the flexibility brought by digitization does not mean the complete obsolescence of the notion of medium, instead he insists that what disappears is the epoch of media differentiation. It is from this approach that we can affirm that digital technologies have become a medium for artistic creation. Moreover, I have shown how Hansen's new media theory can support an understanding of digital art that includes a technological and an aesthetic perspective.

Following this argumentation, I presented a historic analysis of how algorithmic thinking was introduced to art by the used digital technologies as a tool and a medium for aesthetic research. Specifically, I chose to examine the œuvres of Manfred Mohr and Vera Molnar since they are two of the first trained artists who turned to the computer for artistic creation. They also have continued to employ the computer in their artistic practice until the date, and both have worked directly with algorithmic procedures by writing their own computer programs. This historic analysis showed how the notion of the algorithmic sign is present in Mohr's and Molnar's artworks, albeit with differences in each case. I argued that Mohr's works express the computational aspects of the algorithmic sign in a more profound manner. Mohr's works extend their reach beyond the surface and, placed in context, they highlight the subface of the algorithmic sign. In contrast, Molnar's use of the computer as a tool rather than a medium produces artworks than can be defined as computer-aided drawings, which means that *in principle* her works could be produced without using computers.

The study of Mohr's and Molnar's works revealed that already in the early computer drawings one can appreciate some of the qualities of digital art; such as the use of algorithmic procedures, and the aesthetic value of randomness. In this sense, this study offered an introduction to the characterization of digital art proposed by Frieder Nake, which identifies algorithmics, randomness, semiotics and interactivity as the four principles that distinguish digital art. I suggested adopting Nake's characterization of digital art because it is general enough to cover all forms of digital art, and because it describes both the qualities of the digital medium and how it is used for artistic creation.

Nonetheless, Nake's principles of digital art were complemented and contrasted to the analysis of digital art presented by Christiane Paul, Lev Manovich, and Margit Boden and Ernest Edmonds. In this regard, I argued that Lev Manovich's principles of digital media are limited to a computational perspective and that could be contained in the principles of algorithmics and randomness proposed by Nake. Nake's characterization of digital art was extended with Christiane Paul's argument that what truly differentiates digital art from traditional art forms is the use digital technologies as an artistic medium, as opposed to only being used as tools. This distinction suggested by Paul, emphasizes the importance that Nake gives to the principle of interactivity, as he affirms that we can only exploit the peculiar features of the digital medium through the interactive use of algorithms.

This does not mean that Nake or Paul do not recognize as digital art the works produced using digital technologies as tools. What they claim is that these works are not representative of the full potential of digital media. Boden and Edmonds, agree with this distinction and argue that when computer systems are used as tools they are (in principle) not essential for the work. They introduce the category of computer aided art to include the digital artworks in which computers are used in the same way as a paintbrush or a chisel are used. Boden and Edmonds, however, give more importance to the generative quality of digital art than its interactive quality. For this reason they focus on the term "generative art" instead of "digital art". They explain that the term "generative art" has been used interchangeably with "computer art", and trace its history to Max Bense's generative aesthetics. Boden and Edmonds claim that the term generative art serves to describe those artworks that are produced using ruled based systems which have a great degree of autonomy, leaving some (or even most) of the creative decisions to the system itself. When these systems are computer based their products are called "computer generated art". Although Boden and Edmonds maintain that many forms of digital art can be said to be generative in principle, they constrain their definition of generative art, specially of computer generated art, to only art that is produced without the direct control or interference of a human being. This definition makes it difficult, if not impossible, to use the term generative art instead of computer or digital art. Therefore, I have chosen not to use the term "generative art", but only the idea of the use of generative processes in digital art, and in particular in interactive art.

As the importance of interactivity in digital media was emphasized by presenting Nake's and Paul's characterization of digital art, it was necessary to clarify the difference between notions of interaction and interactivity. Both terms are commonly used interchangeably, however, *interactivity* has a more technological connotation while *interaction* includes both a technological and a social or an ideological background. The discussion of the historical use of both terms revealed that the notion of interactivity must be extended to encompass a social dimension, in order to understand aesthetic qualities of interactive art. Particularly, because interactive art has an important ideological component that cannot be acknowledged if the concept of interactivity is restricted to a technological perspective.

A brief analysis of the history of interactive art showed how the notion of participation and the use of generative processes gave shape to what we know now as interactive art. The conclusion of this analysis is that although interactivity has found its place in art history and it has become a defining aspect of digital art, it is a problematic notion. On one hand, interactivity has become so widely used that it has turned into a commonplace that is losing its meaning. On the other hand, the tendency of understanding interactivity as a technological category has played down the importance of the social and ideological aspects of interactive art.

These challenges of the notion of interactivity were presented as the root of the main criticism towards interactive art. However, I have argued that approaching the notion of interactivity from the perspective of the algorithmic sign can help us better understand how we can talk about interaction between humans and computers in an aesthetic way. The algorithmic sign, as a dynamic sign, has the characteristic of being both an instruction and an interface for action. In this sense, the algorithmic sign can be described as a relatively autonomous notation or an executable notation. These characteristics of the algorithmic sign can be used to describe interactive art, in particular computer-interactive art. As the algorithmic sign, a computer-interactive artwork only emerges through the process of interaction with computer systems. Hence, interactive art is always in the process of "becoming", and this is what distinguishes it from other art forms.

Finally, I have taken this exploration of digital art, and specially of interactive art, as the inspiration to create an experimental interactive installation that addresses the idea that the digital medium is ultimately characterized by its dual existence, by its subface and surface. The objective of this installation it to question the assumptions we have when interacting with computer systems, which include ignoring the computable subface of the digital medium. Through this project the final goal is to challenge the HCI idea that we are the *users* of computer systems, and that computers are intelligent machines.

Appendix

A.1 Source Code

The following is the source code for the initial model of the experimental interactive installation “Drawing at a Distance”.

```
/**  "Drawing at a Distance"
This sketch will tracks the brightest pixel in a live
    video signal.
First it stores the x and y location of the tracked
   brightness.
Then uses this information to draw an image.

physical setup:
- make sure there is a strong value contrast between
   your hand and the background.
- works best in a dark room and a lamp pointing a
   your hand.
- set all camera settings to "manual" for the most
   stable results.
Based on Golan Levin's Brightness Tracking
isalomanto 04.07.2011
*/

```

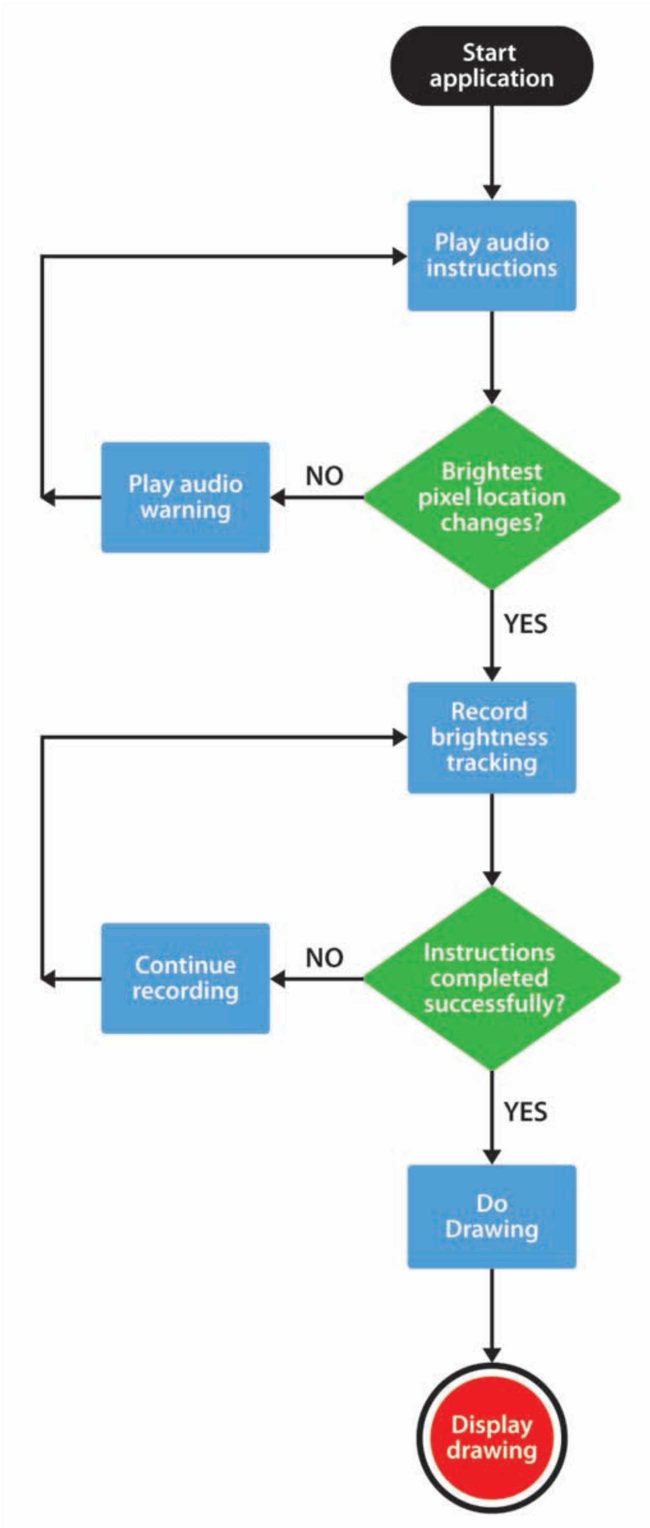
```
color[][] gesture; //Two dimensional array to store
   the gestures
color drawingColor; //Color variable that set the
   color of the drawing

//Boolean to stop the recording more (phase R)
boolean end = false; int endvalue;

int brightestX; // X-coordinate of the brightest
   video pixel
int brightestY; // Y-coordinate of the brightest
   video pixel
float pixelBrightness; // Initializes variable used
   in recordGesture function
int loc; // Initializes variable used in
   recordGesture function

import processing.video.*;
Capture video;

char phase = 'R';  //Sets initial state to record
   mode (phase R)

void setup() {
size(400,400);
background(255);
rect(2,2,width-4,height-4);
stroke(0);
strokeWeight(5);
smooth();
noFill();

//New video capture using processing library
video = new Capture(this, width, height, 30);

drawingColor = color (0);

//Initializes the array gesture
```

```
gesture = new color [width][height];
for(int i=0; i<width; i++) {
for(int j=0; j<height; j++) {
gesture[i][j] = color(255);
}
}
}

void draw() {
  switch(phase) {
case 'R':   //Records and store the participants gestures
recordGesture();
    if (finished()) {
phase = 'P';  //Changes phase to playback
}
break;
case 'P': //Playback mode, stops video, and draws and displays the drawing
background (255);
video.stop();
//Draws the image using the data from the gesture array stroke(drawingColor);
for(int i=0; i<width; i++) {
for(int j=0; j<height; j++) {
color c = gesture[i][j];
if(c == drawingColor) {
point(i,j);
}
}
}
}
}

boolean finished() {
//Realizes the end of recording phase. It is determined by the if clause in the recordGesture function
```

```
return end;
}

void recordGesture() {
//Captures and displays the video
if (video.available()) {
video.read();
}
video.loadPixels();
// Draws the webcam video onto the screen. Disabled.
    Only used for testing
image(video, 0, 0, width, height);

// Brightness of the brightest video pixel. Set high
    to be more restrictive.
float brightestValue = 100;

// Search for the brightest pixel: For each row of
    pixels in the video image and
// for each pixel in the yth row, compute each pixel'
    s index in the video
int index = 0;
for (int y = 0; y < video.height; y++) {
for (int x = 0; x < video.width; x++) {
//calculate the 1D location from a 2D grid
loc = x + y*video.width;
// Get the color stored in the pixel
int pixelValue = video.pixels[loc];
// Determine the brightness of the pixel
pixelBrightness = brightness(pixelValue);
// If that value is brighter than any previous, then
    store the
// brightness of that pixel, as well as its (x,y)
    location
if (pixelBrightness > brightestValue) {
brightestValue = pixelBrightness;
brightestY = y;
brightestX = x;
```

```
}
}
}
gesture[brightestX][brightestY] = drawingColor;

//If the brightest pixel is the area of the pixels
    from (370,370) to (400,400)
//the recording mode ends and the playback mode
    starts. if((brightestX >= 370) && (brightestY >=
    370)) {
end = true;
}
}
```

A.2 Activity Flow Chart



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