

Toward Digital Biodiversity: A View on Correlation of
Digital Technology and Culture
through Analysis of Media Art and Entertainment

アート、エンターテインメントとメディア技術の相関が
デジタル文化の多様性に果たす役割

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A great deal of the support I had come from overseas. The international community of artists, researchers, scientists, engineers, curators and writers always gave me the great resource for creative and critical thinking through formal and informal discussions. I have been extremely fortunate to have opportunities to meet and discuss with many internationally recognized great thinkers and creators. Conversations with people such as Marvin Minsky, Namjun Paik, John Whitney Sr., Nicholas Negroponte, Harold Cohen, Ted Nelson and others brought many inspirations as well as useful knowledge to me, while I also learned a lot from artists and researchers from younger generation.

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Introduction

1. Art and the Digitalization of Culture

Recent developments on the field of digital technology have been changing our lives in many ways. The Internet has become a major medium of everyday communication in less than five years. Enjoying new forms of digital entertainment like video games or home entertainment robots like Sony's Aibo, has already become a widely accepted part of our lifestyles. Digital media technology has not only created new forms of telecommunication -- it has also dramatically changed the whole idea of communication itself by bridging many fields that used to be considered separate. For example, the rapid development of digital data compression technology has added a new feature to the Internet as a medium for delivering both music and moving images. Even mobile phones are providing a rich platform for multimedia entertainment and other services, beside serving their original function as voice-based telecommunication devices.

But what about art? Indeed, also artforms using digital technology are currently attracting growing attention. Digital technology has brought the artists all kinds of new possibilities to realize their ideas and give a concrete form to fantasies which would otherwise be difficult to visualize. Computation, interactivity, and real-time telecommunications involving massive amounts of information are now readily available for both artmaking and the appreciation of art. New art genres like interactive art and web art (or net.art), as well as artforms based on phenomena like alife and virtual reality, have drawn inspiration from such technical innovations.

However, it is a common misconception to believe that we are merely witnessing a one-way influence leading from the field of digital technology towards the field of art. As I hope this dissertation will show, the interactions between art, technology, science and other related fields are much more complex than that. Technology certainly influences our perceptions of the world, triggering major changes in our culture and our identity. Yet technology is created and receives its meanings within cultural frameworks, not outside of them. It is not independent from cultural constraints, including traditional values and visions. From this perspective, not only the relationship between art and technology, but also the interactions among other, wider elements of culture should be considered.

Changes in essential human notions, such as our senses of space, time, body, life, identity and relationships to others, are influenced, but not directly determined by the advent of new technology. Significantly, these basic issues are exactly the kind of themes that art, including contemporary art applying digital technology, deals with. Artists explore such issues from unexpected perspectives, questioning them and reinterpreting them.

Instead of merely mirroring the accepted views and notions about the roles and applications of technology in contemporary society, the artists critically scrutinize its current applications and also look for and propose new ones. The visions of the artists often go further than those of the engineers. But the artists also need the specific skills and knowledge of the engineers and the scientists. This is one reason why the interrelationship and collaboration between art and technology is gaining such a crucial role in today's, and even more emphatically tomorrow's, media environment.

Digital media technology is in the process of becoming the common basis connecting every aspect of media culture. As a consequence of this, the importance of interactions among the different elements of our culture has significantly increased. There is an urgent need for at least three things: to propose new models to describe the ways in which such interactions work, to establish a better collaboration between art and technology, and to create more effective educational programs to further the understanding of contemporary media culture.

2. The Goals of This Dissertation

This dissertation deals with the relationship between contemporary media art and digital technology. The main focus is on the analysis of the nature of interaction between art and technology. Through a series of case studies, various interactions are analyzed. This will be dealt with from a number of different perspectives, yet always within the context of media culture and society. The way media art and technology simultaneously both influence and are influenced by society and culture will be considered from the perspectives of art history, science, perception and media research. The ultimate goal of this research is to develop conceptual models for a better understanding of the modalities of human - computer interaction.

To answer these issues the following conceptual relationships have been taken into consideration.

i. art - society

By examining the history of art, we notice that contemporary digital media art is not separate from earlier changes in art. We might even claim that art had prepared itself for the arrival of digital technology. On the other hand, changes in art history have been influenced by scientific, technical, and cultural evolution. Art cannot exist outside the society and culture the artist lives in. While art is often said to deal with "eternal" values that remain always valid beneath the changing "surface" of culture, the way an artist selects a theme and realizes the artwork reflects the on-going social and cultural situations. Great scientific discoveries and breakthroughs in engineering have influenced art, not only because artists have personally found the new ideas exciting or useful, but - even more profoundly - because such discoveries or innovations have been felt in the society at large. In short, both technology and science influence

artmaking through the cultural processes they trigger/are part of.

ii. art - technology

When we examine the ways media art has applied digital technology, we observe that artists are often directly involved in the development of the technologies they are using. Especially in the field of interactive art, artists have been closely involved in technical development. Interface design, both on the level of hardware and software, is an example of a field where innovations and breakthroughs by artists are getting common. Some technological discoveries and applications conceived by artists are already used outside the art world.

In research laboratories such as ATR in Japan, The MIT Media Lab and the NCSA in the USA or the GMD and the Art+Com in Germany, the collaboration between artists and engineers has produced interesting results. Artists profit from the specialized skills of engineers and scientists, and vice versa. But it is not only through such direct technical collaboration that artists influence technology. Artists have inspired research on fields as varied as computer graphics, virtual realities and the study of alife.

iii. art - culture

Art changes culture by influencing people's visions and ways of thinking, both directly and indirectly. Directly, by visualizing major changes occurring in the society, or dealing with new technologies which promise to change our lives, from an artistic point of view. By means of visual images, sounds, metaphors, or storytelling, art will open the eyes of the audience. Along with other creative fields, such as literature or film, visual art provides people with clues for understanding the world. Indirectly, together with other fields such as design, entertainment, or fashion, art forms a part of a network of influences that is changing our cultural environment. With the advent of digital technology and the Internet, this network seems to be growing bigger and more complex on a global scale.(1)

The way artists transform technology into an artistic experience influences other fields such as design or entertainment, and vice versa. Such interaction has become a main feature of contemporary Japanese media culture. Today, technology plays a key role in the formation of media culture. At the same time, by its nature, it is driven along by social and cultural demand. This is one of the reasons why I claim that the relationship between art and technology is not a simple one-way influence. While technology brings changes to society and culture, including art, art also influences technology through its roles in the society.

iv. technology - culture

As we think about the ways technical innovations are understood and popularized, the role of cultural background and differences should not be neglected. For example, the way mobile phones are used in Japan is quite different from that in most other countries. Another example is the current development and popularization of virtual pets, digital characters, and pet robots in Japan. Historical examples can be found in the way mechanical engineering was introduced and developed for entertainment, rather than for serious use, in Edo Japan. Such an observation underlines the importance of analyzing traditional culture and its influence on the contemporary

media culture. Such comparative cultural study will help achieving a more effective orientation and application of media technology.

3. Original Publication

The basis of this dissertation has been formed over the years. Chapter I developed from six articles I published. The main body came from "Toward Art as System" on "InterMedium Textbook" (Edited by Toshiharu Ito and Fumihiro Nonomura, Korinsha Publishing, Kyoto, pp.82-91, 1997) and "Iwanami Koza Multimedia Johogaku" (Iwanami Shoten, Tokyo, vol.10, pp.1-66, 2000). The notion of art as system in relation to alife concept and interaction developed from a paper published in 1996, co-authored with Christa Sommerer and Laurent Mignonneau (Systems, Control and Information, vol. 40, No.8, pp.344-351). The analysis on the meanings and role of interactivity in media art was first published in "The State of Interactive Art" (InterCommunication vol.7, NTT Publishing, Tokyo, pp.80-84, 1994). The analysis on "A-volve" was published in Annual Intercommunication 95 (NTT Publishing, Tokyo, 1995).

Chapter II originally developed from three writings. An early version of my study on the history of the notion of life from automata to alife was published in the Journal of Researches of the Faculty of Arts of Tokyo Institute of Polytechnics. (Tokyo Kogei Daigaku Geijutsugakubu Kiyo, Vol.1, pp.21-28, 1995) Part of it was updated and published as "From Automata to A-Life" in 1997 from Springer/Verlag, as a part of a book "art@science". (Edited by Christa Sommerer and Laurent Mignonneau, Springer/Verlag pp.99-119, 1997) The last part of the chapter on the concept of originality and Japanese culture is originally presented in Sao Paulo at the conference ARTE NO SEculo (1995), and was published as "Historical Perspective of Art and Technology - Japanese Culture Revived in Digital Era" in the book ARTE NO SEculo XXI- A HUMANIZACAO DAS TECNOLOGIAS. (Diana Domingues, ed. Editora UNESP, Sao Paulo 1997) The analysis on notion of life in relation to Japanese culture was then further developed to form a basis for Chapter IV.

The first part of Chapter III is mainly developed from my essay "Telerobotics and Art - Presence, Absence, and Knowledge in Telerobotics Art" which was published as a part of the book "The Robot in the Garden". (Edited by Ken Goldberg, 2000, The MIT Press, Boston, pp.198-213) The article on works of Eduardo Kac ("From/to Body to/from Robot") was published as a part of Leonardo Electronic Almanac on its November 1999 issue, from the MIT Press. The second part is developed from the following writings and presentations. The analysis on Paul Sermon's works was published for IC95, a large-scale exhibition using network, on the web site of the InterCommunication Center(NTT/ICC). "Body Interface -- Fantastic Phantom Slipper" is a project realized at Tokyo Institute of Polytechnic in 1997 with my colleague Yuichiro Kume and our students, which was shown and presented at the annual conference of VRSJ in 1997 in Nagoya and then in SIGGRAPH 98 Enhanced Realities. The proceedings from these conferences include more detailed information of the project. The paper on Tactile Renga was presented at ISEA 2000 in Paris.

Chapter IV is based on many writings. "Signed by Artists" was originally published in 'Cyber Arts97'. (pp.22-27, Springer Verlag, Wien/New York 1997) The earlier version of "Creating Cultural Correctness" was presented at CAA2000 conference in Los Angeles. An early version of my essay on the playful nature of Japanese media art was published as "It's Good to Have Fun: Game Culture and Japanese Media Art" . (CAD FORUM ZBORNIK RADOVA, Zagreb, 1994) On Japanese network projects, "Flora and Fauna: Japanese Games and Traditional Culture" has become a basis. ('Flesh Factor - informationsmaschine mensch' pp.232-235, Springer/Verlag 1997). Updated and more analytical version of the theme was published as "Avatars of the Virtual World" on Art Asia Pacific. (Issue 27, 2000)

The major body of this chapter, "Non-Perspective as Symbolic Form" has developed from lectures I gave at UCLA, University of Oregon, Japanese ANIME Festival (Japan Society, NY) among other venues and writings over the years. After a presentation at SYNWORLD Symposium (Wien, 1999) and included in CD-ROM, it was published as "Nicht-perspektivische-Darstellung als symbolische Form". (KUNSTFORUM International, Bd.151 2000) This part of my dissertation has been formed through the process of connecting previous researches that are presented in previous chapters. For the analysis of Japanese visual system, books, references, original materials and discussion with other researchers and artists formed the basis. The last part of Chapter IV has developed from lectures and writings. The basic concept was published as "Blurring notion of life in cyberspace" (Monthly Gazo Lab Journal, Oyo Keisoku Kenkyujo, vol.9 No.10 1998 pp.10-14) which was based on a presentation from Spring 1998 at a joint seminar of VRSJ and 3D Forum. The theme was further developed into a paper I gave at ISEA99 (Sao Paulo) titled "Is Your Next Life a Robot, or a Dog?", and into a presentation titled "Growing Virtual Pets" at the Growing Things symposium at the Banff Center, Canada, in Spring, 2000. The last version of this topic was presented at ALIFE VII Conference (Portland), as "The Art of Creating Subjective Reality: An Analysis on Japanese Digital Pets" in Summer 2000.

4. Structure

Because of the nature of the theme, discussions from different perspectives have been integrated into this dissertation. Accordingly, I have structured my research into the following scheme.

In Chapter I, I will analyze the themes and issues that contemporary media artists using digital technology are dealing with. To carry out the analysis, I will begin by discussing art history from the point of view of the development of art as system, which is a concept I propose. In the second part I will analyze the ways in which digital technology has been used in art, particularly applying concepts like interactivity and alife. In the last part, I focus on how alife as concept has inspired artists and how artists visualized alife with different approaches.

In Chapter II, my focus is on the correlation between science, technology, culture and art, around "life" as concept, also crossing between the past and the present. In the first part of

Chapter II, the raise of alife as a concept is examined as the intersection of science and culture. Here, my aim is to prove the wide cultural and historical context beneath what looks like a highly contemporary scientific and technical achievement. In the second part I will discuss how artists take ideas from life science and use them as themes and metaphors. In the last part, the parallels existing between essential issues in art and modern biology are shown. Lastly, I will discuss about the needs for such interdisciplinary development in media culture.

In Chapter III, I will discuss on the issues that telecommunication technology and telerobotics have raised on the fundamental issues of our perception, namely the relationship between our body and space in cyberspace. In the first part, the background of disembodiment will be analyzed. In the second part, artworks using telerobotics technology will be discussed to examine the possibilities to use the technology in expanding our thought and experience. In the third part, the use of body as an interface for telecommunication in art is examined.

In Chapter IV, I will focus on the role of Japanese way of seeing the world in the current digital media culture. My argument is that cultural constraints exist in the profound level so that the critical issues in art such as sense of reality, originality, or notion of life remain under such influence, and related to each other. By examining Japanese literature and art from historical point of view, I hope to prove that such cultural elements are both part and the result of a system through which the Japanese see the world. In the first part I will focus on the notion of originality. In the second part I analyze the Japanese-ness in contemporary media art. In the third part I will make a detailed analysis on Japanese vision/perception model by using materials and connecting knowledge from different sources. The aim is to discover a comprehensive model of Japanese vision system that underlies the contemporary media culture. In the last part, I will discuss about the notion of life in Japanese culture, from both historical and contemporary aspects. In each part, the discussion will be carried by relating art and entertainment to technology and to culture.

5. Methodology

My point of view toward the culture and "the way of seeing" in relation to science and technology have been inspired by books and papers written by authors such as Walter Benjamin, Erwin Panofsky, Edward T.Hall and Jakob von Uexkull. My way of research is influenced especially by authors such as Hall and Wolfgang Schivelbusch. Their influence will be particularly visible in Chapter IV.

In terms of philosophical point of view, my standpoint that the way we see the world cannot be independent from the society and the culture -- as well as our physiological entity -- is largely influenced by the philosopher Bertrand Russell, especially with his book "My Philosophical Development" (George Allen & Unwin, London, 1959) and the contemporary researcher/thinker Yoichiro Murakami.

The approach I have taken on examining history as a basis for the analyzing contemporary culture shares the similar methodology with fellow researchers and colleagues

such as professors Toshiharu Ito, Shin Mizukoshi, Erkki Huhtamo (UCLA), Lev Manovich (UCSD), Margaret Morse (UCSC), among others.

According to the theme and the nature of discussion, different methods of research are applied to each part of this dissertation.

The first part of Chapter I is mostly based on researches done on books, catalogs, and what I have known from artworks and artists. I will try to integrate the pieces of information and knowledge into a flow that consists of correlational elements, represented from the point of view I propose. In the later part of Chapter I, I will take more like case study approach to artworks because each one of them is unique and cannot be discussed as a total, for one reason, but also because the issues I will be raising in this chapter can be examined more clearly through each case.

In Chapter II, I consciously applied a cross-cultural approach, since the aim of this chapter is to examine the way science, technology, and art correlate in the cultural context. It is a conscious mixture of a study in the history of science and technology, with a cultural study on the way technology and art relates in the society.

Chapter III consists of artists' files and theoretical discussions around the theme. Through the case studies and analysis, the role of technology in art and culture will be outlined.

In Chapter IV, two different methods will be applied. Taking the methodology of cultural studies, observations and facts from the daily life, or what is happening in today's media culture, will be analyzed, to find the structure beneath the phenomena. Then, by examining more historical phenomena and using the body of existing studies, a structure in a deeper level will be proposed.

There is a growing body of books and articles trying to explain how technology has changed the art and culture, and what is the significance of digital technology in the history of art. This dissertation owes greatly to this literature. Also, having worked for years as a researcher and a curator, I have had opportunities to attend many conferences, jury meetings and research gatherings in different parts of the world, attended by artists and researchers in the fields of art, media studies, cultural studies, computer science, technology, philosophy, among others. Besides the lectures and public discussions I followed at these venues, private discussions I had with the professionals I have encountered at these occasions have played a major role in forming the basis of this dissertation. A large part of this dissertation is based on presentations I have given at conferences, symposia, and workshops over the years. The feedback from the international audiences has helped me to clarify my points and develop them further.

6. Source Material

The following books and writings have become the basis of this paper among many other articles which have been published or presented in journals or conferences. Also, information and ideas given from individuals played important roles in the fast changing field of digital technology and its application.

Regarding the relationship between art and technology, I started with classics such as books by Walter Benjamin and Susan Sontag dealing with the impact of reproduction technology on art. "The Art in the Electronic Age" and "Art, Action and Participation" by Frank Popper (2) are the classics in this field along with books such as "Cybernetics, Art and Ideas" edited by Jasia Reichardt in 1971. (3) The publications from Ars Electronica(4) over the years from 1990 to present have provided me a wide resource on issues regarding science, technology and art in the changing society. Regarding computer and art, while Cynthia Goodman's "Digital Visions"(5) gives a basic overview on digital art from art point of view in the 80s, Melvin Prueitt sees the issue from a point of view of information science in his book "Art and the Computers". (6) John Whitney's "Digital Harmony" (7) , books written or edited by Yoichiro Kawaguchi (8) and Ivars Peterson's "The Mathematical Tourist" (9) deal with the relationship between image and algorithm. The role of computer in art has been discussed in publications such as ACM/SIGGRAPH's annual art show catalogs, including several outstanding analysis on the issue. (10) Regarding later technologies such as virtual reality, books and writings by researchers such as Myron Krueger, (11) Brenda Laurel (12) and Scott Fisher (13) give points of view to bridge technology and art while books by Howard Rheingold (14) overview the field and books ,writings and lectures by Michitaka Hirose (15) gave aspects on the future application. Anthologies such as "Iterations: The New Image" edited by Timothy Druckrey covers these issues with more recent examples from the perspective of art. (16) Academic journals and publications from ACM/SIGGRAPH, IPSJ (17), VRSJ (18), ITE (19) and JASIAS (20) provided me with the latest information in digital technology and its application in image creation.

Focusing more on the role of technology and art in relation to society, Paul Virilio's book "War and Cinema" became a model for my research as well. (21) Publications from Ars Electronica covers this issue over years. From contemporary point of view, discussions held at media theory symposia such as Ars Electronica, ISEA, Doors of Perception (22) and DEAF (23) offered great opportunities for me to exchange ideas with other researchers. About digital entertainments,

I learned a lot from the conversations with professionals in the field I came to know for many years. These first-hand information were then examined with magazine articles, conversation with students, and also by visiting game exhibitions and joining conferences.

Regarding alife, besides Christopher Langton's writings and interview, Richard Dawkins' "The Blind Watchmaker" (24) offered the basis of my research, while works and writings by Yoichiro Kawaguchi and Karl Sims (25) among others became the source of ideas from artistic aspects. Texts and technical information contributed to Computer Graphics Anthology(26) and Computer Graphics Access(27) by artists and researchers including Sims, Craig Reynolds, Michael Girard and Susan Amkraut offered accurate and detailed information on this field. While D'Arcy Thompson's " On Growth and Form" (28) is a classic, Claus Emmeche's "The Garden in the Machines" (29) was useful in overviewing the field. Books on modern biology and philosophy including Francois Jacob's "Le Jeu des Possibles" (30) formed the basis of my thought. Shoji Tatsukawa's writings and lectures bridges alife and the history of technology in Japan. (31) A

paper I co-authored in 1996 became a source for relating alife and art for further development.
(32) Alife conference proceedings helped me to understand the wide range of this subject matter.
(33)

On Japanese culture and art, books and writings by Fumikazu Kishi (34), Yasumasa Oka (35), Haruo Suwa (36) and Fumihiko Gomi (37) provided me with facts and thoughts. Writings by Timon Screech offer innovative points of view on Japanese art and culture in Edo period. (38) Paintings, prints and literature I came across over the years and what I was taught in studying Japanese paintings made the basis of this part of my research. On contemporary media culture such as comics and animation, while classics such as "The World of Animation" (39), magazines such as New Type or Comic Box provided me with the latest information and the reaction of readers and viewers.

Quarterly InterCommunication Magazine has been a great source of information and thoughts in every field of my research. Above all, the most valuable body of research material was brought to me by artists, curators, researchers, engineers, and others in these fields.

note

1. For example, at "Au dela des Spectacles", which was a large-scale exhibition that took place at Centre Pompidou in Paris in 2000 the above mentioned double roles of art were clearly demonstrated with the choice of artworks depicting current pop culture and transforming it into a series of evocative experiences. In this exhibition which included Japanese artists such as Takashi Murakami and Mariko Mori, we could see how recent technical achievement are mingled with cultural icons and metaphors that are both old and new, to create a strong vision on our contemporary culture. Similar observation can be made with many works by artists, which will be discussed in this dissertation.
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Chapter I Art as a System

1. The Evolution of Art

1.1 Introduction: Art, Society and Technology

The roles and definitions of art have always been changing. In different cultures around the world art was originally (prod)used mainly for religious purposes. "Artworks" were essentially cult objects. Only much later did the concept of art come to refer to materialistic products made by professional artists in accomplished forms, commissioned and appreciated by wealthy people. Such a period of transition was the Italian Renaissance in the 15th and 16th centuries. Artworks became symbols of their owner's or donator's social status, and treasured investments as well. In the Western world the 19th century saw the development of a full-scale commercial art market, related to the growing importance of the bourgeoisie with its cultural and social pretensions. Art became in a sense democratized, yet it was still firmly rooted in material and symbolic values. Although more people could now afford to own artworks, these were still associated with social status, class and material wealth.

Nowadays art is no longer considered merely a beautiful painting or a piece of sculpture ornamenting a gorgeous salon or a museum hall. Particularly since the 1960's the notion of art has undergone a process of transformation that has shaken its foundations. In her influential formulation, the American critic Lucy Lippard wrote about the "de-materialization of the art object", referring to a radical turn in the ways of conceiving art: an artwork no longer had to have a material basis, to be a tangible, concrete object; it could quite as well be a process, an assemblage of various kinds of elements, or just a conceptual thought, an idea.⁽¹⁾ The ground for such a radical reformulation of art had been prepared by earlier art movements in the first half of the 20th century (from Futurism to Dadaism and Surrealism), but also by various kinds of cultural, social and technological developments, some of which had begun much earlier.

Among the factors that have contributed to the changes in the ways of making, distributing and appreciating art have been various technological developments. Historically these have been connected with wide-ranging social changes. For example, the Reformation is believed to have been made possible because of the printing technology and the shipping system that covered all Europe ⁽²⁾. Yet the influences go to both directions, from technological innovations to social needs and requirements and vice versa. An important role has been played by the introduction of technologies of mechanical reproduction from printing to photography, as well as by the creation of new channels of communication from the modern print media to the Internet. The large-scale production and dissemination of texts and images has had a wide-ranging social, ideological and cultural impact. Not only has the potential audience for art been enormously expanded; the very notions of art, the artist and the art audience itself have undergone transformations as well. Pinpointing the exact nature of these transformations, particularly with reference to recent

technological art, will be one of the important goals of this dissertation.

Cultural theorists like Walter Benjamin and Susan Sontag have discussed the interconnected changes in art, society and technology from a historical point of view. In his celebrated essay "The Work of Art in the Age of Mechanical Reproduction" (1936) Benjamin emphasized the social and cultural impact of photography.(3) Photography, first introduced in 1839, played a pivotal role from the point of view of the subsequent developments of other media technologies, such as cinema. According to Benjamin, the introduction of photography meant a shift from the "cult value" to the "exhibition value" of the art object. The "aura" of the unique, original artwork (according to Benjamin, still connected with ritual functions) disappeared and was replaced by a potentially unlimited number of copies.

In the culture of mechanical reproduction, as Benjamin observed, the notion of the unique artwork hardly made sense anymore. Photographs only exist as copies, not as originals. New copies can be produced at will when the earlier ones wear off. Seeing and owning such "copies" is much easier than gaining access to artworks was in earlier times. The introduction of amateur photography also gave new kind of tools of expression to the hands of private persons, as Susan Sontag has explained.(4) Of course, such a radical shift has not happened without controversy. There are still many of those for whom "art" is closer to the mindset of a Renaissance prince than that of Benjamin or Sontag.

The major difference between today's world and earlier societies is the importance and volume of information. Information is the main resource of today's world; digital technology forms the basis and key feature of the information society we live in. Printing technology and photography brought changes to art history, but the changes brought by digitalization may be even more radical, because digital technology is changing our ways of communication. Of course art has always been a way of communication. While artists do not necessarily specify what they mean by their works, preferring a certain ambiguity, art is essentially a communicative act.(5) When we move to the information society, communication itself becomes both a source and a carrier for art. Innovative artists, like Man Ray, Marcel Duchamp, Fernand Leger, John Cage and Nam-June Paik, have been aware of this for a long time. Today, very different kinds of creative personalities, from the composer Ryuichi Sakamoto to the filmmaker George Lucas, are influencing the world with their keen awareness of the new possibilities of communication technology.

I consider artists to be those who see beyond the present, either to the future or to the past. -- To the future, because they sense the slightest signs of change in the air and foresee phenomena that have hardly begun to appear in our society. To the past, because by dealing with and perceiving phenomena that belong to the cultural heritage (including cliches, formulas and "received ideas"), the artists can also reveal the nature of the true novelties and discoveries of our times. This is one of the reasons why art is indispensable to contemporary society and why it makes sense to analyze artworks in a dissertation submitted to a department of engineering.

While there are forms of art that do not change drastically over the years, there are other artforms that challenge and electrify our thinking about contemporary culture. There are artists using digital technology not only as a tool for painting or presenting images, but also for demonstrating what digital technology might come to mean to us. Some of these artists deal with

the nature of communication in the digital era by exploring, designing, and even providing different possibilities for communication. Others deal with the critical meaning of digital technology in terms of simulating life, changing the notion of life.

Although the relationship between art and technology has been discussed in earlier research from a number of points of view, in this first chapter I am proposing a different approach by dealing with digital art as a system. The purpose of this chapter is to bring this idea into the perspective of the history of media art. While some parts of it are already known, the chapter is primarily meant to offer a different point of view, a new reading differing from the existing research in this field. The introduction of the idea of autonomy in art will be further discussed in chapter II in the context of the changes in the notion of life.

1.2 History: Technology and Art before the Computer

Traditionally visual art was considered to be the result of the creative activities of professional artists. Using a combination of learned craftsman-like skills and creative imagination the artists would give their vision a tangible form and sell it to a buyer and/or expose it to the public. If the artwork was successful, the viewers were probably impressed by it, contemplating its vision and enjoying its colours and forms. However, they were not expected to effect or change it in any way (although sometimes this happened against the artist's will, as exemplified by the fig leaves painted on the naked bodies in Michelangelo's *The Last Judgment*). The artwork was a unique physical entity, materially existing as paint on a canvas or perhaps as a carved piece of stone or wood. Except for the natural aging of the material or possible accidents (the effects of a fire or an earthquake, etc.), the artwork, once completed, was expected to remain without any changes, admired from a distance.

Already in the early 20th century avant garde artists began to object such an idea. Futurism and Dadaism (6) during the 1910-20s and Constructivism in the 1920s were major movements that questioned the prevailing notions of art. The Futurists reacted against traditional artforms which they considered outmoded from the perspective of the modern industrial and urban society. They called for new artforms which would give an expression to modernity, embracing the notions of speed and dynamism. In their Manifestoes, the Futurists also encouraged artists to use the new communication media (such as film and radio) as their artistic tools.

The Dadaists wanted to destroy the idea of the finite, static artwork and embraced the idea of art as a process. Dada artists also brought random chance operations and automatism (further developed by the Surrealists since the mid 1920s) into the field of visual art and poetry. Man Ray, a true multi-media artist of his time, scattered pins and crystallized salt on undeveloped film to create an experimental animation without shooting for his film "*Le retour a la raison*" (1923), which was shown at a notorious Dada event organized in Paris.(7) This film can be considered one of the first cameraless animations, a technique which has since become a commonplace approach on the field of computer graphics. The introduction of random chance operations derived from the idea that a piece of art should not necessarily be under the perfect control of an artist.



Fig.1 Film strip from "Le retour a la raison" by Man Ray, 1923

The Dadaists also experimented with chance operations and what might be called "open systems" in their deliberately scandalous performances and events, which were often meant to provoke chaos. Although the basic structure of the event was determined by the artists in advance, the final outcome was left open. Another indispensable element to the development of the idea of art as a system was added by Marcel Duchamp, a radical artist loosely connected with Dadaism. Duchamp's notion of "Ready made" questioned the idea of traditional artistic skills. By selecting readily available mass-produced items and exhibiting them as artworks in the gallery, Duchamp cleverly played with ideas like authentic vs. unauthentic and open system vs. closed system. Duchamp's works were deliberately ambiguous and provocative, often tempting the audience to interact with them (for example, they could spin by hand the "Bicycle Wheel", 1913, constructed of ordinary everyday objects, a stool and a bicycle wheel).

While Dadaism contained a destructive and critical element focused against both the technological society and the established art world, Constructivism aimed at harmonizing the previously separate realms of art, design and technology. The movement began in the Soviet Union and spread to other countries like Germany, where it found a stronghold at the Bauhaus, an experimental art school. Significantly, the Constructivists often characterized themselves as "engineer-artists", underlining the need for combining engineering skills with a creative artistic vision in the technological society. According to the Constructivists, a machine designed and constructed by an artist-engineer could be a new type of artwork, as exemplified by the art-machines created by Vladimir Tatlin, Naum Gabo and Laszlo Moholy-Nagy.

After the Second World War, the criticism of the traditional art object was continued by movements like Fluxus (8) and the E.A.T. (Experiments in Art and Technology). Fluxus, active since the early 1960s, was an international movement, which continued the irreverent, anarchic and critical activities of Dadaism (it was also known as "Neo-Dada"). Both Dada and Fluxus artists denied the traditional concept of artwork as something to be hung on the wall and appreciated passively. They experimented with new ideas and even invented new kinds of technological systems. A case in point, the Fluxus-artist Nam June Paik developed one of the first real-time analog video synthesizers with the engineer Shuya Abe at the University of Tokyo in the late 1960s.(9) Already in 1965 Paik and Abe had built a functioning robot (named "Robot-K456") which was presented as an artwork.

Fluxus- artists realized many performances and "happenings" in public places. These often included new technology, altered or "prepared" for the purpose. The presence and active involvement of the public was an essential part of such activities. Art became a form of communication: the reactions of the audience were conceived as its integral part. In Nam June

Paik's notorious Opera Sextronique (1968) even the police and the press were incorporated into the artwork: Paik and his co-performer Charlotte Moorman were arrested by the police, suspected for committing obscene acts. The next day the event was featured in newspaper headlines. The public attention "crowned" the performance and finally brought it to a closure.(10)

"Participatory" events like this anticipated the development of interactive computer art. However, the focus shifted from an interaction between human beings to an interaction between the audience (redefined as "users") and a technological interface (often a computer).

Another contribution Fluxus made to the evolving notion of art as a system was the concept of art as reconstruction of information. Because many of the Fluxus activities were ephemeral, conceptual or even self-destructive in nature (like the "bachelor machines" constructed by the Swiss artist Jean Tinguely), documentation and the building of collective, cumulative databases attained an important role in the strategies of Fluxus as a way of self-preservation and creation of identity. This aspect could also be detected in the activities of artists like Yayoi Kusama, whose film documentation of Fluxus performances were conceived as artworks in their own right.(11) Today, with the application of the creative potential of the Internet, the creation of collective databases is becoming a sub-genre of media art in its own right, as demonstrated by the projects by artists like Muntadas and Akke Wageneer. I will discuss about their projects in more detail in Chapter II, 7.

While Fluxus could be seen as a follow-up of Dadaism, E.A.T. (Experiments in Art and Technology) had more to do with the line of development tracing its roots from Constructivism. E.A.T., another international movement, aimed at harmonizing the worlds of technological engineering and artistic creation, which were often felt to have fallen too far apart. Artists collaborated with engineers from the top industrial laboratories of the time (including Bell Labs) to harness state-of-the-art technology into the purposes of artistic creativity. Although the results were often disappointing (including E.A.T.'s greatest effort, The Pepsi Pavilion at Osaka Expo, 1970), E.A.T. presented a collaborative model for harmonizing art and technology, which has been more fully realized in later media art, the topic of this dissertation.

1.3 Influences: from Information Theory to the Ecology Movement

Information theory and the related discipline of cybernetics, developed since the late 1940s, influenced technology-oriented art, as Jack Burnham convincingly demonstrated in his seminal *Beyond Modern Sculpture* in 1968 (12). The writings by Claude Shannon, Norbert Wiener and Abraham Moles, among others, had a strong impact on pioneering artists like Nicolas Schaeffer and Enrique Castro-Cid, striving to integrate electronic technology into their art practices. The influence was felt in the fields of kinetic art from the 1950s and in cybernetic art from the 1960s on.(13). In such artforms, a system takes an input from the environment and transforms the signal into another form of output, typically into light or sound or movement. Feedback systems and loops were also frequently used in video art in the 70s. All this demonstrates that artists were becoming aware of the nature of the system they were employing.

Particularly since the early 1970s, partly influenced by events like environmental

catastrophes, the Vietnam War and the global Oil Crisis in 1974, the increasing public awareness about the environment and ecology also played an important role in artistic activities. Environmental art, land art and "earth works" focused on the interaction between natural phenomena and human action, becoming an established category of art. In earth works, the "beauty" or power of nature is extracted through the modification of the nature which is achieved by human being (i.e. artist).(14) The convergence of imagination and science was observed in various approaches within visual art.

Cybernetic art can be considered as a direct predecessor to the interactive art as we know it today; its basic idea revolved around the notion of feedback.(15) The main difference lies in the fact that for cybernetic art the presence of the human being was only one possible source of input among many. The actions of the human were mediated by the environment that the artist had selected or created. Today's interactive art is mainly focused on conscious human-computer interaction mediated by the user interface, often custom-designed by the artist (Nam June Paik's "Participation TV" pieces from the 60s anticipated this emphasis on the user interface).

The integration of natural phenomena in earth works can be regarded as the forerunner to the artforms using algorithmic and/or autonomous forms of behaviour. There is a difference in the material involved: while the artists creating earth works dealt with the real nature, media artists today deal with the simulated nature in the digital realms of the computer. (16)

1.4 Changes in the Concept of Art: the Traditional Point of View

Concepts and practices of importing elements such as a chance operations, audience reactions, natural phenomena or feedback from the environment into the framework of art has inevitably changed the paradigm of fine arts. The earlier notion of the artwork as a physical object, a permanent form fixed by the artist, still remains the basis for the commercial evaluation of art, but it no longer applies to such a new form of art. This is a major change compared with the forms that were earlier defined as the arts in the reproduction age(17), such as photography or film. From the above mentioned perspective, photography and film still share the same paradigm with more traditional forms such as painting or sculpture.

The change incorporates the following points(18).

i. Openness to Environment:

A piece of art can change its form according to the influence from outside.

ii . Openness to collaboration :

A piece of art can be realized as the result of a joint activity of an artist and other human or non-human entities who are not artists.

iii. Freedom from materialism:

A piece of art does not necessarily take a physical form.

iv. Autonomy:

A piece of art can be driven by an external system(such as an ecosystem) or an internal autonomous system(such as an algorithm) once the artist has defined its mechanism and the initial

state.

Logically, these features have also made the distinction between art and entertainment much less clear. According to the traditional paradigm, an artwork is conceived and created by an artist (or artists) and then fixed at the moment of its completion. The message of the artwork remains there unchanged, while the way the message is translated to an individual might depend on the background of each viewer or changes in the society. Hence a major difference between art and entertainment in the paradigm of contemporary art is in the existence of a message in a piece (i.e. a piece of entertainment does not need to convey a message), an art piece which changes its form all the time, or a piece which is not produced under the artist's strict control, would not fulfill the notion of art in the traditional sense. (19)

2. Art as a System: The Technical Point of View

If we took a philosophical approach, the concept of art as a system could be expanded to apply to any form of art, hence there is a certain system of perception of art on the viewers' side, and it is through such a system that an artwork is perceived and appreciated by a viewer.(20) However, in this paper it is necessary to discuss the concept more precisely from a practical approach. Therefore, traditional art forms such as paintings, sculptures, non-interactive installations, films and videos that do not have a mechanism of changing forms in itself after the completion of the work are excluded from the following discussion.

I will begin by classifying different types of systems of art in order to make the definition I use in this paper clearer. We observe different types of systems around us, in nature, in our society, or in connection with machineries such as computers. Likewise, there are different types of systems in art which can be classified into the following categories according to the functions they employ.

2.1 The Autonomous System

In general, an autonomous system involves a built-in, time-based function which gives outputs that represent the status of the system. In other words it is a representation or simulation of an environment that stands by itself. It is essentially a closed system which does not take input from the world outside. The audience (the viewer) is only allowed to observe the change. In case such a system is applied in art making, an artist would define the system, set the initial state, and select appropriate values for parameters including the time rate and the degree of change and then let the system operate by itself. Even though the rest depends solely upon the time, the resulting representation along the time axis can be complex and unpredictable typically when the system includes a chaotic nature. Often such a system takes certain random parameters to simulate the reality.

2.2 The Environmental System

Another type of system has an ecological or environmental approach. Such system has an open end that allows input from outside which are not the result of an intended action caused by audience. The input is typically provided by natural phenomena such as light, temperature, wind, tide, or by human factors in environment such as noise.

Naturally the resulting output would not allow an intended intervention of a viewer to the system. Here, the audience might be allowed to influence the resulting image or sound or movement, but the system is not designed for interactivity.

2.3 The Interactive System

An interactive system, or more precisely a user-interactive system, takes inputs from viewers/visitors. The artist conceives and designs the system according to what he/she wants to represent by such system. The system, no matter what kind of hardware it involves, does not function as an artwork without inputs from viewers/visitors. However, it is possible that the system exhibits certain function or image as the initial state when there is no input from users. Often it is more favorable to make it in such way both for the aesthetic reason (especially for an exhibition) and to encourage users to interact.

Being interactive does not necessarily mean the use of computer. Mechanical, optic, electric or electronic technology can be used for interactive systems. Nevertheless, since computers provide with more complexity or flexibility in interactive art, most of the serious interactive systems are built around digital technology.

Different levels of interactivities can be observed among interactive artworks. Followed are typical interactivity used in such systems for art. The level of interactivity is usually chosen according to the nature and aim of the artwork and the performance of the hardware that the work would be installed or viewed.

i. Interactivity for browsing or navigation

The lowest degree of interactivity can be seen typically in CD-ROM publication of photography, paintings or museum guides, as well as with most of the web sites. Users are allowed to navigate through already existing image or text files without changing them. It is an interactive but static way of database retrieval.

ii. Look around / walk through / fly through

A user would be able to look around, walk through, or fly through in a 3D (or pseudo-3D) space. The space and its representation is usually precalculated. The image is refreshed according to the viewpoint of the user. Often there are spots with links to other files so that the user can go into another landscape or get more information one needs. QTVR or VRML can be used for such purpose among other possibilities.

iii. Interactive storyboard

Higher yet still limited interactivity can be observed with the most common type of video games such as role playing games. The story branches according to the user's choice. Also the events that take place on the screen such as the speed of movement or the way of fighting against enemies reflect the user's action. But all the possible events and storyboard are pre-designed and prepared by the game developers. Nothing unexpected by the designers/artists would happen.

iv. Program-based interactivity

Artists can provide spontaneous interactivity on the Net and on local computers by programming or using scripting languages. Users can see texts, images or sounds which are generated or reconstructed on the fly, not as precalculated or prepared files. The degree of freedom in interaction depends on the concept of the work and the technology available. With the advent of tools such as LINGO and JAVA, the amount of interactivity on the Net and in package media has greatly increased. By combining the possibilities these tools provide with other forms of interactivity as mentioned above, highly complex and user-oriented interaction can be achieved.

A higher degree of interaction is available with the use of computers with higher performances and appropriate pieces of software usually written for specific purposes, typically seen as interactive installations. It is in this category of interactivity that a real time simulation and/or visualization of an imaginary environment is made possible when combined with an appropriate user interface, which would be typically applying virtual reality technology. Such an interface allows spontaneous interaction between the imaginary environment and the user(s) when the designed interaction is intuitive enough.

2.4 Interfaces for Virtual Reality Art

Currently the most advanced technology used in interactive art is that of virtual reality. Virtual reality technology allows an artist to realize one's imaginary space as an immersive environment and let the audience/the users interact with the space itself and often also with objects placed in the space. The nature of objects in such a virtual environment varies according to the concept of the work.

In the history of virtual reality, the term itself originally used to mean an immersive environment which one can experience by means of stereoscopic vision. The head-mounted display (HMD) was long considered the most reliable and realistic hardware to achieve an immersive stereoscopic vision in real time, yet it caused disturbing physiological problems for the user (partly because of its weight) that have largely remained unsolved. Research and development to achieve a better interface for immersive stereoscopic vision with less burden for the users has, however, continued, as demonstrated by the success of BOOM, developed by FakeSpace Labs in the USA.

However, the approach some artists adopted in relation to the sense of immersion was

different from that of researchers and engineers. Already in the 1980s, Myron Krueger introduced his Videoplace, a system which did not resort to using HMD or any other stereoscopic displays, yet it incorporated virtual environments within real spaces.(21) David Rokeby developed a system called Very Nervous System (VNS), which detects a movement (of a user, usually) in a physical 3D space and transforms it into a sound or an image. Both systems employ video cameras and real time image processing. These systems became known to researchers through venues such as SIGGRAPH, and influenced the development of virtual environments with more natural interfaces.(22)

There are two major reasons why artists, beside their artistic aims, have pursued the realization of virtual reality without using HMD or other physical wearable interfaces. (23) Their motivations differ from the more general interest in interface design from an engineering point of view.

i. As to the nature of art, the audience/the users should be placed in an environment within which they can focus on the artwork as well as possible. Should the user be aware of the weight or the cumbersomeness of the interface all the time, he/she fails to immerse oneself subjectively into the world the artist is representing.

ii. A work of interactive art is meant to be used by multiple users, not necessarily together, but a certain number of visitors should be able to use the piece within a certain period of time. If a piece requires too long time per user, including the time spent for preparation (i.e. mounting, calibrating and dismounting), and if other visitors have to wait without being able to share the experience, showing such a piece to the public is practically impossible. From this point of view an interface like HMD or any system which requires calibration for each user separately is not the right choice for an artwork in many cases. (24) Since it is important for artists to have their pieces shown in public venues, artists are under pressure to seek for appropriate interfaces for presenting virtual reality artworks.



Fig. 2 -4 D. Rokeby "Very Nervous System" , the space without any visible sensors

The major advantages of systems that use a video camera and real time image processing are that the visitors do not wear anything, and that there can be multiple users in the space (25). The CAVE system, which is based on the combination of a stereoscopic immersive projection environment and a sensor (3D digitizer) to locate the user, has solved the problem of multi-user, non-HMD requirement for virtual reality art to a certain degree and has become a standard

platform for virtual reality art. Recently even more immersive CAVE-based systems have been developed, such as CABIN in University of Tokyo and other six-screen CAVEs in Gifu, Stockholm and other places. Interaction between more than two CAVE systems using telecommunication has also started. Yet offering enough interactivity to multiple users during one session remains a problem -- usually only one visitor interacts at a time and the others are merely spectators (26).

2.5 The Elements of Interactive Art

An artwork that involves a high level of interactivity is usually represented as an interactive installation mainly because of the originality which is required in designing a user interface as well as in visual presentation.

The concept, the aesthetic of representation, and a well-thought user interface are the major elements of a successful interactive work, whether it uses a computer or not. Aesthetic representation includes the images and the setting. The user interface can be either straightforward and easy to learn, or deliberately weird and difficult to handle, according to the concept. These elements should have a consistency among them even though the requirement for real time response makes it more difficult to achieve. These points will be discussed later with reference to particular works.

2.6 Cyberspace

The term cyberspace refers to a networked virtual environment such as the communities on the Internet. Cyberspace is more related to the subjective sense of sharing a virtual community than to the physical sense of being immersed. However, with the current technical developments in networked virtual reality from VRML to the networked CAVE, a high-end VR environment will be soon to be realized as a multi-modal cyberspace.

A network offers a platform for interactive art as already described in chapters 1.2 and 2.3. Using the network as a medium to generate a conceptual shared cyberspace is an interest often observed in the field of interactive art. On the other hand, an increasing awareness about the feeling of "virtuality" and reality on the network has given rise to a new approach in art. As will be discussed later, the relationship between the real space and cyberspace is dealt by artists from various aspects, often with underlying critical thoughts.

3. Alife and Interactive Art

3.1 Life as Theme of Art

Life is one of the great themes of art - human beings have always been interested in and

wondered about the origins, the nature, or the outcome of our lives. Whether we approach life from a philosophical, biological or social point of view, we cannot escape from thinking about it. Probably every civilization that has existed on earth has had its own myth or story about the origins of the different life forms. Countless works of literature and film can also be regarded as presentations of simulated life stories of individuals or societies, either from a historical or a contemporary point of view. A typical case is a literary genre like science fiction, where an imaginary environment inhabited by human beings or other life forms can be presented with the explanation about their origins as imagined by the writer. The representation of such imaginary worlds in art and literature is not new. Classic painters like Hieronymous Bosch or writers like Jonathan Swift, among others, have created and illustrated their own imaginary worlds.

With the advent of the computer, it has become possible for an artist to systematically create an imaginary mode of life, or an environment inhabited by virtual creatures, and present it as a series of static images or an animation, or even as an on-going virtual world inside a computer. This is an advantage for an artist -- not only because he/she can create an interesting scene, but also because the imaginary "world" of the artist can be realized in its entirety in a virtual space. In fact, even in the case of traditional paintings, artworks are often artistic "snap shots" from the imaginary world of an artist. For certain artists such as Yoichiro Kawaguchi, the imaginary world seems to exist all the time in the artist's imagination with its own time and space as well as its own ecosystem, almost as a parallel to the real world.

In Troy Innocent's "Iconica" visitors communicate with aliens who live on their planet and lead their own life. Alife as a concept has provided a bridge between such an artistic approach and scientific research. In fact, since the first alife conference in Santa Fe, artists have played an important role in establishing and enriching the notion of alife. Craig Reynolds, a computer scientist who has worked with Hollywood animators to realize a flock animation, presented a paper at alife I; Karl Sims, who is an artist as well as a researcher, and even a co-founder of a Hollywood-based animation production company, has powerfully visualized the impact of alife. The concept of alife has encouraged artists working around the idea of art as a system. Works by major artists in this field, such as Karl Sims, Christa Sommerer and Laurent Mignonneau, will be discussed later.

3.2 Life for Conceptual Media Art

Conceptual art is a form of art where an artist would present his/her concept in a symbolical manner rather than showing it through certain visual (or audio or textural) form which would directly convey the idea to the audience. What is essential in conceptual art is the concept itself rather than its representation. Naturally such a form of art is often difficult to understand or enjoy for the general public. Also, the types of concepts that artists can convey without much visual representation are limited.

As a computer can simulate the real world as a system, not necessarily through visual means, it has become a new medium for conceptual art. Abstract forms of life in a computer are

opening a new possibility for conceptual art. For example, computer scientist Tom Ray's TIERRA and its network version (Networked TIERRA) have attracted attention in media art circles, not because of its visual representation but because of its concept. Even though Ray did not intend to make a piece of art in the course of his research, his experiments are appreciated as a form of conceptual art. Such appreciation is based on the widely accepted idea about contemporary art after the paradigm shift, as already discussed.

3.3 Beauty of Nature

Even though the paradigm of art has changed, aesthetic is still a theme of art. In the art history, while some artists including the artist/scientist Leonardo Da Vinci took an analytical approach to seize the beauty of nature through its mechanisms, most artists continued reproducing or copying natural beauty based on the outer appearance of things. Even though the scientific approach became a part of the practice of art in certain fields such as the expression of light and the depiction of the human body, bridging art and science is not yet commonplace in the history of art making.

Computer scientist Benoit Mandelbrot discovered that the nature's beauty (rocks and mountains, in particular) could be simulated by using a fractal algorithm and showed such images at SIGGRAPH 1978. It brought broad attention toward the possibility of simulating the beauty of nature by using computers. In 1982 the artist Yoichiro Kawaguchi surprised computer graphics researchers with his GROWTH model which was based on the idea by D'Arcy Wentworth Thompson that made the procedural modeling of organic figures possible. About the same time, the artist/researcher Alvy Ray Smith applied particle systems to represent bushes and trees. These achievements represented a major breakthrough in the representation of natural objects and their behaviour by computer graphics. Consequently, research in physically based modeling and dynamic simulation made it possible to simulate animals realistically. AMAP from France and L-system from Canada made realistic plants modeling and animation possible. Instead of the combination of geometry-based modeling and key-frame animation, these procedural approaches based on simulation of the law of nature can be applied in representing the outlooks and behaviours of creatures and their environment. These technical innovations that took place during the 1980s and the early 1990s contributed to the formation of the concept of alife.

Artists now have tools to reconstruct plants or animals and their environments through simulation. It is an approach to natural beauty from the inside, while observing the nature and illustrating it with paint brush is an approach from the outside. The great advantage of such an internal and algorithmic approach is that an artist can modify the algorithm and the parameters according to his/her aesthetic, and still the result is consistent with the system he/she applies. For example, the imaginary aquatic creatures designed by the French artist Louis Bec swim elegantly according to simulated fluid dynamics; natural beauty based on a zoological concept is combined with artistic quality. Yoichiro Kawaguchi's creatures (even though the artist has chosen

to present them to audiences as prerecorded sequences of animation) reflect the artist's unique aesthetic while following the growth rules defined by him and modeled after the nature's laws. These examples show that the concept of alife combined with the use of the computer can be a powerful tool for an artist to develop and expand one's imagination.

3.4 New Possibilities for Creation

As demonstrated by Karl Sims' "Genetic Images", which will be discussed more closely in Chapter II, 9, an alife based approach, particularly one applying genetic algorithms, has provided many possibilities for new forms of creativity. Forms and colors which are difficult to model and render solely through one's imagination can be achieved by designing a system instead of designing a new product every time. For the moment there are not many artists who can work with computers in such a manner, but in the near future we will surely see more works in this field. Such an approach will certainly raise a serious discussion as to the definition of art and the role of the artist. Let us imagine a typical (or rather, "generic") alife-based interactive artwork -- visitors would design virtual creatures and leave them in a virtual environment; the creatures would live or die autonomously, according to the system the artist has initially designed. Then, what would be the role of the artist? Once the initial design and setting of the system has been accomplished, the virtual world continues without any intervention by the artist.

This feature of alife art inevitably pushes the boundary of art to the direction I have described earlier. An alife artwork cannot be under the strict control of the artist. However, this does not mean that such an artwork would be out of the artist's control. For example, in Christa Sommerer and Laurent Mignonneau's "A-Volve" or "GEMMA", visitors can create their own "creatures" through interaction. The creatures gain their look and behaviour as the result of the visitors' action, yet the way they look and behave would still remain within the range of possibilities the artists had anticipated, displaying their "signature". It is a part of the artist's decision and skill to achieve what might be called a meta-design of possible future characters or scenes.

Of course, there can be more neutral systems that allow users more freedom in the design process. With the technology currently available, it will be soon possible for an artist or a business to design a system with which users (possibly via Internet) create human or animal characters according to their own choices with capabilities such as face animation, body action, emotional expression, speech, etc. These features are already more or less available in entertainment products as well as on the research level. While businesses would hesitate to take risks launching such features because of ambiguous copyright issues, artists might find them interesting and meaningful. In fact, one of the goals of art is to visualize the conflicts between traditional paradigms and the emerging new paradigms brought by social changes.



Fig. 5-6 GEMMA by C. Sommerer and L. Mignonneau



Fig. 7 Galapagos by K. Sims, exhibited at ICC



Fig. 8-9 The Menagerie by S. Amkraut, M. Girard, S. Fischer
Earlier version(left) later version(right).



Fig. 10 The inside of a bug-shaped robot
U. Gabriel's "Terrain"



Fig. 11 Knowbotic Research 1993

This is closely related to the whole on-going paradigm change in art. Digital technology, especially through the changes of meanings it has brought to the notions of copying, multiplying, editing and communicating, is changing the basis of art, just as it is changing the society. Contemporary artists like Yasumasa Morimura, Noriyuki Tanaka, Katsuhiko Hibino and others have been using digital technology to probe experimentally this change of meanings of personal life in the society. (See Chapter II, 11.) Alife art is an art form which has evolved exactly from such changes in the cultural environment. The experiments and works by some of these contemporary artists will be discussed in the later chapters.

4. Different Approaches in Alife Oriented Art

4.1 The Criteria of Life

As biology deals with life from different points of views, so does alife. Artists applying it look at life from different points of view to reconstruct it from an artistic perspective. The criteria of Farmer and Belin apply to alife related artworks as well. In short, it can be said that there are as many artistic approaches to life, as there are corresponding biological elements of life in the list that follows:

- a. pattern in time/space
- b. self-reproduction
- c. self representation
- d. metabolism
- e. organism/environmental relation

- f. parts in a functional coherence
- g. dynamic stability
- h. evolution
- i. autonomy

4.2 Art and the Criteria of Life - a Brief Overview

Genetic algorithms and behavioral patterns in the time/space of virtual creatures have been often used in alife art. Genetic algorithms have been used by previously mentioned artists like Karl Sims, Christa Sommerer and Laurent Mignonneau. These artists have not only used these algorithms for their art, but they have also contributed to the study of alife by visualizing the role of genetic algorithms in a much clearer way than could have been achieved with real creatures.

Craig Reynolds developed the Boid algorithm to simulate the behavior of flocks and schools. It was used in the animation "Stanley and Stella - Breaking the Ice", and since then in many films including "Batman Returns". Susan Amkraut and Michael Girard also developed a flocking algorithm in the mid 80s together with other algorithms for the realistic animation of animals. Their algorithm was used in the virtual reality artwork "The Menagerie" which provided visitors a possibility to enjoy the beautiful movements of flocks of virtual creatures.

Michael Tolson, co-founder of XAOS Co., developed a widely used commercial software package which for the first time applied biological simulation to image processing. With this algorithm, the colors of pixels are regarded as if representations of different microorganisms. Thus an image can be considered a color pattern represented by colonies of such virtual life forms. By defining the nature of each microorganism and modifying the ecological status of the environment, the map of colors would change according to the migration and degree of prosperity of each species. The effect is quite different from other image processing/filtering tools based on geometric features. Tolson himself used his original algorithm in his artwork "Las Meninas" (1995). In it a 3D environment inhabited by abstract patterns would create a real time experimental animation according to the interaction. The piece was exhibited and awarded at the Interactive Media Festival in Los Angeles in 1995.

"The Flock" by Kenneth Rinaldo and Mark Grossman (1993) demonstrated the emergent behaviour of a flock of arm-like robots provided with their own communication system. Kenneth Rinaldo further developed the concept in his most recent piece titled "Autopoiesis"(2000), commissioned by Kiasma. The Museum of Contemporary Art in Helsinki, Finland, for its Alien Intelligence exhibition. This version incorporates web-cams that some of these robots use to distribute the images they see with their camera-eye. Also Ryoichiro Debuchi belongs to the artists who have realized such algorithmic autonomous environments with different species of creatures, although realized as a series of animations.

Ulrike Gabriel's "Terrain 0.1" puts the visitors in a paradoxical situation. A participant is

invited to sit by a circular arena on which little robots are moving around. The flock of bug-like solar robots gets energy from a lamp on the ceiling. Its intensity changes according to the state of the visitor's brain waves. However, the circuit is designed in such a way that if the visitor gets interested in the movement of the robots (and thus gets excited) the light intensity will diminish. The concept of the work is to show the relationship between human beings and technology through a non-straightforward interaction. Such a deliberately difficult interaction is also intentionally used in her other works, reminding the visitors that the human body and the mind do not work as machines. The behaviour of the bug-like robots looks natural, but in fact they are driven by simple rules (1. run toward light, 2. avoid others, 3. if neither 1 nor 2, stop), reminiscent of the flocking algorithm created by Craig Reynolds. One might find a certain cynicism in Gabriel's endeavour. The piece will be analyzed from the point of view of interaction in later part of the dissertation.

A series of projects by Naoko Tosa and Ryohei Nakatsu at the ATR Research Laboratories, began with Tosa's *Neuro Baby*, is another example of an attempt to create life-like creatures as an interface to more natural communication by depicting our daily life behavior or physiological elements. Rebecca Allen's recent work *Emergence*, experiments taking input from the user's mood to define the behaviour of virtual character in a mythical world. The experimental agent system "ALIVE" by Pattie Maes and her collaborators at The MIT Media Lab, has been considered a piece of art as well. ALIVE is an experiment purporting to realize a friendly agent as an interface to communication systems.

The German artists' group Knowbotic Research seeks for a relationship between their invisible knowbots on the network and the audience. The New York -based Japanese artist Seiko Mikami has experimented with a virtual wet-wear approach on the Internet. In her *Molecular Clinic* the users are allowed to take a molecule from a virtual spider, change its RNA and return the molecule. The DNA of the spider's molecules thus goes through a continuous change as a result of these operations taking place through the network. I will further discuss her work in Chapter IV.

On the web, there are now more activities which aim at providing an environment where users can deal with a group of virtual creatures. While some of them are rather simple, created using off-the-shelf tools such as MacroMedia Director, there are more sophisticated works realized by artists and researchers. Some of them are related to the idea of agents or cyberspace.

Among the works mentioned here, some fulfill quite a few of the criteria of life and thus give a stronger impression of virtual life, while others focus on more limited elements and show a more abstract approach to life.

4.3 Interaction or Observation?

Another important factor in alife oriented art is the relationship between the artist, the audience, and the work (the system) itself. According to the theme and the intentions of the artist, a system can be designed as an autonomous system which allows the audience only to observe (as

in the case of Tom Ray's works), or the interaction may take place with virtual creatures or an ecosystem, the audience being an essential part of the work both in terms of the concept and the architecture, as in the case of Sommerer and Mignonneau's works.

A more limited form of interaction can also be employed, as in the case of "The Menagerie" realized by Scott Fisher, Susan Amkraut and Michael Girard. The user looks into and (virtually) visits a virtual world filled with animals by means of a BOOM 2 by FakeSpace, a telescope-like stereoscopic viewer with the sensing device to locate the viewer's movements. If one goes too close to a flock of animals they will run away. Here the interface and the level of interaction match well the concept of the work, since the user is supposed to enjoy watching the virtual animals without scaring them, as if he/she were in a natural park on the African savanna. As mentioned in the previous section on interaction, the important thing is the consistency between the concept and the system, including the interface design.

5. A Case Study: A-Volve by Christa Sommerer and Laurent Mignonneau

5.1 The Basic Principles of the Artwork

A-Volve, created by the artists Christa Sommerer and Laurent Mignonneau, is an installation, the main part of which is a pool inhabited by artificial "living" creatures. Their evolution is open to outside influences - the creatures react to and interact with both their "natural" and "artificial" environment.

After entering the space of the installation, the user is supposed to draw with his/her finger on a touch-screen an outline for a creature he/she wishes to create. There is no need to restrict oneself to the shapes of actual existing creatures. When the outline for the creature is ready, the user presses the "send" button; a few moments later a "living" creature with the outlined features swims out from the depths of a "pool" (actually a video projection on the surface of a shallow pool of water) a few steps away from the touch-screen. The creature expands and contracts its brilliantly colored body, swimming like a jellyfish or a squid. According to their shapes, some creatures swim around quickly, while for some the resistance of the water is so strong that they float in a swaying manner. When one reaches out one's hand, the creatures try to escape; the idea, however, is to capture them in the water to pet them. The creatures may live shorter lives if there is no-one to care for them. The visitors reach out their hands towards the attractively shaped creatures. The organisms with no one to touch them sink into the depths of the pool and disappear, or may end up being eaten by stronger organisms. The slightest twist of imagination or even the careless movement of the finger on the touch-screen may not only determine an organism's shape and color, but its fate as well.

5.2 Water as a Medium and an Interface

The world of the "living" creatures in the aquarium is related with the individuality of the

viewers surrounding the pool. The touch-screen and the pool are physically connected with cables through the computer. There are "waterways" invisible to the eye, sending the organisms born from the touch-screen out into the pool of water. The creatures whose "time has come" sink into the depths and disappear.

In A-Volve water is used metaphorically as the medium for nurturing virtual life. Water is the medium in which primordial life was first born and began to evolve. At the same time water is used as an user interface. This is a very clever and practical choice from both a technical and a psychological point of view.

From a conceptual perspective, water is the environment in which these artificial creatures live, an interface connecting the unreal with the real. By sticking their hands in the water, people disturb the borderline between these. Thus the artificial creatures in the virtual world live within the zone of interactions between the real and the unreal.

The user's impression of these creatures, which might be little more than patterns of light projected in real time, mixes together with the sensation of the water. As a result one gets the feeling as if they have soft, jelly-like bodies. Water is used to provide the user with a tactile sensation, although there is no real interactivity between the form and the touch. Because of the basic design principles of the virtual creatures (their transparency, the way they move, etc.) the visual impression helps the user to virtually feel the jellyfish. Realizing the tactile sensation is one of the most difficult challenges facing the creators of virtual reality experiences; to solve this problem Sommerer and Mignonneau have skillfully used water to contribute to the creation of a multi modal environment.



Fig.12-13 A-Volve by C. Sommerer, L. Mignonneau Fig. 14 Genetic Images by K.Sims



Fig. 15-17 C.Sommerer and L.Mignonneau: Interactive Plant Growing

The creatures in A-Volve have also been programmed to mate. When the user manages to capture two of them simultaneously and bring them together, the coordinates of their bodies overlap. After this they sink into the depths and disappear, but in their place a small organism appears, growing larger before the user's very eyes. A new life is born in exchange for the lost lives of its parents. As this example shows, A-Volve hides within it many metaphors. Its concept is very far from the naive formalism and simplicity sometimes associated with technological art by traditional art critics.

5.3 Other Artworks based on the Genetic Approach

The concept of A-Volve, based on the idea of imaginary organisms designed freely and then giving birth to new life-forms according to genetic algorithms, has points in common with the principle that the British artist and computer scientist William Latham has called the "god's gardener", referring to his own role in creating virtual organisms as his artwork. (See Chapter II, 8.) It also has to be stated that the idea of the interactive creation of virtual life forms by means of genetic algorithms had been developed already earlier by Karl Sims, another artist-computer scientist, whose work involves the behavioral animation of such creatures.

Furthermore, in that A-Volve algorithmically determines the movements of the designed forms, it can be compared with the imaginary ecological systems created by the French artist Louis Bec. (See Chapter II, 3.3) Bec asserts that by systematically creating imaginary life forms matched to their environment it will be easier to achieve a complete biology than by supplementing current biological systems. Bec uses the rationality and purposiveness of living creatures as a criterion to discriminate between the real and the unreal. One of the innovations of A-Volve, however, is the awareness that recognizing imaginary life forms also has psychological implications. The freedom to design forms at will means not only that you can enjoy seeing forms that you have chosen personally swimming in water; it also means that those imaginary creatures become an extension of yourself, and you must accept responsibility for their ways of living. Sommerer's and Mignonneau's collaboration with the computer scientist Tom Ray aims to complete A-Volve as an ecological system. No doubt differences in species and sex will emerge within this system. Generational changes based upon genetic algorithms will also arise. The individual organisms born from people's fingertips will eventually construct, within the pool, a coherent ecosystem.

Sommerer and Mignonneau's works are characterized by their relationship to nature and life. This has opened up a new genre within alife art, not only because the interfaces of many of their works are natural objects, such as plants or water, but also because the birth and the development of virtual life forms is brought about by the interactive, communal work between people and nature, also incorporating the non-quantifiable aspects of feelings, emotions, and moods of plants and people.

While there are many aspects to A-Life, the approach developed by Sommerer and

Mignonneau is not mainly focused on nurturing life inside the computer; rather it aims at creating modes of natural communication between humans and other possible "living" beings (including imaginary digital creatures) via the computer. This endeavour necessarily takes an interactive form. Interactive Plant Growing, Sommerer's and Mignonneau's first artwork, already dealt with this issue. Interactive Plant Growing has been exhibited around the world, and will undoubtedly remain an important work in the history of interactive art. In this installation actual living plants are used as the user interface. They have been placed in a space where neither computers nor cables are visible. Touching the plants makes corresponding life forms grow on the screen. The viewer's actions are not the direct cause of the result; rather, they are translated into the reactions of the plants, which induce the growth of the imaginary plants.

The biological, physical fact that human beings are electrified and form magnetic fields by their movements means that through the sensual experience of discovering plants and approaching to touch them, people produce an effect upon the plants' life (as they respond to the magnetic field); this response is transmitted to the computer, giving birth to imaginary plants. Here, we realize that we ourselves as viewers give birth to plants by being there, with our body. The mechanism inside the human body has become the interface between the real world and the virtual world.

The originality of the concept of Interactive Plant Growing lies in the fact that the user's self-expression was routed through the response of the Other (the plants). In contrast, A-Volve gives life to the viewer's imagination more directly, and at the same time assigns the responsibility for him/her. In addition to the "corporeality" of the imaginary organisms, the users materialize a psychological and ecological reality. By doing so Sommerer and Mignonneau are exploring the possible meanings of interactivity; at the same time they are also investigating the very relationship between the real and the unreal.

5.4 Alife and Art: Conclusion

It can be claimed that art as a system is constantly gaining in importance. An artwork applying such principles creates a new kind of field of meaning influencing and being simultaneously influenced by the audience / the users. A dynamic system based on logically consistent principles, yet providing ample room for variations and interactions ("openness"), offers possibilities, which can be applied on numerous fields in contemporary society, also outside the realm of the arts. Technological art can give an important contribution to exploring these possibilities and even discovering new possible fields of application.

Generating fully realistic images is still complicated and expensive in terms of the realtime computing power. While it is the task of engineers to find solutions for creating better and better "objective" simulations of reality, the artists may choose a different approach by creating more subjective realities. However, to achieve the best goals these approaches should complement each other. A convincing context and an intensive sense of involvement are crucial factors for providing an audience/the users the sensation of being immersed into a virtual environment. But these alone are not sufficient, if the general concept of the work is shallow,

unchallenging and lacking in originality.

In spite of the current technical limitations the popular and critical success of the artworks dealt with in this chapter has already proven the viability of the alife approach. Artworks like Christa Sommerer's and Laurent Mignonneau's A-Volve or Karl Sims' Galapagos lead people to think about life from a new kind of perspective. Life has always been a theme in art, but earlier it had to be transformed into a story or images to be able to trigger thoughts and emotions in the recipient. In the case of the artworks analyzed in this chapter the visitors experience and effect the birth, the selection and the death of virtual lives they are responsible for. According to my own observations, some people interacting with Sims' Galapagos when it was shown at the InterCommunication Center in Tokyo, hesitated to "kill" the "not interesting" life-forms they had created. Through interacting with virtual creatures or a virtual ecosystem, visitors come to think about the real world in a different way. This is one of the goals the interactive artists aim at when dealing with art as a system. All this shows that the alife approach has broadened the possibilities of creativity.

6. Conclusion

In this chapter I analyzed the history of art from the point of view how science and technology, not only by themselves but through cultural influence as well, changed the art both in concept and practice. Art has taken the concept as being a system, rather than a static result of creation. Such concept of art overlaps with what alife has brought up. In this cross-section of art, science and technology, what artists do is also influencing the others and helping raising new ideas about creativity.

notes

1. Lucy Lippard: *The De-Materialization of the Art Object*. London: Thames & Hudson, 1971.
2. Elizabeth L. Eisenstein: *The printing press as an agent of change*, Volumes One and Two, Cambridge: Cambridge University Press, 1979.
3. Walter Benjamin: "The Work of Art in the Age of Mechanical Reproduction" (1936), in: Benjamin: *Illuminations*, London, Fontana Paperback, 1979.
4. Susan Sontag: "On Photography", Farrar, Straus, and Giroux, New York, 1977.
5. There is an arguments that an artwork starts having a meaning at the moment it is produced. However, if we consider such a case that a piece of painting is done, but is stored in an attic without being known to anyone else except the artist him/herself, and then lost without a piece of information about the piece told to anyone else, it is clear that the piece practically did not exist. It is not the physical existence of the piece which is the most significant. What it conveys to people makes the meaning of the art piece. This point is also related to the meaning of reproduction technology in art appreciation, and further to the meaning of the artwork itself in digital artform and interactive art.
6. Artists like Marcel Duchamp and Man Ray, who were related with Dadaism, can be considered forerunners of media art.
7. See Malcolm Le Grice: "Abstract Film and Beyond", Cambridge, Mass.: MIT Press 1977, p.35.
8. Neo-DADA movements in the 1950s in the USA, with participants like John Cage, Robert Rauschenberg, David Tudor and others, developed into FLUXUS. About the early developments, see: Alan Kaprow: *Essays on the Blurring of Art and Life*, Edited by Jeff Kelly, Berkeley and Los Angeles: University of California Press, 1993. FLUXUS-related artists like Nam June Paik, Yoko Ono, Genpei Akasegawa and others gave rise to the concept of art as process which involves the presence of the public. They are also considered pioneers of electronic art who started using electric and electronic technology as their major tools for creation.
9. About the history of early video synthesizers, see *Eigenwelt der Apparate - Welt / Pioneers of Electronic Art*, edited by David

Dunn, Linz: Ars Electronica, 1992.

10. Among the numerous publications regarding Fluxus, see "Happenings & Fluxus" , Koeln: koelnischer kunstverein, 1970, which includes the materials from their performances that show how the participation of the audience was taken into their works.

11. Kusama's art practice can also be discussed from the perspective of the notion of originality in art. In a sense Kusama "used" other artists' works to create her own artwork. This concept has been rediscovered with the arrival of network communication. The issue will be discussed in more detail in a later chapter in relation to Renga projects and the Japanese culture.

12. Jack Burnham: *Beyond Modern Sculpture*, New York: George Braziller, 1968, p.343. Significantly, the first major exhibition of computer art was titled "Cybernetic Serendipity". It was curated by Jasia Reichardt and took place at ICA in London (1967). The naming of the show and its timing demonstrates that early forms of electronic art were related to the information theory. See: *Cybernetic Serendipity. The Computer and the Arts. A Studio International Special Issue*, edited by Jasia Reichardt, London: Studio International, 1968.

13. One of the main practitioners of cybernetic art is Wen-Ying Tsai. He combines microphones as the input devices to control his optical sculptures. Devices which were already common place at that time such as microphones, optical sensors or mechanical sensors (such as pressure sensors) were used as input devices. The changes of electric current from these devices were then transformed into a different form of output such as switching, frequency or volume of sound, light color or interval, frequency of motor which might generate image or sound, etc. Alexander Calder was the first artist who consciously used environmental energy as an input. His idea of mobile sculptures that use wind and move freely as the wind blows was a new concept in art both in terms of the use of environmental input, and the disappearance of the concrete 'final form' of the artwork. Calder's mobile sculptures usually consist of several pieces which move independently. See: Cynthia Goodman: *Digital Visions. Computers and Art*. New York and Syracuse: Harry N. Abrams and Everson Museum of Art, 1987, pp. 143-144.

14. Artists like Christo, Robert Smithson and Andy Goldsworthy are known for their earth works. In Christo's Valley Curtain, for example, the wind that blows among the complex slopes and valleys was visualized. Goldsworthy rearranges fallen leaves, rocks and other objects he finds in the nature.

15. Jack Burnham: *Beyond Modern Sculpture*, New York: George Braziller, 1968, pp. 312-320.

16. Some contemporary artists, for example James Turrell, employ both real nature and its simulation, or simulacra.

17. As Walter Benjamin analyzed, art based on reproduction technology has a different nature from traditional artforms when we consider the value and meanings we project on such works. However, at this point we deal with the issue of artworks being fixed after the production, hence discussing artforms such as photography or film together with paintings or sculptures.

18. Some of these features are essential in music and in performing arts. In these genres the relationship between the score or scenario which is given by the composer or the writer and its realization by the director and performers can have many possibilities, sometimes even additional elements coming from the reaction of the audience. John Cage brought a new paradigm in music by deconstructing and reconstructing the traditional relationship between the composer, player and the audience, changing the meaning of music itself. This paper does not cover music and performing art.

19. Opposition to the old paradigm of art was in fact what DADA and FLUXUS artists meant. They used technology in their artmaking partly because it was an act against the old paradigm of art that refused new technology.

20. An artist might claim that his/her piece is a representation of a psychological mechanism where a thought of a viewer would go through a change (if the piece is successful enough). Of course such function is the major element of art without which any audio-visual physical mechanism would be a mere gimmick.

21. Myron W. Krueger, "Artificial Reality II" Addison-Wesley, 1991

22. Myron Krueger called his approach "artificial reality", a notion which preceded "virtual reality". David Rokeby's work was introduced at SIGGRAPH's first Tomorrow's Reality exhibition, which was the first showcase of technical and art pieces using the idea of virtual reality. Use of video cameras in the real space to detect the action of the audience/visitor is the key technology in their approach, and since then this method has been widely used among artists. Christa Sommerer and Laurent Mignonneau belong to this lineage.

23. Polarizer 3D glasses are usually accepted as a natural interface, since they are as light as normal glasses people are used to wear.

24. This depends on the concept of the artwork. In some pieces a feeling of isolation from the rest of the world is required. Artists like Knowbotic Research, Ulrike Gabriel, Char Davies and Keisuke Oki have used HMD's in their works. In most of cases a larger projection screen is used to present a view of what the user/visitor is seeing so that other visitors would be interested to stay as observers.

25. Works such as A-Volve (Christa Sommerer and Laurent Mignonneau) and Moppet (Tamio Kihara et al) are notable cases where interaction between users/visitors is a main feature of the work.

26. In CAVE applications only one user functions usually as the navigator (or the "driver"), while the other participants have to adapt themselves to his/her actions and point of view. The artist Jeffrey Shaw has developed a multi-user interface for his

collaborative work "ConFiguring the CAVE". The interface is a large wooden puppet which is placed in the center of the CAVE. The puppet's limbs can be manipulated by different users simultaneously. The sum total of the gestures triggers changes in the image environment. The French artist Maurice Benayoun has developed yet another kind of interface for his artwork "World Skin" (realized with Jean-Baptiste Barriere). A set of pocket cameras hanging from the ceiling is used as an additional interface. The concept of the work - a virtual photo safari in a landscape of war - matches the situation where one user drives and others take photos.