The Impact of Information Tools

From Simulation to Stimulation

Dear Ladies and Gentlemen,

I think we live at the threshold of a material revolution. Inventions in nanotechnology, in molecular chemistry, and molecular biology will radically change our view of matter. Many new materials will emerge, many new features of material will be discovered and invented in the next decades and completely change our civilization. We could claim the shift of paradigms in the digital age from simulation to stimulation in the post-media era. In the beginning, I will shortly introduce you in the triumphs of visualization – how we become able to simulate perfectly the organic processes of mind, matter and nature. And later I will show you that we are capable to the pure simulation of life, pure imitation of life, mind and matter, which was the direction of the digital revolution up to now, and that now we will enter in a new phase which I will call stimulation.

First I would like to show you some examples, classical examples of visualization. Visualization is, as I said before, the man made visual simulation of processes of nature. For example here at the ZKM, we have, with the head of the Department of Visual Media, Bernd Lintermann, we have, since 1995, developed a program called xFrog, which consists

mainly of genetic algorithms following Przemyslaw Prusinkiewicz (Polish Computer Scientist) and Aristid Lindenmayer (Hungarian Biologist, 1925-1989) and their *The Algorithmic Beauty of Plants (The Virtual Laboratory)*, (1990). These genetic algorithms can imitate in real time the natural processes of the unfolding of plants of all kinds. So when in classical art, people just could visualize the form of nature – of flowers, of trees, or the human body – we have learned that in non classical, digital art, with the help of computers, we can visualize not only the form of nature, we can even visualize the growth of forms. D'Arcy Thomson has said in his famous book *On Growth of Forms* (1917) we are now able to have mathematical models, which basically are linguistic programs, and we are able now to use these mathematical models to simulate the growth of form in nature. This is the classical step. When we have this, we can originally develop algorithms to simulate processes of civilization, not only of nature, processes of human construction, for example constructions of buildings, so we can simulate the construction of sentences and with the help of these formalized languages like ALGOL (algorithmic language) etc. which are programming languages we can not only simulate the construction rules of nature, we can also simulate the construction rules of civilization itself, for example here, another work by Bernd Lintermann *Sketches of Utopia* (1995-2005) we can show in real time the evolutions of buildings, not only the evolutions and unfolding of trees and leaves but also the unfolding of forms of buildings. And using these technologies, we can even imitate in a deeper sense, the communication processes in civilization compared to nature, like here *Web of Life* (2002) by Jeffrey Shaw shows. The imitation of life was the aim and now we can imitate one

of the processes of life simulation, which is the Web of Life. This means, communication between animals and men as it was the subject of the famous science of cybernetics. (Norbert Wiener*, Cybernetics, or Control and Communication in the Animal and Machine*, 1948)

A widly unknown experiment, to simulate life with the help of a machine, is the so called *Machina Speculatrix* which was presented to the public by W. Grey Walter, neurophysiologist and robotician, in 1950. As part of his studies of brain capacity at the Burden Neurological Institute in Bristol, England, he had built mobile and autonomous robots. The robots “Elsie” and “Elmer” (ELectro MEchanical Robots, Light Sensitive) had motors as well as light sensors and could react to contact. These simple programmed machines helped him to study his theories of complex behavior on the basis of neural connections/interfaces. Walter once described why he called his machine *Machina Speculatrix* – it was because of the speculative movements while the machine explored its environment. In 1950 Walter published an essay on his research in the journal Scientific American called „The Imitation of Life“ (Grey Walter, “An Imitation of Life”, in: *Scientific American*, Vol. 182, No. 5, 1950, p. 42-45, see also, *The Living Brain*, Duckworth, London, 1953).

The English cybernetic Gordon Pask made *the The Colloquy of Mobiles* for the exhibition Cybernetic Serendipity which took place at the ICA London in 1968. It was a reactive, adaptive, computer based system of five mobiles. The rotating elements were hanging from the ceiling and could communicate with each other via light and sound, independently

from other circumstances. The visitors could intervene into the conversation of the machines using torches or mirrors. Pask realized with this installation his idea of a “aesthetic potential environment”. To give the conversation/communication between the mobiles a meaning Pask designed the *Colloquy of Mobiles* as social system. Three out of the five mobiles were designed to be female, the two remaining to be male. After a phase of inactivity the females would shine brighter and the males send out a beam of light. When the beam of light hit a mirror, which was installed inside the female, the female tried to send this beam back. To achieve these moments of satisfaction was the aim of the communication. The mobiles learned to optimize their behavior so that they could reach this state as fast as possible.

The aim of the new generation of machines was not any more the imitation of movement, but the exploration of the imitation of life: Self-preservation through self-regulation and learning as well as reproduction. Cybernetics revealed that this machine must be seen as a system and also part of a complete system that is bound into it. Only systems can imitate life-alike processes, but only feed back systems can imitate thought-processes.

The next important step has been the triumph of the medical image. For many decades, medicine was the art of the sound. Every doctor had a stethoscope and was listening with the stethoscope, which was attached to the body, to the sound of your body. So he could find out if you had a problem with your lung, your heart or whatever. But today, with the help of computers, doctors of medicine do not look any more on the patient -

which makes some patients feel insecure – the doctors do not look at the body any more, but they look at the computer images. In fact by looking at the computer, they see more than by looking at the body of the patient. And medical visualization is something even better than the pure visual simulation of the processes of nature because medical visualization is not just an image, it is also a tool, because you see, this would be an image, for example on the right side, this would be a normal visual simulation of the breast bone, on the left side you have a single normal image. But we have developed now techniques, program techniques, to get more out of the image. With ray-direction for example we can achieve that the following image becomes a 3D-visualization of volume. After adaptive editing of the volume we get a 3D structure of the breast bone and with the help of local approximative reconstruction, with the help of ray-direction, we can reconstruct band-values and therefore the doctor knows much better then before how he should operate. In future we should not make any operation without a 3-D model beforehand.

Other machines are for example nuclear magnetic resonance. With the help of all of this machinery, not only medicine but also in cosmology it is possible to describe more precisely as ever before phenomena of nature. So here we have already one step. We are going beyond pure visual simulation that means we can also construct what we want to see. This is not only possible in anatomy this is also possible in cosmology. For example we have so many cosmological particles, millions of particles are floating onto the earth and we have screens that record those traces of particles but we don’t know how to describe them, therefore Mr. Drewermann from CERN has developed a visualization software and

named it DALI, after the famous artist. He developed the so called Aleph Detector which makes a visual image of all this incoming stream of cosmological particles and then with the help of this software he can make a visual order of this incoming random stream of particles. This picture gives some ideas to the scientist so that he can say: “I think these are neutro-particles, these are proto-particles, etc. Without the help of these images the cosmologist would be unable to identify the particles that he sees. So here we realize again, the real step of visualization today is a detection method, is a tool, a tool of description and detection. It is more than just an image of a flower or a tree like in painting today computer assisted visualization software helps us to understand the world, to understand what we see. So visualization today has become an epistemological tool. We can see here another structure of matter, which can be discovered though visualization. Visualization today is a tool of discovering the structure of matter etc. This goes back to the old ideas of Gestalt recognition to the methods of 19th centuries experimental physiology. Maybe you can discover the horses on the picture – today we also use it in biometrics, say, by describing and recognizing patterns in the eye and the pupils we can identify persons without doubt. As another example of visualization, we have developed at the ZKM | Center for Art and Media Karlsruhe, together with the University of Karlsruhe, a method to optimize nature. When you act physically, then you have difficulties to optimize your motions. Motion studies, from Eadweard Muybridge to soccer games are the classical field of experimental physiology and of classical media. And today, with the help of the computer, we can really go a step further and dig into the core of the intention why we use

visualization that is to optimize motion. For example, you are physically active when you are gaming – but sometimes we cannot optimize our motions. So we simulate virtually the optimal motion to bring the ball into the goal. What we did then was, that we put a device on the player's head so that the player feels his physical motion but at the same time sees with a head-mounted display and the help of the computer the visual simulation of what would be the optimum motion. So the virtual reality shows the player the optimum motion and the player himself with his natural organs realizes his physical activity and natural defect motion. So we have precisely these two realities. We have the physical reality of motion perceived as our natural organs, so we have natural sense data, which tell us about our physical activity and at the same time you have the other reality, the virtual reality, the virtual motion that is told us by the computer, the virtual motion, the virtual reality, the virtual space, the virtual time, is the optimum motion. And by learning this, the player learns to accommodate the consilience of the real motion and the optimum virtual motion as fast as possible.

The same happens with androids. Androids are not only more than prosthesis that substitute any natural organs simulate parts of physical activity. But our aim are so called multi model robots. Multi model robots are cooperating with us, they learn from us and they help us to improve ourselves. With the help of mechanical humanoid robots it is possible not only to imitate our physical reality, but virtual reality implemented in humanoid robots can help us to improve our physical behavior, our physical reality. You see in this little film a development of the ZKM together with the Institute of Applied Informatics in the Research Center in

Karlsruhe. It is called a hand with fluid-actors. This is the most important point. In the future, as I said before, we say humanoid robots, we don't only have whole medical bodies, we have also parts of bodies. So we have not only multi model operating robots we also have multi part robots, we will have kinds of robots, artificial agents, and these artificial agents can be visible or invisible, or like this hand, an actor, which acts with water, which are pneumatic actors or fluid actors, these little actors and agents help us to improve not only our body, they improve our environment. So that means, the human subject becomes a system surrounded by a collective of artificial organs, artificial actors, artificial agents, and therefore the interaction between natural and artificial, real and virtual becomes more and more blurred. One of the most important steps in this direction is the famous Josephson junction from the famous English scientist who won the Nobel Prize for Physics in 1973. Brian David Josephson (born 1940) is a genius, and the Josephson junction is very helpful to bridge the organic and the artificial, the technological and the physicality of matter. This kind of Josephson junction is the very core of any chip technology that will bridge the gap between organic and artificial fabric. Josephson himself is a wonderful scientist who, in his last decades, turned to Taoist and Buddhist ideas and became therefore a little a kind of *persona non grata* in the scientific community. But to my opinion his inventions and his concepts are very important for the new material revolution. Because with his junction, he has, for the first time, given us a technology at hand that really can perform the new consilience and convergence between artificial technology and natural organology.

In Kathryn Bigelow's stunning movie *Strange Days* (1995) we already find such a device, which is based on the Josephson Junction. The film sketches already such a quantum cinema of the future with an extremely advanced interface technology. This technology functions with a direct connection to the brain, it is like a subjective camera eye, which enables the people to see with the eyes of others. The small machine you need to do so is called "Squid" (Superconducting Quantum Interference Device), and is based on the Josephson Junction and is also the first example of quantum cinema. A resembling apparatus was also shown in Douglas Trumbull's *Brainstorm* in 1983.

You see, every neurochip is the direction how we can improve not only to simulate our brain but also to stimulate our brain. How can we stimulate our organs, how can we stimulate processes in our body, how can we stimulate processes in the world in the cosmos and in our brain. This is beyond simulation, so we are going in the direction of stimulation. This is what I mean when I say we live at the threshold of a new material revolution. The neurochip, based on the Josephson junction is one of the most important concepts.

You can see on the next image two photographs. On photograph a you see electron micrograph of a snail neutron immobilized by a picked fence on a two-way contact after three days in culture (scale bar 20 nm). On photograph b you see a micrograph of neuronal net with cell bodies (dark blobs) on a double circle of two-way contacts with neurites grown in the central area (bright threads) after two days in culture (scale bar 100 nm). Pairs of pickets in the inner circle are fused to bar-like structures. So here

we have precisely what I have described to you, a fusion of mechatronics, media on one side because we cannot see these nano-technological structures without new tools of visualization and these mechatronic mechanisms can in fact stimulate our neuronal activity. One of the most important examples is naturally the research done even in Austria in Innsbruck or Vienna. There we have wonderful quantum physicists, like Anton Zeilinger or Rainer Blatt, and the ideas of quantum computing are widely discussed there. Here we have a picture of an ion trap where you can single out one or two or four and we would be happy to have eight ions in one trap. With ion traps quantum computing and the phenomena of super-contractivity we can create new micro-electronic technology. All active elements and interconnects are made of nano tubes. Due to the quasi crystaline nature of the nano tubes high quality devices are possible without the need for a single crystal silicon substract. By the implication of well-known back end of line techniques post effective stacking of 3D structure is feasible. I show you again these nano tubes.

As you know there is a theory by Roger Penrose and Stuart Hameroff that nano tuboli are the place of our consciousness. So let us repeat again, we are not here to discuss how we make models of consciousness. When we have the possibilities that I showed before, that we can operate on nano tuboli, we can stimulate our consciousness. Until now, we could stimulate our consciousness with the help of hallucinogens but the damage and deficit of hallucinogens is, that you cannot control them. William Borroughs, the famous writer and expert on this field, has once given a novel the title: “The Ticket that Exploded”, that means with hallucinogens and drugs you enter on a trip, a journey, but your ticket can explode any

time, that means you cannot control it. Now we see the possibilities that we can stimulate and not only simulate, stimulate in a controlled way our consciousness, our phases and states of consciousness.

One next important step in quantum computing is the famous Hamiltonian path problem. The task is like in the famous traveling salesman problem, to find a path, which is maximizing the effectiveness, that means minimizing the distance of the travel. That means you start at 0 and end at 6 and if you, as you see in the image, follow the arrows you can manage that you visit each number exactly only one time. It would be a mistake or deficit to visit a number more than one time. So the idea is, as you can see here, we have to invent an algorithm, a method, to minimize the path. This is what we also call the graph problem and we realize slowly - this is my personal detection and invention - that we do not need the idea for intelligent design and we do not need the idea of God to explain the path of the evolution of nature. Instead of God or intelligent design we can say mathematics is part of nature and mathematics has solved problems of selection by the Hamiltonian path problem itself. The graph theory explains us why nature is so effective, why nature itself does not repeat itself all the time. Nature itself delivers us a mathematical model that you start with 0 and end with 6 and have never visited a number a second time. So nature is already mathematics, nature is already a programming language and implicit in this language of nature is for example graph theory. And graph theory is about minimizing distance. So nature has an implicit mathematical model itself to work as effective as possible. And naturally we can use this mathematical graph theory that we can improve our calculating routines for example in a DNA computer, that means a

computer, which is built on biological material. So I could say frankly that here in my organic fabric, we have millions of DNA computers. We have only to develop technologies - this precisely is the new material revolution - that we can use our own DNA as computers. And we already have such computers, these DNA computer - in our brains. We already calculate very very well but we want to calculate faster and better and bigger numbers, we want to become real number crunchers. And to become such number crunchers we must stimulate not only our nano-tuboli, we must help to create DNA computers built on our own DNA, therefore the computer of the future will be part of our fabric our organology itself.

To give you a clear prediction from the inventor of nanotechnology of K. E. Drexler (born 1955), you see here on the image, precisely a table of macroscopic and molecular components. First you see the technology, from cables, motors to tools, and production lines, then you see the functions, for example "cables transmit tentions" etc., and then you see the molecular examples. What was for example a motor would turn shafts would become a flaggelar motor in the size that it could operate in our arteries etc. And you see a clamp with the function to hold work pieces would become enzymatic binding sites. And for example the famous assembly line already exists in our body as enzyme systems or ribosomes. And what we have to do now is to enter into this micro world into this molecular world: molecular biochemistry, molecular biology, and here we will develop on this level on the bottom of the scale, very very down to a nano scale we will discover and operate with new material. For example in the 19th century there was a very famous problem by James Clerk Maxwell (1831-1879, Scottish Physicist) called Maxwell’s demon. He

already had this idea of an intelligent agent that operates on a molecular level. Maxwell's demon is a strange little being that in a thought experiment by Maxwell - could detect the velocity of the individual molecules and could use it to crate a temperature difference between the two parts of a closed system. This means - for example - one system is hot water and one system is cold water, normally if you open the gate, hot and cold water would fuse and the temperature of the hot water would sink, the cold water would get warmer - it is not possible to make the cold water colder or the hot water hotter. Maxwell had the idea - more than 100 years before Drexler and others, He already had the idea of a molecular intelligent agent that opens the door and takes each single molecule to a direction. With the help of this intelligent agent of molecular size one could make the hot water even hotter and the cold water colder. This was a thought experiment but naturally the idea would clash with the second law of thermodynamics. Here we have the idea of reversible processes - this comes to the idea of reversible computing. It would be great if we could develop stimulus models that would violate the second law of thermodynamics in a very new way, naturally in a way, which does not really violate the law. But on molecular level we can think about it how with the help of strange little beings, molecular agents, we can circumvent, we can go around the second law of thermodynamics. So Maxwell already was the inventor of the philosophy of molecular technology.

Here you see another example - a rotaxane is a supra-molecule consisting of a ring molecule and an axis threaded trough it. To stop the assembly from disintegrating, the ends of the axis are plugged with bulky molecular groups. The axis can be designed such that there are alternative binding

sites for the ring to dock onto under different conditions. This arrangement can serve as a molecular switch. Again you see here, we have precisely what was Maxwell dreaming about: a local molecular agent, switching between two systems (e.g. from hot to cold from cold to hot). So we have already developed this kind of molecular switch. We can use these techniques for so called scanning tunneling microscopes, microscopes, which can go much farther than normal visual ones. They can touch with electric positioners they can touch the surface of _____. As you all know today you can write the name of whoever you think of, your beloved or your company in the future we will even be able to write with the help of ions. So we are really moving to a new threshold of materiality. Here you have the proof - the Stanford University writing was written with the help of a scanning tunneling microscope in a graphite surface that was molecular covered in April 1989. So we already landed in the horizon of molecular worlds. After molecular chemistry and biology the future will be molecular electronics.

Let's take a look at the content of a book *called Nanoelectronics and Information Technology, Advanced Electronic Materials and Novel Devices* (by Rainer Waser, Wiley, 2003, 2nd and advanced edition 2005) that just recently appeared. You see here a completely new horizon of materials. The content of the book confirms what I said in the beginning: we are living at the threshold of a new material revolution.

For example the ZKM together with the University of Karlsruhe developed a new kind of *Laserfilm* (2000) where we did not use like in normal optics the refraction of light, we used the de-fraction of light. The future of light will not be to calculate the refraction of light the future will be to use the

wave form of light which is called the de-fraction optics. And with this kind of new technology we can develop - precisely as the subject of our theme. New ways of virtual reality - like in this image: a near eye virtual projection display using a color sequential LCOS (Liquid Crystal on Silicon). That means you will have virtual projections very close to your eye, so it is not necessary to blow up screens, and then your eye will see on the same level a virtual and a physical reality.

This next projection is a time line that illustrates the use of materials during the past ten thousand years. Note that the time axis is logarithmic with the length of each arrow corresponding to the factor of ten. This is my own tree of evolution. So Darwin has given us an idea what looks a tree of nature like, this is my idea of what looks a tree of artificial evolution like. The evolution of materials, of tools in the last ten thousand years.

As already stated there is an interface between the world and us. The interface between machines and us is a special case – but is facilitates the analysis of our problem. The interface affects our perception and our capacity to act. Determining is that this interface is variable. The borders can be removed both, in the models that we create from reality, and in the real physical practice. What is there now in our environment can, with the next step, be a part of the system. What is in the system can be a subsystem for the environment. That means: when I am an observer in one system, I could be a part of this system for someone, who observes me from another environment. Nevertheless, we usually behave like in classical cinema. We think, we are the outer observers of the image and with our behavior we do not effect the image itself. We are however only

able to construct systems where our observations are part of the system that we see.

Therefore quantum theory and its effects on observation techniques (see Werner Heisenberg's uncertainty principle, 1927 or John Archibald Wheeler's participatory universe, 1983) became an exemplary model for observer-dependent media as we find them in interactive image installations and interactive systems. To speak of the universe as a self-excited circuit is to imply once more a participatory universe." (John Archibald Wheeler, „Law without Law," in: *Quantum Theory and Measurement*, J. A Wheeler and W. H. Zurek (Hg.), Princeton University Press, Princeton, 1983, p. 182-213)

If you, for example, step in front of my work *Die Wand, der Vorhang (Grenze, die), fachsprachlich auch: Lascaux [The wall, the curtain (border, the)]* (1994), you realize quickly that the own observation, the own behavior, has influence on the installation. The observer is part of the system that he observes. You see yourself while you watch in front of an object. Naturally, you can also step back and be part of the environment, not part of the system. The border between system and environment is variable. We cannot destroy the idea of the border as we need it, but we can vary the borderlines. The interface takes care for the variable exchange of signals between environment and system. Therefore we can, in the future, expect a lot of movement in the field of architecture, which will explore ways to connect the inner systems – like in a house – and the outer environment, like the city. Architecture will find new interfaces.

MEDIA react on conditions of human existence. Man is taking part in evolution such a short time that he is not really able to observe it. From this great part of evolution he just sees a little sequence. But media makes it possible to enlarge man's little time slot of about 80 years. Media are, as Freud already said 1930 in his essay *Das Unbehagen in der Kultur (C*ivilization and its Discontents), media of absence. Script brings us near, what is chronologically and spacialy far away. So do also technical media. They continue the efforts of scripture. With the help of scripture, it was possible to step beyond the direct horizon of experiences. With texts and pictures we could conquer epochs and spaces of the past and the future, which were beyond our physical experiences. We could enjoy things that were long gone and visit places, which exist no more. Texts and pictures tell from absent things. The evolutionary sense of these technologies of memory, to store memories, can be seen as a wish of mankind, to bring your experiences into time and space – over the borders of the here and now. Human existence is not satisfied with the experiences we make in real time, because this is not enough. Therefore we invented culture techniques, techniques of absence etc. that enable us to step beyond the real space and to share the experiences, needs, thoughts and ideas of people who lived in different times and at different places. The evolutionary sense of culture techniques is, to expand the time slot, which is given man as his own personal life, as measured by the billions of years of evolution. The evolutionary sense of media is to bypass the laws of evolution – the core of which is death. The aim of media is to liberate us from the prison of space and time. We are all passengers in a plane, whose captain is telling us, how long the journey will take. We only know,

that the journey will be too short. We are longing for nothing more than to extend our journey. But the pilot defines the time slot of our life and defines, how long we will be here on earth and can take part in evolution. We therefore expand the time slot symbolically as long as much as we can to enjoy more of the evolution as we will be able in reality.