The 1st European Conference on

Science, Art and Technology

in the Service of Man

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SAT 2006
Conference Proceedings

SUOMEN MATEMAATIKKO-,
FYYSIKKO- JA TIETOJEN-
KÄSITTELYTIETEILIJÄ-
LIITTO SMFL

TEKNIIKAN
AKATEEMISTEN
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sf

Julkaisijat:
Suomen Matemaatikko-, Fyysikko- ja Tietojenkäsittelytieteilijöiden Liitto SMFL
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Ulkoasu: Mari Lohisalo
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Forewords

Dear SAT 2006 participant,

The idea of an international conference came up already five years ago in a seminar of SMFL (Finnish Union of Mathematicians, Physicists and Computer Scientists). The original idea was to organise an event where people working in different branches of science and technology could exchange their experiences and ideas. The idea of organising a more interdisciplinary event and including art as a central theme followed somewhat later. Now, looking back in those past five years, the course of events seems de rigueur. The connection between science and technology is incomplete without the third one, art.

When we look back in history, it becomes clear that the connection between science, art and technology is by no means artificial. The ancient Greek word techne translates to art, craft, or skill. The modern words technique and technology originate in techne. This fact serves as an early example of the close connection between the three themes of the SAT 2006 conference. Not only has the modern technology inspired new forms of art, but the artistic dimensions have also become one of the features of modern technology. During the past years design has become one of the essential features of modern technology. Mobile phones, computers and other pieces of people's everyday technical devices are no longer only auxiliaries, but the physical and aesthetic appearance of the apparatuses also plays an important role.

SAT 2006 is not a traditional scientific conference, but rather a platform for exchange of interdisciplinary new ideas. The session programme consists of five keynote presentations and seven parallel sessions. The total number of speeches is more than 30. The themes of the presentations range from music to finance, and from computer simulations to improving the quality of life. Health care is one of the central themes of the conference. The common factor for all presentations in SAT 2006 is interdisciplinarity. One of the highlights of the conference is the Millennium Prize award lecture, which is one of the keynote presentations of the SAT 2006 conference. The prize, given every second year, is the largest technology prize in the world. It celebrates innovations that have a favourable impact on the quality of life and wellbeing. Thus, the award lecture is a perfect complement to the conference.

I wish you a memorable conference in Helsinki – let it be a unique event in the spirit of techne.

Antti Lauri
Chairman of the SAT 2006 programme committee
Chairman of SMFL

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Counsellor Jaakko Ojala:

SMFL has launched Publications and Research Activities

- Summary of Some recent Books

Members of SMFL have had various professions in both the private and public sectors, from research institutes to large companies and governmental authorities. Their jobs represent a large variety of duties and tasks in the society. The main groups are mathematicians, physicists and computer scientists. However, their roles do not meet your expectations if you try to consider them on the basis of their education, mathematics teachers in schools or researchers in laboratories. These were the most traditional professions in the past if you graduated in mathematics or physics.

SMFL has gathered information from jobs and professions of its members to take a closer look at the areas in which mathematics, physics and computer science are applied in working life. This aim has been targeted through many studies and research activities. The results have been published in the publications, one of them titled "Tools for the information technology society". These publications describe unconventionally the people of our expertise in different professions, and how the represented fields of science are utilised in the society. The publications of SMFL give some insight of who we are. Currently the publications are released regularly and they have long traditions.

In addition, the general meetings of the association, SMFL, have always included a training section. It has normally entailed a presentation of a topical issue that interests the members. The subjects have naturally varied greatly. We have had presentations about "globally known Finnish mathematicians", the Big Bang Theory, astronomy, applications of mathematics, physics and IT in different fields, and even stress and work fatigue management. Often the presentations have been printed afterwards or published in the newsletter of SMFL.

In 1990 SMFL published a study dealing with the outlook of life among members of the association. Ms. Ulla Halonen graduated from University of Helsinki in psychology. This publication described the reasons why our members had chosen to study mathematics, physics and computer science as their studies. The main reasons had been interest in these sciences and they regarded these sciences as important and attractive. They had ranked these sciences very highly. They expected that they would be able to develop themselves through such studies and they could have an influence on the society.

Science has influenced strongly their outlook of life. Science was seen as a tool for obtaining and adopting information. The members explained in various ways their understanding of the world and life. The cornerstones were technology options and technique as such on how to solve problems in practise and analyse reality in their surroundings. They had confidence in solving problems through science.

The first publication “Professionals at Work” was published on the 20th anniversary in 1981. The book introduced the members who were highly educated and experienced in sciences and they had a lot of work life experience, too. The publication presented main sectors teaching in mathematics and physics, health physics, radiation protection and safety, mathematics in insurance and computer sciences. These were as well the sectors that represented the members at that time.

Some mathematicians have been employed recently in industry and finance sector. One publication published in 1990 described the content of the members´ jobs in those sectors. It was found that there are two main groups among those members namely researchers and administrative people in managing staff. In the industry sector there was a third smaller group in which members were oriented towards computer sciences in using advanced computer software. There was an indication of increasing involvement of mathematics in the industry sector.

In 1991 Ms. Päivi Ala-Poikela studied the views of a group of members regarding skills and knowledge needed at work according to their understanding and experiences. Many of the interviewed members were in charge of anticipated future development pathways in technology and in information technology. Most of them worked as experts or advisors to the high-level decision makers in private companies. One of their objective was to predict the future trends and changes. The benefit for professionals or companies was the relevant information to face the future needs and challenges. After all, up-to-date information is a key issue in maintaining the competitiveness.

The published books of SMFL form a very useful set and source of information for the association. These books function as a tool for directing activities of the association and for organising training for its members. Proper training is crucial when trying to meet the requirements of the modern work life. SMFL will continue these activities in future as well.

More information see www.smfl.fi

Key Note Speeches

T1: SCIENCE, ART, PHILOSOPHY & RELIGION

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INTRODUCTION

As modern science has pushed to what seems to be the edge of human understanding, and to begin to express it in mathematical form, it has come to other worlds, and different kinds of understanding that are not reducible to mathematical formulae -- the world of the arts and the world of the spirit (represented in different ways by both psychology and religion).

C. P. Snow (1959) wrote many years ago of the wide and apparently growing gap between the “two cultures” (as he called them) of science and art. These worlds are different, but not ultimately incompatible. However, we cannot reduce any one of them and express it completely in the language of another.

To bridge these different worlds and find our way to the unified whole of which they are different aspects, we need to approach our study not only with the thinking mind but also with the emotions and the body, and to begin to see how all of these are connected.

THE WORLDS OF FORMS AND CHANGES

Perhaps first it might be helpful to look at what science and art have in common. Both deal, in different ways, with both the form of things around us – how they are made, look, feel, etc. – and how these forms may change under various conditions. In science we see this focus on both form or structure and changes in that structure in physics, chemistry, geology, biology, astronomy, meteorology and every other field of study. In the arts, the same can be seen in poetry, the plastic arts (painting, sculpture, architecture) and the performing arts (music, dance, theater).

This interplay between form and change can be seen as a kind of complementarity, a dance between the yin of form or structure that nurtures and sustains and the yang that is constantly bringing about changes in that form or structure and thus creating a sense of vitality. Form is what gives us our sense of space, and change is what gives us our sense of time. The complementarity between matter and energy, the particle-wave duality recognized early in the last century, is another example of this two-faceted aspect of the world.

Philosophers have long recognized this kind of general picture lying behind the ordinary everyday experience of the world around us. Plato wrote about the idea of forms existing beyond the specifics that we see and touch. The Chinese classic I Ching, or Book of Changes, deals with how different forms may respond or change in accordance with different conditions.

In recent times this effort to see beyond specifics and to find general expressions that may describe many different situations having similar structures and patterns of change has given rise from the 1960s to the cybernetics of Norbert Wiener and to general systems theory.

CONNECTION AND INTEGRATION

On a parallel but independent track, my own experience led me to similar results. Already during my academic studies in the 1950s and early 1960s I had discovered that the mathematical formulations of both thermodynamics and micro-economics (price theory) were essentially the same. In particular, for example, price plays a role comparable to temperature, with a ¢p needed to cause a response in supply and demand just as a ¢T is required to cause a thermodynamic response. Commodity markets also were seen to behave like hydraulic systems.

During the 1960s I extended these observations and formulated them more broadly in the context of abstract systems theory, which I later found was more or less equivalent to the general systems theory developed by others.

What seemed to be of more interest than the mathematical theory, however, were experiments expressing these ideas visually, through painting and sculpture. The results were found to be roughly comparable whether described in a scientific or an artistic way, but neither approach could be fully described in terms of the other. Both approaches were treated in a short manuscript written in 1968, circulated widely among some others working in these areas but published only in part.

The work continued into the 1970s and focused increasingly on making use of the complementarity of different approaches as a way to connect and integrate the different aspects of experience. One result was a paper on using both science and art to involve the two different hemispheres of the brain during the educational process (1976).

The work of integrating various approaches involving science, art and philosophy as well as other fields made it quite clear that thoughts, feelings and physical sensations are all closely related and are complementary aspects of our total experience of all of our surroundings and also our inner world. In this connection, it is appropriate that health is one of the several themes of this conference. It is becoming more and more recognized that to be fully effective, health care must take into account the total mind, emotions and body system.

THE INNER SEARCH FOR MEANING

As these explorations into both science and art grew deeper, they came to many of the basic questions of philosophy, psychology and religion that have drawn serious students for many centuries. It was more than a search for explanations but rather an inner search for meaning. At its heart were, and still are, such basic questions as “who am I?” and “why am I here?”.

The reference in the title of this paper to “religion” is not to the organized religions of the world but to this inner search and the spiritual development that can come from it.

Many will question whether such a personal experience has any place being discussed in connection with the usual explorations of science or of art. Art itself is often thought of as being simply emotional and subjective. But it is also possible for some art to have an objective quality, to transcend the personal element of the experience of the individual artist. In the same way, it is possible to reach objective levels of inner development and consciousness, and those who have reached such levels over thousands of years have all described them in much the same way.

Modern science actually is leading toward a confirmation of the reality of the worlds of art and of spirit. For example, it is now recognized that both thoughts and emotions correspond to specific biochemical and electrochemical states of the body, and is becoming understood that everything that occurs is ultimately matter and energy (two different aspects of the same thing).

It was said by the Russian philosopher G. I. Gurdjieff, as quoted by his pupil P. D. Ouspensky (1949), that everything is material, even the highest spiritual experience. But how could this be verified? This leads us back to our original question about the connections between science, art, philosophy and religion.

SCIENCE, ART AND INNER DEVELOPMENT AS EXPLORATION

When we come to the study of anything, we need to ask, what do we know, and how do we know it? The most reliable tool that has been generally accepted is the “scientific method” of framing hypotheses and then testing them by direct experience. Many experiments need to be made to confirm that results are not simply accidental, and others should be able to repeat these experiments and obtain the same results.

This approach can apply equally well not only to science but also to art and the inner search for meaning. All of these in one way or another explore the mystery that lies behind everything. The essential point in the case of art or spiritual development is in how to verify that results are objective. Can others obtain the same results, if they carry out the experiment under the same conditions?

The key question here is what are the "same conditions"? One cannot expect to obtain the same results in a spiritual search after meditating for a week as compared to someone who has prepared for decades. Certain results require certain organic changes in a person as a result of years of practice of special techniques. But in principle everything can be verified by direct personal experience.

In assessing our level of comprehension of things, it may be helpful to distinguish between information, knowledge (connecting different elements of information), understanding (connecting the different forms of knowledge of the mind, the emotions and the body) and wisdom (connecting individual understanding with something "higher").

In this way, we may proceed with our exploration of both outer space and inner space. In all our efforts, we need to see whatever results are obtained as tentative and subject to further refinement based on further experience. An answer to the initial question may, and should ideally, lead to a deeper question. In the end, all science, art and inner development is the pursuit of an open question, which can never be fully answered in one's life as a human being.

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F1: THE BEAUTY OF MEDICAL RADIATION PHYSICS IN CANCER THERAPY

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Abstract

The aim of the presentation is to illustrate how modern nuclear physics, radiation biology and accelerator physics together can help solving one of our most difficult medical problems. Multiple examples of the beauty of the individual dose distributions obtained with different radiation modalities and of the advanced science and technology needed for optimal patient cure, will be presented. Radiation therapy is today in a state of very rapid development with new intensity modulated treatment techniques continuously being developed. To be able to cure also the most advanced hypoxic and radiation resistant tumours of complex local spread, intensity modulated light ion beams will really be our ultimate tool for cancer cure. Biologically optimized intensity modulated photons, electrons and light ions represent the ultimate development of radiation therapy where the absorbed dose and biological effect to normal tissues are as low as physically possible at the same time as the therapeutic effect on radiation resistant tumors is as high as possible. The only problem with the ions is the large capital cost requiring an initial investment in the order 100 MEUR. However, once the new treatment method is up and running the society will save the same amount of money per year due to a higher curability and less cost for palliative chemotherapeutic treatments. Light ions will be the ultimate radiation modality to exploit the genomic instability, the hallmark and Achilles heel of all tumors, in short, cost effective treatment schedules with minimal normal tissue morbidity as well as surrounding healthy tissues.

F22: SCIENCE, TECHNOLOGY AND ART AS MUTUAL INSPIRATIONS : THE COMPUTER AS AN INTERFACE

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Keywords: Music; Art; Science

INTRODUCTION

There is no need to remind the help that science and technology have brought to the arts : but art has also often inspired science and technology. This point will be emphasized in the field of music. Throughout history, science, technology and art have entertained fruitful relations. This became specially striking in the case of computer music. The exploration of the musical potential of digital sound has brought new musical possibilies, in particular composing the sound itself insted of merely assembling sounds, and realizing sonic illusions taking advantage of the idiosyncrasies of perception. The computer has served as a workshop and an interface helping to bridge gaps between aspects of music usually considered as separate, while facilitating communication of important knowledge and knowhow between researchers and users : this has benefited science and technology as well as music. The author will also attempt to answer certain of the questions asked at SAT 2006. The presentation will be illustrated by sound examples.

MUSIC AS AN INSPIRATION TO SCIENCE AND TECHNOLOGY

There is no need to recall that music has benefited from science and technology. However the inspiration which music has brought to science and technology is largely underrated. Music has a special kinship with scientific disciplines. According to Jon Appleton, "music inspires the kind of rational thought necessary to produce scientific work." Together with arithmetic, geometry and astronomy, music – theoretical music - was one of the disciplines of the medieval quadrivium, inspired by the antique Greeks. Many scientists have developed the theory of music or written music treatises – among them Pythagoras, Aristoxenus, Cardano, Descartes, Huygens, Newton, Leibniz, Farey, Pierce, Mathews.

Pythagoras had the vision that numbers were ruling the order of the world – the harmony of musical intervals as well as the motion of celestial spheres. His application of arithmetic to the observation of vibrating strings is sometimes regarded as the first instance of physics. He developed a mystic of numbers that was influential in developing western science.

Aristoxenous disagreed with the view of Pythagoras : he argued that the justification of music was in the ear of the listener, not in a mathematical ratio or rationale. He was already a psychophysicist – or a phenomenologist.

The organ can be considered the first information machine : the performer lowering the keys specifies information which is not coupled to the energy producing the sounds (this energy is provided by a pump). The organ key seems to have been the first remote switch and the organ keyboard the first keyboard – long before typewriters and computers. Four centuries before Fourier, organ makers were already implementing additive sound synthesis in the so-called mutation stops, where timbres are obtained by adding the sounds of pipes tuned as harmonics of the intended tone.

The Western musical notation resorts to a time-frequency representation. Musical automata such as music boxes or barrel organs code music according to an early form of Cartesian coordinates, developped long before Descartes. In fact Geoffroy Hindley, a British historian of science, believes that Cartesian coordinates developed in the Western world – rather than in China, for example – because it was suggested by the music notation. Needless to say, Cartesian coordinates were important in the explosion of science in the Western world : Laplacian determinism stemmed from the possibility of predicting motions from present positions and speeds through the resolution of Newton's dynamic formula F = m G, transcribed in terms of differential equations involving the coordinates. Musical automata also provide the earliest known example of a stored program, long before the Jacquart loom. To establish his experimental laws of dynamics, Galileo did not have a stop watch : he was helped by musically-trained monks tapping a regular beat.

Many concepts such as logarithms, modulo and groups were used in music long before being defined in mathematics. According to the mathematician Yves Hellegouarch, the careful consideration of musical phenomena can inspire more intuitive and holistic mathematical approaches. Indeed Hellegouarch himself became a briliant cello player instead of attending high school, and he was the first who suggested (around 1970) to link Fermat's arithmetic theorem to algebraic elliptic curves : this unexpected path lead to the demonstration of the theorem by Andrew Wiles. Fifty years before Noam Chomsky, the Viennese musicologist Heinrich Schenker introduced the notion of transformational grammar in his theory of tonal music.

Artificial intelligence was probably first envisioned in the field of musical composition. Around 1840, Lady Lovelace, who worked with Babbage, the designer of the Analytical Engine – a forerunner of the computer – wrote the following : "(The Engine's) operating mechanism might act upon other things besides numbers, were objects found whose mutual fundamental relations could be expressed by those of the abstract science of operations, and which should be also susceptible of adaptations to the action of the operating notation and mechanism of the engine. Supposing, for instance, that the fundamental relations of pitched sounds in the signs of harmony and of musical composition were susceptible of such expressions and adaptations, the engine might compose elaborate and scientific pieces of music of any degree of complexity or extent...” This idea was exploited later by John Pierce, Lejaren Hiller, Pierre Barbaud, Iannis Xenakis, Göttfried-Michael Koenig, Fausto Razzi, Denis Lorrain and others.

Around 1875, the invention of the phonograph and the telephone changed the status of sound : no longer ephemeral, it could be treated as an object and reproduced – or produced - in the absence of a mechanical cause. It could be processed and transmitted with the help of electrical technologies. In this domain, a turning point was the appearance of electronics with the invention of the triode by Lee de Forest – whos wanted to generate electrical oscillations in order to electrically create musical sounds. The first patent called the triode “audion”, and Lee de Forest indeed constructed the first electronic musical instrument, later perfected by Leon Theremin.

THE CASE OF COMPUTER MUSIC

Non-digital electronics had to use tricks to exploit the whimsical characteristics of vacuum tubes and transistors. Computer synthesis permits to create, from a specification of the physical structure of the desired sounds, a “virtual” sonic world - one which has the virtue to produce sounds which are not the audible trace of objects that can be seen and touched.

The computer appeared around the time of the second world war, followed by the transistor and microelectronics – eventually electronics became digital. The computer is more than a fast calculator. It is not a tool, a machine or an instrument : it is rather a kind of workshop which allows to design and build a variety of tools, machines or instruments. It permits to deal in similar ways with intellectual and material processes. It offers unprecedented possibilities to represent and model complex situations. With its memory, its digital coding and its boundless programming possibilities, it can act as an interface of many sorts. It can link diverse protocols of different natures - even pertaining to different sensory modalities (images can be coded digitally as well as sounds). It can also link different workers of different disciplines, at different places and different times, helping the cooperation of efforts in the exploration of a new field.

The computer can deal with strings of coded numbers regardless of their corresponding to mathematics, speech, music or images. This brings considerable changes not only to the generation of images and sounds - their morphogenesis - but also to the way they can be represented, stored, reproduced, distributed. The programming of artistic media implies language, formalism, computation : it affects our conceptions and our notion of reality, and it alters the reception and the perception of art as well as the processes of creation.

In 1957, Max Mathews produced the first digital recording and the first digital synthesis of sound: his primary incentive was music, even though he fully realized the potential for speech and psychological stimuli. Mathews designed powerful programs : the Music n compilers, specially Music4 and Music5 and their descendants Music10, CMusic, CSound ... These modular programs inspired the analog synthesizers such as Moog or Buchla, but also the notion of data-flow and object programming, widely used in computer science, for instance in the simulation of speech or electronic circuits.

With programs such as Music4 or Music5, one could manufacture an immense variety of sounds from the complete specification of their physical structure. There seems to be no limit to the world of sounds that could be synthesized. However the initial results were disappointing, which quickly lead to the realization that auditory perception is much more complex and demanding than one thought. So the exploration of the musical resources of synthesis was inseparable of a genuine research in psychoacoustics about the relation between the physical structure of the sound and its auditory effect. Several sound examples illustrate some important steps of this musical and scientific exploration.

****Several sound examples illustrate the two following paragraphs*******

For instance it is hard to mimic the sound of certain instruments such as the trumpet or the violin: the research realized to achieve a satisfactory simulation brought insight about the cues for identifying sound sources. Once satisfactory synthetic instrumental simulacra are achieved, it becomes possible to gradually transform them initimately, for instance to turn the tone of a oboe into that of a cello or a horn – not by using cross-fading, but by realizing a genuine metamorphosis (a process now called morphing in the field of synthetic images). One can also compose bell-like or gong-like sounds just as chords, and turn them into fluid textures with the same internal harmony.

Imitation is important to gain understanding, but also to achieve certain musical goals, specially in pieces mixing acoustic instruments and synthetic sounds. However the most exciting perspective is that of producing new sounds. In particular one can achieve intriguing hybrids, in the line of Cézanne, who wanted to “marry curves of women with shoulders of hills”. One can also produce auditory illusions – illusory movements in space, or paradoxical tones that seem to go down for ever or to go up and down at the same time. Such illusions can produce strong musical effects, but they are also important from a scientific standpoint since they reveal perceptual mechanisms. As Purkinje stated, “Illusions are errors of the senses but truths of perception.”

Computer synthesis of sounds was an important new musical possibility. It also brought a host of new knowledge and knowhow about musical sound and its perception. Initially the features of hearing appeared whimsical and arbitrary, but their raison d'être finally became clear, as explained below (cf. the proposed answer to the question "Does a physical reality exist or is there a different reality for each of us?").

More generally, the computer played an important role as a musical interface, helping to bring together processes hitherto separated : instrumental and electronic sounds; real-time and delayed synthesis; digital synthesis and processing; composition and performance. Also it allows to use the same kind of digital coding to represent sound and image as well as text, thus facilitating, for instance, the conjonction of image and sound. And it is of course precious to help cooperation. The user of a music program benefits from the work of the author of the program, and he or she can often take advantage of the experiments and knowhow realized with the same program: scores describing the recipe of synthesis for a variety of sounds with a program such as CSound can be passed and disseminated. The central use of the computer as a musical tool – or rather as a musical workshop – was the main specificity of an institution such as IRCAM.

ANSWERS TO SOME QUESTIONS ASKED AT SAT 2006

What would be the breakthrough of the next Einstein?

The breakthrough of Einstein's relativity theory clearly was not anticipated by first rate physicists such as Lord Kelvin, who claimed that no drastic innovation should be expected in physics. Another breakthrough had happened shortly before relativity, thanks to Henri Poincaré (who apparently has also strongly contributed to relativity), namely the notion of extreme sensitivity to initial conditions, which Poincaré emphasized in his work on the three-body problem. Although this work did not go unnoticed, its considerable implications were certainly not realized at the time. It is now well understood that many systems are "chaotic" at certain scales – in fluid mechanics, meteorology, even astronomy. Poincaré also established that the unpredictable destiny of chaotic systems would display quasi-cycles, echoing Nietzsche's concept of the eternal return.

Perhaps a major breakthrough has come with string theory. I am by no means an expert in this domain, but it does not seems established yet that such a fancy theory is mandatory. Perhaps an alternative approach can be founded on the non-commutative geometry developed by Alain Connes, where space is no longer an a priori but a consequence – just as our subjective space arises from interaction between sensory signals and our perceptual schemes. The developments of Alain Connes may also be a key to a sound introduction of time in mathematics – the fact that time does not play a genuine role in mathematics may be related to certain mathematical aporias.

It would be a breakthrough to understand consciousness. However it seems that even if science learns about the neural correlates of consciousness, the phenomenon may still remain a mystery.

How can new technologies be used in medicine?

Here again, I am by no means an expert, but I would like to remind the breakthrough introduced in the XIXth century by Laennec and his stethoscope : today, advanced signal processing and human hearing could be used more extensively for medical exploration and diagnosis.

When we look at an image, our vision compares, evaluates, analyzes. Perception deals in an intelligent way with images, but with sounds too. Human hearing achieves sophisticated and intelligent sound processing : in France and other countries, the Navy takes advantage of trained listeners, who are better than programs at sorting and interpreting underwater sounds (noise of whales, of ship engines, transposed radar echoes). The transcoding of complex data into sounds for aural interpretation (so-called sonification or auralization) is a growing discipline, already used to unravel information about the stock exchange. In particular electrocardiograms are mostly inspected visually : advanced methods of signal processing are being developed by the team of Pr Haïssaguerre in Bordeaux to interpret electrocardiograms in more informative ways.

What is there in common between science and art?

Curiosity and passion - the passion of going beyond and exploring new territories - are common to science and art. Science does not have the monopoly of rigor – “Ostinato rigore” was the motto of Leonardo. Art does not have the monopoly of esthetics : it is often the quest of beauty that moves great researchers. Just as artistic creation, scientific innovation often calls for a vision that is intuitive, sensitive, and synoptic, summing up implicitly a discursive path.

Both science and art are ways of understanding the world beyond the individual subjective view of reality. Victor Hugo wrote : “La science va se raturant sans cesse; l’art est une fois pour toutes” (science keeps correcting itself; art is once for all). Science objectively studies the world around us : it provides a provisional description that is to be furthered in future developments. The late Luciano Berio viewed art as the path to what is beyond us. According to Jacques Mandelbrojt, science is good at describing reality in itself (en soi), while art is more apt to express or translate reality in us (en nous) : its exquisite sensitivity and its extreme quest of subjectivity capture human universals and archetypes.

How can a composer be modelled?

One of Stravinsky’s nasty remarks was that Vivaldi did not compose 600 concertos, but 600 times the same concerto. Around 1955, the availability of the computer revived the idea that the process of composition could be modelled – an idea that had been exploited as soon as the XVIII century (scores had been sold under the name of Mozart enabling musically-ignorant users to compose waltzes by throwing dices).

John Pierce, Douglas Bolitho, Lejaren Hiller, Wilhelm Fucks and Pierre Barbaud were the first pioneers of automated composition.

Initially the process was to assemble elements – notes with their pitches, durations and timbre – in order to realize a statistical approximation of a composition (or a corpus of compositions) from a statistical analysis of the elements (note pitches and duration) in the music of the composer considered. Counts were made for the statistical frequency of occurence of each pitch, also of the digrams giving the probability that a given pitch be followed by another pitch, of the trigrams, etc. Then one used the so-called Monte-Carlo method : elements were randomly chosen and kept only insofar as they would contribute to produce a composition with a statistics close to that of the original composition (or corpus). This produced scores of automatically-composed music. A fragment of such music often reminded of the composer that was modelled – at least for a few bars : but on the long range, there was no clear evolution, no sense of form. Clearly form cannot be dealt with in this fashion. The statistical evaluation of a composition only provides the statistical trace of a process that is inherently not statistical. This effort toward artificial creativity has helped sort out what can be mechanized easily and what remains hard to model. Even though the musical outcome was generally disappointing, it motivated composers such as Lejaren Hiller, Pierre Barbaud, Iannis Xenakis, Michel Philippot, Göttfried-Michael Koenig, Denis Lorrain, Fausto Razzi, to produce compositions that would rigourously mimic a statistical description.

It was tried to use the Monte-Carlo method of randomly choosing elements and filtering them so that their succession would follows the rules of harmony and/or counterpoint. Hiller used the rules explicited in Fux's XVIIIth century treatise of counterpoint : the results were grammatically correct, but foreign to the spirit of counterpoint, which elicited the following remark by Milton Babbitt : the rules of counterpoint state what you should not do, not what you should do.

A more insightful approach was to try to isolate generative procedures according to certain architectonic rules. The Viennese musicologist Herbert Schenker proposed a procedure for generating tonal music – prolongating a basic scheme, a central kernel (tonic -> dominant -> tonic) according to specific rules. This proposal preceded the transformational grammars pionnered by Noam Chomsky for language. Such an approach has been elaborated in detail by Frederic Lerhdal and Ray Jackendoff. Different processes have been combined ingeniously by David Cope to try to define the characteristic features of different musical styles.

Today the computer game industry is trying to find keys to achieve certain descriptive musical material or music giving rise to specific affects – the goal is closer to manipulation rather that to art or creation.

Occasionnally, artificially-composed music can achieve satisfactory results (some are classics of contemporary music, such as Xenakis' ST4 or ST10; some have been used in commercial movies such as Les abysses or Chronique d'un été). At this point it remains clear that human creation resorts to processes which keep some complex and mysterious features.

Even though one could develop a program automatically composing great music, composers would no longer be concerned : it would not be their music, but something like found objects. One can think here of the book "The beauty of fractals" by Hans-Otto Peitgen and Peter Richter : fractal figures are akin to found objects, they are not art. Found objets can be beautiful, such as the stones selected by Roger Caillois; they can only be given the status of art by an artist committing himself to sign them, as Marcel Duchamp did in the twenties.

At most, a true composer could only be modelled when he is dead. As soon as a model could realize what a creator invents and constructs, the creator will invent and construct something else. The many different contributions of the late György Ligeti testify of his adamant concern for independance and imagination.

Does a physical reality exist or is there a different reality for each of us?

To say that a physical reality exists is a matter of faith. Virtual environments can now be a convincing surrogate of reality. When we dream. we are generally unaware that we dream : solipsim asserts that external reality is an illusion - our dreams are dreams of a dream. I do believe that a physical reality exists, but I am sure that the reality appears different for each of us.

Our senses are our only windows to the world, and they are by no means transparent – they are not simple copies of the physical reality. Art is received and perceived through the senses. When the artist constructs a work of art, he deals with the physical world, using tools that can be elaborate - brushes, paint, carving tools, music notation, musical instruments, architectural blueprints : but most of the time the sensory effect of these tools can be appreciated at once. The composer predicts to some extent the sounding effect when he writes an instrumental score. As was mentioned above, this is not necessarily so when he or she composes the digital sound.

Structures can often be defined in a rigorous, objective way, for instance in terms of mathematical descriptions. However what counts in art is not the objective structure - per se - but the structure in us, as we experience it through our senses. Ancient Greek architects were said to correct geometry to satisfy our senses. The idiosyncrasies of perception can be illustrated by some simple visual illusions.

Examples of visual illusions (Hering, Muller-Lyer, etc)*

It is often a delusion to rely on a physical description for predicting the appearance or the effect of a visual or an auditory scene realized with elaborate technical processes : one should be aware of the complexity of the relation between the physics of the signal and the way it is perceived. If you take the case of light, the color of a "pure" light depends upon its wavelength : but the same color can also be evoked by adding an appropriate mix of two pure lights, each of which in isolation would evoke different colors.

In the case of music, we use sounds of different frequencies, and we hear pitches, an attribute of perception, extracted from our auditory experience. This attribute does not correspond to a mere measurement of frequencies : I have synthesized sounds which appear to become lower in pitch when their frequencies are doubled.

**********Sound example f/2f********************

One can find cases where pitch judgments are different for different individuals – for instance a pair of sounds which appear to certain people to go up and to others to go down. In certain cases which I studied myself, it depends upon the musical training of the listeners. In other cases studied by Diana Deutsch, it depends upon the native tongue of the listeners.

Similarly, I have synthesized rhythmical beats which appear to become slower when one doubles the speed of the tape recorder on which they are played. The experience of rhythm cannot be reduced to chronometric counts.

The working of our senses is complex, it occasionnally seems whimsical: but it is not arbitrary. Animal senses have evolved so has to provide in the best possible way information about the environment that is useful for survival. To do so, evolution has taken in account the regularities of the world – the physical laws. Thus the idiosyncrasies of perception embody an implicit understanding of the external world. This point of view explains intersubjectivity : we can reach a certain consensus about the world, even though it appears different to each of us.

Around 1935, the Gestalt psychologist Kurt Koffka asked : "does the world appears the way it does because the world is the way it is, or because we are the way we are?". Recently, the cognitive psychologist gave the following answer : "The world appears the way it does because we are the way we are; but we are the way we are beacause we have evolved in a world that is the way it is." This thoughful answer reconciles materialism and idealism.

CODA

The scientist seeks knowledge; the artist and the engineer rather seek action. Art and science are two different ways to take the world in account : they bring about complementary kinds of knowledge. Certainly art cannot rival with science for the description of the external reality : but through art, we come to grips with the internal reality and we can approach what is beyond us.

The cooperation of art, science and technology is precious for all three disciplines. Artists often react to novel possibilities. The sharp demands of art has forced artists to develop ingenious and stimulating theories and knowhow. The artistic exploration of new media helps to understand the phenomenal reality.

Music – “the shaping of the invisible”, according to Leonardo - may be closer to science than any other art, and it has always called for advanced technologies. According to Olivier Messiaen, the advent of electricity in the sonic domain was the most important musical event in the XXth century. The case of computer music is specially enlightening. Max Mathews, trained as a scientist and engineer, wanted to turn the computer as a musical instrument, and he developed highly valuable human applications of computers. John Chowning, a musician by training, has contributed important scientific knowledge and inventions, one of which (FM synthesis) that lead to a Stanford University patent that was one of the most profitable ever. I have myself worked as a researcher (at C.N.R.S.), as a composer (at IRCAM) and as both (at Bell Laboratories): I received the highest French awards in both domains of music and science, and I strongly feel that my scientific and the musical activities, although very different in many respects, have nurtured each other.

The computer is not a mere tool, rather, it is a workshop fostering the design and implementation of tools, intellectual as well of material, and offering compatible representations for numbers, texts, images and sounds : an interface favoring interdisciplinary encounters and conjonction of efforts. The development of computer music is an inspiring example. Scientists and artists have a responsibility to demonstrate that the computer is not necessarily a tool of oppression and uniformization, and that computers and the web should not be shaped merely by short-term commercial pressures, but that they could – they should – provide a friendly partnership, a personnalized auxiliary, leaving space for individual creativity while making the exploration of new human possibilities a cooperative and cumulative endeavour.

ACKNOWLEDGEMENTS

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S1: BENCHMARKING USING VALUE EFFICIENCY ANALYSIS

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Abstract

In this presentation, we propose the use of Value Efficiency Analysis in comparing similar units (plans, people etc.) like hospitals, schools, universities, sales men, health care plans, among others. The units are assumed to use several inputs and produce several outputs. Using an interactive multiple criteria approach, we first assist a decision maker to find one or some units which produce the outputs the decision maker prefers and uses the resources as little as possible. These "example" units are then used as benchmarking units for the other units. The Value Efficiency Analysis developed by Halme, Joro, Korhonen, Salo, and Wallenius (1999) is a tool enabling us to make comparisons. The value efficiency score provides a concrete measure for evaluating the performance of other units in relation to those example units.

Numerical examples are used to illustrate the use of the approach.

Keywords: Benchmarking, Evaluation, Data Envelopment Analysis, Multiple Criteria Decision Making, Value Efficience Analysis.

1A:
Technology & Visual Arts

F2: SCIENTIFIC ART OR ARTISTIC SCIENCE?

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Keywords: History, Art, Vision

ABSTRACT

In historical terms, it is only recently that art and science have been considered as separate disciplines. The study of natural phenomena could be pursued with regard to their representation (art) or interpretation (science) and in previous centuries the same people engaged in both endeavours. One consequence of the division and the attendant specialisation is that histories of art and science are surveyed by those steeped in one tradition or the other. This has resulted in the neglect of areas of common enterprise, like vision. Visual artists and visual scientists are often concerned with examining the same phenomena, but the methods they adopt differ radically. Scientists try to discover new facts regarding old phenomena. New phenomena are rarely discovered but they do determine different conditions under which old ones operate (perhaps using some novel apparatus for generating stimuli). Artists are concerned with arranging phenomena in a manner that has not been seen before, or perhaps to increase the spectators' awareness of the phenomena. Often this involves complicating the effects rather than simplifying them. Thus, scientists rarefy and isolate phenomena to control them in the laboratory, whereas artists embrace complexity and manipulate phenomena intuitively. The differences in method have resulted in divergent vocabularies for describing similar visual effects, and the two approaches can appear more disparate than their phenomenal commonality would suggest. This is evident in the illustrations accompanying texts on vision. It could be argued that visual scientists have not represented adequately the subject matter of their own enquiry and this want was supplied by visual artists. Not only have artists provided more engaging examples of visual phenomena, but they have also enhanced their range in ways that are scientifically novel. Thus, art and science can provide complementary approaches to the study of vision.

INTRODUCTION

Colour and contour are the elements of art and science. Pigments have been employed to represent objects for tens of thousands of years and rules for the combinations of colours have a shorter but still considerable history (Wade, 1998, 2005a). With this legacy it is surprising that the science of colour did not materially influence the practice of art until the nineteenth century. The situation is otherwise for spatial representations, where issues of contour interactions were addressed by artists before they were appreciated by scientists. Considering this history, it is surprising that phenomena disclosed to the scientist's eye are often reported as discoveries. In many cases, those practitioners of vision, artists, have discovered and manipulated the same phenomena often centuries before they came under scientific scrutiny, and often with greater subtlety. A possible reason for this arrogance displayed by visual science is that pictorial stimuli were latecomers to the discipline. Prior to the invention of a variety of instruments for presenting stimuli to the eyes, most of which were invented in the early nineteenth century, vision was examined with respect to objects rather than representations of them. The instrumental revolution transformed not only our vision of pictures but also our picture of vision (Wade, 2004). Pictures could be paired, to appear in depth, or presented in rapid succession, to appear in motion, thereby replacing the two dimensions missing in static and single pictures. Theories of vision developed thereafter emphasized its constructive nature, and placed greater emphasis on the manipulations that could be made of two-dimensional stimuli. One consequence of this shift from solidity to surface was a neglect of the centuries of surface (pictorial) manipulations made by artists. Thus, a large body of phenomena was rediscovered in the confines of the visual laboratory.

VISUAL ART AND SCIENCE

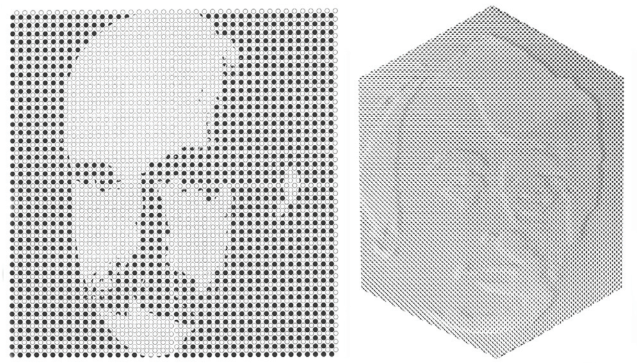

Figure 1. Left, Good Gestalt 1, portraying Max Wertheimer (1880-1943) in a pattern of filled and open circles. Right, 2 _-D Sketch, containing a perceptual portrait of David Marr (1945-1980) within a representation of a dimly defined cube. (Portraits from Wade, 1995.)

For example, we find some of the clearest examples of this in the most modern form of scientific vision – that involving pixelated images in computers. Pixels can be adjusted in brightness and colour to give the impression of contours, continuity, curvature, and conformation. They are taken as expressions of spatial integration and also Gestalt grouping principles, so elegantly expressed by Wertheimer (Figure 1, left) in the early twentieth century and computationally encoded later in the century by Marr (Figure 1, right). These principles have, however, been embraced by artists for more than two thousand years! Roman mosaics combined both pixelated images and Gestalt principles. The pixels were real rather than virtual, being tesserae, or small cubes of marble, glass or stone. They were used to represent scenes and also to display geometrical decorations. It is in the geometrical motifs that the Gestalt principles were beautifully expressed (see Wade, 2004a). Of course, mosaics were produced long before the Romans: geometrical designs assembled from small cones were produced in Mesopotamia thousands of years earlier, and Greek mosaics made up from pebbles were produced centuries before. The distinction between the mosaic artists and Gestalt psychologists is that the former represented the phenomena whereas the latter interpreted them. Many more examples of artistic science are presented.

VISUAL SCIENCE AND ART

Visual scientists, through their investigations and interpretations of visual phenomena, have pointed to avenues that artists have explored. For example, the manipulations of visual persistence to yield apparently moving images by Faraday, Plateau and Stamfer has had an enormous influence not only on art but also on popular culture (see Wade, 2004b). The illusory dots seen at the intersections of black and white grids were reported by the physiologist, Hermann in 1870 in an arrangement of Chladni figures; they were initially published in a book by Tyndall on sound (see Wade, 2005b). When it was translated into German, Hermann observed dark grey dots at the intersections of the non-fixated white lines; Hering later described the converse, and they are now called Hermann-Hering grids (Figure 2). Victor Vasarely has employed the phenomena in a variety of his op art works. Many more examples of scientific influences on art are presented.

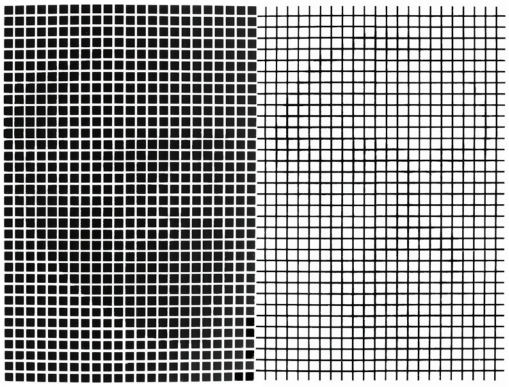

Figure 2. Hermann-Hering Grids (from Wade, 2005b). Dark grey dots are seen in the grid on the left and light gray dots in that on the right. The Hermann grid on the left contains the face of Ludimar Hermann (1838-1914). The Hering grid on the right contains the face of Ewald Hering (1834-1918). The faces will be seen when the figure is viewed from a distance.

CONCLUSION

Visual phenomena are examined with regard to their representation (art) or interpretation (science). They pass through the representational phase before the interpretive one. Artists have often provided descriptions of phenomena long before they have been rarefied for examination by scientists. The richness of the representational phase should not be disregarded by visual scientists.

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F3: FINE ART TRADITION AND IMMERSION TECHNOLOGY: A PRACTICAL APPROACH

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Keywords: Traditional Fine Arts; Virtual Reality; Presence; Situated Action

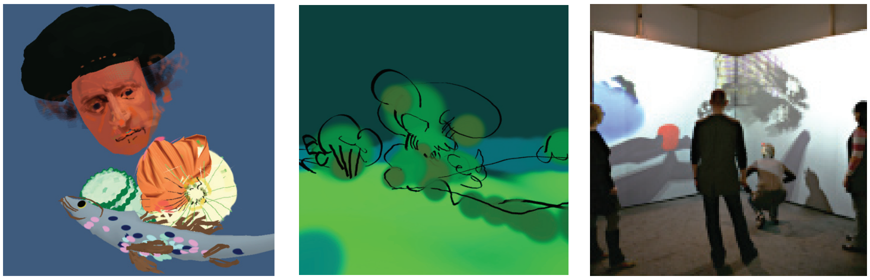

Figure 1. Left and middle: Spatial paintings by Wille Mäkelä. Right: Immersive exhibition in Kiasma.

INTRODUCTION

Though, e.g., the CAVE Automatic Virtual Environment was sensationally presented already in early 90's, real killer applications for industrial usage of immersive stereoscopy have not appeared to beat the common user interface with desktop and mouse. The technology has stayed expensive. Researches of immersive interaction for variable purposes have been made just in a few laboratories round the world. In the context of art history, immersive painting could potentially become a real turning point. My research question has thus been whether immersive free hand art could add something essential to industrial "3D" computer graphics and animation. In this paper I discuss some features of immersion and fine art, found in my project with an immersive tool and guest artists, and in public reactions on our immersive fine art exhibition in the contemporary art museum Kiasma, Helsinki, November 2005.

METHODS

My methods come from what I am, a professional artist with backgrounds in several media: first oil painting, then film and theatre. My roots may lie in the modern art tradition, where individual self and locally situated life are not yet wiped off by conceptualization and globalization. I started my doctoral studies 2001 in Media Laboratory at UIAH, once again with a new medium. When I saw 3D animations made irrationally just at desktop with a mouse, I realized the fact I wanted to paint into air.

This urge led me to a practical method, a five year dialogue and co-research with engineers in the Experimental Virtual Environment EVE at HUT [1], three walls and the floor displayed in stereo with real-time-tracked viewpoint. I had to organize the funding, but that gave me a possibility to really influence research foci. Interactive virtual tools, reported in engineer conferences[2], were developed by engineers and tested by me, while I made serious efforts to create again my own way of painting: it had been years since I last painted with oils. In the new interface, I really had alternative directions enough to choose. After some progress, it became clear I could not handle the experiences of depth as the only artist. This led to a guest artists' project that took place at the EVE in the year 2004.

After some seeking I had ten well known artists, used to drawing and interested about three-dimensionality. Four women and six men, ages from 28 to 66: four painters, three sculptors, two graphic artists and an architect. In the short tutorial for them about the tool interface, I gave some simple exercises for getting comparable user data. The rest of their time was dedicated to a free experimental dive into immersion, in order to produce public works. Four days per each artist was a rather short time to adapt to new phenomena, but they could just jump in with their matured themes and routines from traditional tools. My deepest interest concerned their free work, the fuzzy questions about what happens: How do they seek their own ways? What do they find? Can they express themselves in immersion? I was standing by all the sessions, in case of any kind of support needed, and recording automatically just by a security camera, and interviewing the artists afterwards.

Later at the exhibition, I would repeat these kinds of routines with the public and be able to check again some of my findings. In Kiasma, three sets were seen: some of my early works (2003), ten works of the ten guests (2004), and some of my latest works (2005). A set got selected by walking against its virtual symbol, and the works started to appear automatically, one after one. In the end, the symbol menu appeared again. The exhibition installation was based on low-cost wireless camera tracking in a two-screen corner [3]. One active user could wear marked polarization glasses, tracked by two web cameras, and step into the corner to walk freely among and inside three dimensional free hand paintings. Passive users around, with unmarked polarization glasses, could watch on the screens the active user's stereo view at the paintings, bound to her movements in real time (Fig.1, right).

RESULTS AND DISCUSSION

The very first tutorial exercise for the guest artists was drawing into depth with a wand - a remote controller taped together with a tracker sensor – that emitted a narrow cloud of soft, hairy particles. The artists, odd stereoscopic shutter glasses on noses, bound with sensor wires, were charmed and confused by the strong feeling of presence with the immaterial 3D graphics. Below are some answers to the question "How was it to draw a sphere with a particle line?"

- It's important how it reacts to your movement, that line.
- A usable line. Softer. If I could clutch that cursor, I would draw like with a pen. In the other hand, some people draw with a long stick…
- Not so charming a line. I would prefer a sharp one with possibility to regulate the thickness.
- I drew with computer 15 years ago. Good to memorize how weird it is. And the three-dimensionality.
- I am used to two-dimensionality. In sculpting, material is surface. Fingering red-wax plates, the other hand in behind gives response.
- No surface. More like being inside than controlling the whole vision by eye. Not necessarily a line nor a touch, but something that happens in space. Like one does not understand what he is in contact with.

The real-time display started to slow down after a certain amount of data, restricting paintings to relatively small amount of details. A relative inaccuracy in the magnetic tracking system of EVE disturbed most of the artists. A new hand device after the first half of their sessions confused many and helped some. In such limits, each guest worked her own paths well motivated and was able to give out one experimental sketch for the exhibition. Trying to answer in the shortest way the question "How did they seek their own ways to immersive expression", I am happy to be able to point a personal adjective for every one: Shyly, Bravely, Pragmatically, Painfully, Playfully, Massively, Minimally, Openly, Brutally, and Persistently. I suppose these adjectives would stand for them with any medium. They all felt it possible to recognize their own handwriting in the immersive graphics. They all found it interesting and most challenging to place color directly into deep space, into air, with free hand, in the full scale of human body's reach. One of the high-valued professionals said it is like starting everything all over again, like first time, as a child.

The public as well had something new to approach, technologically and culturally. Altogether, the experience was confusing, disturbing, even frustrating to those who stayed in less than a minute, paying attention only to the interface, without really getting over it. Those more open learned easily and got a fascinating opportunity to use a new interactive display. Families with kids were a typical gaming user type, using the installation as amusement park. Possibly a gamer would dive and run around in a virtual model of a dentist's waiting room as happily as in a painting. A more meditative user type was even able to forget the new apparatus and concentrate on scrutinizing what it showed. Of course in practice these two stereotypes, the gamer and the thinker, were always more or less mixed in a person who enjoyed the installation. Char Davies has reported gliding from action-gamers to thinkers, even till a cathartic passive experience, concerning her immersive works Osmose and Ephémère [4].

Our public in Kiasma seemed to love most of all the paintings of Anna Tuori and Elina Merenmies (Fig. 2). Anna represented universal loveliness whereas Elina brought in a horror mystery. In addition to the unique visions and personal strokes of these two painters, I suppose their success is partly due to their spatial constructions, letting the spectator to enjoy actually being situated into a deep scene. Let us imagine the possible base constructions: Objects can be the name given to things like heads or bodies that you paint from outside, not purposed to be watched from inside. Rooms, or nests, are painted around you, at a few steps' reach so that everything still matches the real space between the screens. Very interestingly, spaces continue through the screens, into the virtual space behind them. Painting a space requires dragging, turning, or scaling some parts of the painted figures "through the screen". It might be notable that rooms and spaces appeared only in works by all the four painters and the architect. This could be understood with respect to the fact that many sculptors are used to work objects' surfaces, not spaces. One should, however, remember two facts that encouraged working on objects: Possibilities for multiple details were restricted by the increasing display delay, and my stressed point in tool development was fine motor drawing at the closest reach of hand.

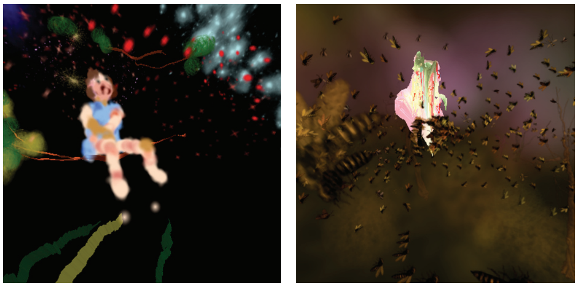

Figure 2. Snapshots from immersive paintings by Anna Tuori (left) and Elina Merenmies (right).

CONCLUSIONS

Three-dimensional free hand traces have been brought into computer graphics with promising results of expressive communication. Immersion allows not only hand but the whole human body to leave spatial traces and read them. This primitive level of presence and interaction appears highly interesting for both fine art professionals and their public. However, a real culture of immersive vision could rise only with practical affordability of these techniques. That would require a lot more industrial interests and innovations in the broadening field of low-cost immersion solutions.

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F4: ANISOTROPIC EVALUATION OF MONDRIAL-LIKE PATTERNS

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Ms Kaori Kurihara
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Abstract arts are generally simple and they lack reality as they are not accurate representation of real form and texture. Nevertheless, they give us some impression by using elements such as line, shape and color. Piet Mondrian made many paintings with horizontal and vertical lines and with the primary colors (red, yellow, and blue).

His style was based on an absolute harmony of straight lines and pure colors. Behind the essences of their beauty there could be some ethological base of human visual perception. Especially, anisotropy of impression in color arrangement seems to influenced much on visual arts. In order to make it clear, we analyzed impression of simple Mondrian-like color arrangement pattern with red, yellow, and blue, and find out some anisotropy in their impression. We made 18 square patterns composed of four small squares in same size. Diagonal two of small squares are white and another two are filled with different two colors from red, yellow, and blue. Fifty eight subjects are asked to judge “naturalness”, “brightness”, and “preference” under the simultaneous presentation of two square patterns with different color position. The results show that there is anisotropy of impression in color arrangement. “Brightness”, for example, is significantly different in some pairs of patterns which are mirror image each other. There are also some statistically significant difference in the choice of “naturalness” and “preference”. These results suggest that there are anisotropy in our aesthetic judgment of visual patterns, and that artist realize and utilize them in their composition.

F5: MUSIC GENERATED FROM PICTURES

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Keywords: Pictures; Generative Music; Algorithmic Composing; Psychology of Music

INTRODUCTION

The most common way to generate music from pictures has been the “Piano player method”. The vertical positions of pixels are interpreted as pitches and time goes from left to right. The results using this simple method have not been impressive. The method presented here uses pictures to generate music in a different way.

METHOD

The Synestesia method I have been developing generates music (midi files) from any pictures. Sculptural work is a good metaphor for the method: the sculptor starts from a block of stone which inspires the artist towards a certain final result. Synestesia Method is based on filtering pixels “away” and on using several selectable parameters. Using parameters is like looking the sculpture from different angles or in differernt lightings and environments. The picture and the list of parameters together

form the metascore of the composition. The challenge is to find pictures generating interesting music. But why does this method work?
The Synestesia method will produce complete compositions, modern art music. By selecting specific parameter sets one can build quite different styles or composer profiles. The pieces composed have lasted from one minute to 10 hours. The generation itself will take about 5 seconds. Link for the full presentation of the method is shown in REFERENCES section.

Many people interested in Synestesia method have been asking about the inverse process, generating static pictures from midi files. By going back and forth in this way one could get a kind of generalized cell automaton creating music and pictures forever. That is possible because those mappings are irreversible.

Most philosophers of music think absolute music has no semantics. The noun “cat” refers to things called cats but sad music has nothing to refer to. Sad people walk slowly and sad music is slow but that is only an isomorphism or a cliché. Pictures on the other hand have semantics. The mapping from pictures to music is always more or less artificial, there is an infinite number of possibilities.

PICTURES

On the site synestesia.fi one can find about 200 mp3 pieces which have been generated by using many kinds of pictures, landscapes, drawings, barcodes, cash receipt, ruins of WTC, falling space shuttle, hand writing, portraits, dogs, Aurora Borealis and so on. The main question here is this: how can Synestesia Software using Synestesia method generate so interesting music that month after month 5000-6000 files are downloaded from the Synestesia Internet site?

MUSIC

One might postulate the following paradigm set: absolute music, titled music, picture music, program music, songs.

Absolute music doesn’t tell a story. It is more like ornaments in art. The titles give listeners a kind of context for listening the piece. Changing the name moves the listener to a different listening context and the piece may create new impressions. Many listeners erroneously think that the piece “represents” something. Even in art the name of a painting may be important. One can see the sunset over a lake only after hearing the name of Turner’s painting “Sunset over Lake”.

Pictures correspond to the titles of “normal” compositions. Generating music from pictures creates the contexts for listening. Using both a picture and a name may even magnify the effect. Because of the parameters it is possible to influence the piece to be generated in a pseudo-synesthetic way. Quite often the generated music seems to have its own character “asking” the user to go to a certain direction. The “picture music” is a new and unmapped area of music, connecting art and music. But one must always remember that pictorial representation of music is not possible because music doesn’t have semantics..

Program music is based on descriptive texts. Film music may be a kind of program music, or film “on the background” can make absolute music programmatic in the ears of film lovers. Good examples of this are Stanley Kubrick’s films “Eyes Wide Shut” and “Space 2001” using extensively György Ligeti’s music.

COMPUTER CREATIVITY

Can computers be “creative”? It is a well known fact that some of the most original moments in Beethoven’s Ninth Symphony have been the result of printers’ error. Also the Finnish composer Einojuhani Rautavaara has reported that he has got some of his ideas when hitting a wrong piano key during composing. So it seems that live composers may use randomness or serendipity as a creativity tool. It is a kind of a paradox that computer music based on randomness has not been so successful. The Synestesia Software does not use randomness at all, all pieces are deterministic.

Many creative composers have developed sets of algorithms for creating their compositions. Good music must move on midway between the expected and the unexpected. Synestesia music typically does something else than expected without randomness. Professional musicians may experience this negatively as if the music would be trying to fool them. However, the pieces are not based on old clichés that are so typical especially in film music. Even professional creative composers could profit from Synestesia Software as a creativity generator.

COMPOSITIONS

Synestesia music doesn’t use the model of tension/release/resolution but many pieces are still highly emotional. The structures and rhythms of Synestesia pieces are mainly based on the structures and colors of the pictures used for generations. Anybody can use Synestesia Software for generating music and the music will always be coherent when compositions of amateur composers may be less coherent.

According to an old myth Beethoven composed his pieces in his head before writing on paper. That myth has been proved to be false. The documents show that Beethoven wrote his pieces tens of times on paper before the final version. When using Synestesia system one starts from the chosen picture and one is able to listen to the generated piece after only 5 seconds. Some parameters can be changed and after additional 5 seconds the piece can be listened again. The process is very interactive and rewarding.

Sometimes Synestesia music may be like semi-repetitive tapestry still having inner variability. The method is based on gravity of pitches. Perhaps that is one of the secrets of the system.

Much of the enjoyment of modern art music is based on rehearing the music many times. Synestesia pieces can be perceived during first hearing.

Older art music has the feature of persistence of illusion, the same music can be enjoyed again and again. Synestesia music creates the same illusion.

It is well known that musical notation is only part of the truth and musicians playing the piece create their own version the piece. Synestesia midi files can be printed as preliminary scores and processed into full scale scores with articulation etc. Synestesia Software creates the control codes to be used by the software instruments used for playing midi files, but the notation or the sequencer programs don't understand these articulations. On the other hand it is possible to use instruments in such a way that normal instruments can't follow, unplayable rhythms and piano glissandos are good examples of this.

FUTURE

One interesting tool for research (and fun) is under development as an application of Synestesia method: Snapshot Music.What you see is a camera lens and loudspeakers on a side of a box. If the camera detects some change on the view the system will wait until the view is nearly static and then the system will generate music using up to 16 instruments and after a few seconds one can listen to the music. The piece will last about one minute and the process will start from the beginning. This tool could be used for experimental musicology in many ways and for music therapy for example.

The main problem at the moment for using Synestesia music is the price of the software instruments used for playing the midi files. Also the software instruments call for a powerful computer having a lot of ram. Synestesia Software (Java applet) itself can be used in any computer, PC or Mac. My guess is that in a year or two the situation will be quite different and the opportunity window will be widely open for the approaches like Synestesia method. Many new applications will be developed for "emotion conversions" from pictures to music – even for mobile phones.

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Method description: http://www.synestesia.fi/method/synestesia_2003.html

F6: DIALOGUE BETWEEN ART AND SCIENCE – EXAMPLE: DIGITAL FILM

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Keywords: Science; Digital Film Making; Art

MONOLOG

Since a while I am drifting between the field of art and science. As passionate film-maker in 'private life' and as passionate scientist in 'business life' I have been wondering what gained my interest in these two disciplines and their similarities. Many artists had doubts about my artistic capabilities – and many times I heard "you are only an engineer". On the other hand many scientists told me, that my approach towards my work is sometimes too creative and I should focus. At the beginning I perceived film-making as chaotic and too less precise. But I should learn different, and the beauty of this medium. Film-making allows a high degree of freedom, but also underlies many rules and structures. But it allows self-expression. Self-expression is hardly to find being a scientist. Self-expression reduces to motivate oneself to hold through in succeeding in solving problems. With artistic work I can express myself, my thoughts, and feelings – the work becomes a piece of mine. Don't forget, there are many artists, and there are many scientists – only few are geniuses and create new. And these geniuses have things in common: creative minds that create compelling new, being passionate about their craft, strong followers of their own ideas, and like to play with the challenges.

ART, SCIENCE AND FILM-MAKING – AN IMPOSSIBLE COMBINATION???

Art and science seem to be two completely different worlds. Science seeks to discover the rules how the world works, and art seeks expression. But both worlds are somehow similar, considering, that the way of approaching discoveries or artistic masterpieces. Only a brilliant brain can create something that is 'novel' in both fields. Focusing on the history of media, it becomes visible, that each media form was enabled by new technological innovation. An artist has to learn this new technology to be capable of creating a new art piece. Film-making undergoes a tremendous change nowadays: digital production techniques, digital cinema, digital workflows, etc. More and more computer science vocabulary enters the world of film-makers. Film-makers rather purely understand this world, but also engineers do not understand the artistic world. Film directors tell stories – stories they have a personal relation to. The goal of this work is to create a dialogue between the crazy scientist that develops and invents latest technology, and the artistic director that uses this technology to tell his story.

This work shows similarities, differences, and creates a relation between artists that utilize latest technology to create their artistic masterpieces.

But what is the key in science? There are successful scientists improving single formulas by a few details and further on they publish myriads of articles about simple improvements. These scientists are specialists in one single field – following the general trend towards specialization. A real scientific break-through is rather seldom made by specialists. Mostly visionaries have the capability to converge thoughts and disciplines to find a new conceptual model. And only conceptual models leave a trace in history. Examples are EINSTEIN, NEWTON, or LEONARDO DA VINCI. They understood the theoretical background as well as they had the creative mind to develop a completely new conceptual model by converging fields to conclude to new. So, the key in science is to find new conceptual models.

TECHNOLOGY, FORM, AND STRUCTURE WITHIN THE PIECE OF ART

To answer the relation between technology, form & structure and the piece of art, we have to ask ourselves what the theory behind film-making actually is. What is the research behind the medium film and which theoretical frameworks are relevant to bring this medium forward. As in any field of art, at first there is a scientific invention. In film-making it was the invention of photography, motion pictures, colour film, and nowadays digital technology. These are the tools the artist has to work with.

Creative scientists came up with new conceptual models that where further utilized by creative artists in their works – new technologies for letting new forms of art emerge. In this case it is simply film-art. The field of film art combines research related to film including history, aesthetics, genres, form & style, analysis, and techniques (see (Bordwell et al. 1997)).

Performing film-making as an art allows a higher degree of freedom than to create scientific work. Sometimes it creates a feeling, that the creation of a piece of art is less constrained by an underlying formalism, that art is simply more laissez-faire. However, this is not the case. Along with the development of any new form of art – in the case of film making, film form – a theoretical framework for describing ways how to create works was developed. Film form gives information how to create photographs and compose object into a frame; how to put shots into a sequence to create the desired psychological effects for the audience (montage); and the principle of mise-en-scene, describing what should actually be in a scene. A more descriptive framework (called film grammar) was developed by DAVID LLEWELYN GRIFFITH, who established a formal language for describing shots, scenes, and sequences and the events that are taking place within each of them (Wikipedia). On a more concrete level, also particular mathematical models found their way into film-making. SERGEI EISTENSTEIN, the father of montage, described in his works many ways how to mount films on mathematical models as e.g. the metric montage based on joining parts of a film according to a mathematical formula (Eisenstein et al. 1949; Eisenstein et al. 1970; Eisenstein et al. 1975). Film-techniques deal with the more technical or methodical issues required creating a film. It includes camera work, light, sound, editing, effects, formats, and nowadays digital technology. It is more related to the lower level tasks to be enable the desired film-form.

Many things are common in science and film-making:

- film and science have structure and form with underlying principles and con ceptual models;
- technology determines the film form and therefore the artistic possibilities of the medium;
- use of digital technology in form of high-definition, computer graphics and distribution;
- capturing light, colours, and the narrative space as key sciences to create a new art work;
- film grammar and language as formal system to describe events in shots, scenes, and sequences;
- mathematical models as basis for montage for piecing film components to gether;
- certain degree of perfectionism to create a work with highest quality.

CREATING AN AUDIO-VISUAL DRAMA

The very simple goal of a film-maker is to create an experience for the audience by telling a story. During the creation phase, the director is the story-teller, psychologist, logistic expert, cameraman, sound engineer, actor, etc. The director's task is to guide the production process to tell his viewpoint of the story. Today, more and more technology enters the world of film-making. This includes special effects, digital compositing, high-definition, computer graphics, or blue-screen. The director is concerned about the creation of the highest quality piece with the tools available to him. All is about creating drama. As ALFRED HITCHCOCK stated, "drama is life with the dull bits cut out" (Famousquotes). Nevertheless, the ways and technology how drama is created changed tremendously. Film technology evolved from analogue to digital and this creates a lot of confusion around existing directors.

The approach to create a piece of work, either in science or in film-making differs strongly. We can simply call it "rationalism vs. intuition". A scientists asks himself, "how can I improve this?, which methodologies can I introduce to optimize?, how does this work?, are the results of my experiments better?, or why are we doing this?". The artists has more an intuitive approach, and asks questions such as "how can I express this?, I would like to achieve this, but how could I do it?, how can I tell my message to society?, or how can entertain my audience?".

At first let us consider the potential relationships between science and digital film-making: despite seldom happening, at first there is the scientist as film-maker; as second the scientific mind highly contributes to the advances of film; and as third, the film-maker as the developer of future visions of how society and the world might evolve.

If a typical white-coated scientist would be a director, he would ask for technical set-ups, organization plans, word documents, more transparency and more logical work flow, better equipment, or even think how he could improve something. But he would completely not understand the point – to create a fictive story universe for the audience in time and space. In conservative film making, time is linear – a sequence of actions in the film. The space is created as place where the happenings are located. The film-space “is a means of using visual manipulation to take real spaces and real objects and look at them, perceive them, and feel about them in many different ways – ways we can not command” (Brown 2002). But he would be all wrong!

Film-making deals with characters, persons, their stories, artistic environment, and creativity. It does not deal with improved camera systems or data storage media. These are just tools that you need to be professional in working with. Film-making deals with the abstraction of story in an artistic environment, rendering it audio-visually, and to create a mood for the audience. Despite scientists work also in teams, it is mostly ’one’ that creates the new – in film-making it is the ‘we’. Not essentially this is always true, strong personalities as directors always attempt to tell the story the way they want. One example is STANLEY KUBRICK, which simply told his cinematographer RUSSELL METTY in Spartacus (1960) simply to do nothing, as he determines the style. Later, RUSSELL METTY won an Academy Award for his (or KUBRICK’S?) artistic work (see (IMDb) and (Gelmis 1969)). It is important to understand, that film-making is an evolutionary progress – story pieces are put together step by step and whole teams decide upon its evolution – but this argument seems to be not valid for strong personalities heading the project.

Discussing about scientists as film-makers, we have to mention PAUL VERHOEVEN and his works (e.g. Starship Troopers (1997)). PAUL VERHOEVEN is holding a degree in mathematics and physics, and came to the world of film by making documentaries for the military (IMDb). It seems also scientists can make films. A very important field of film-making in science is scientific visualization. To make complex conceptual models such as the Relativity Theory more understandable, a little movie helps.

A VERY SIMPLE CONCLUSION

Nevertheless, artists and scientists (if not being Steven Spielberg or Albert Einstein) have one thing in common: “science [and art] is a wonderful thing if one does not have to earn one’s living at it” Albert Einstein (Famousquotes).

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1B: Modern Technigues in Health Care

F7: READING BRAINS AND MINDS: An introduction to modern brain imaging

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Recent technical advances have made it possible to follow brain functions of awake and behaving humans noninvasively and accurately, with millimeter-scale spatial and millisecond-range temporal resolution. An introduction will be given to the basic principles of two modern imaging methods: the functional magnetic resonance imaging (fMRI) monitors changes of oxygen level in the brain, and the magnetoencephalography (MEG) picks up weak magnetic fields associated with neuronal currents. Both methods have been widely applied to study the brain basis of human sensory, motor, and cognitive functions. Many of the obtained results indicate a tight action–perception connection within each individual and both motor and sensory "mirroring" between individuals to support intersubjectivity.

F8: POSITRON EMISSION TOMOGRAPHY - A NEW METHOD TO SEE THE FUNCTION OF THE BRAIN

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Keywords: PET, physical performance

INTRODUCTION

Positron Emission Tomography (PET) is the method of choice in a number of brain research and drug development applications. PET has opened new possibilities to investigate oxygen consumption, blood flow, energy metabolism and the function of brain in normal and disease condition.
In drug development PET can provide unique information about the distribution and properties of drug targets in the living organism, about biological effects and mechanisms of action of drugs, about pathological changes and biochemical and physiological processes in various disease states.
Recently PET has shown to have more clinical indications also in brain pathophysiology.

The aim of this review is to evaluate results from new dedicated brain PET device for finding smaller brain areas and with better quantitative accuracy. This is done both with phantom and human data.

METHODS

Cyclotron produced short lived isotopes such as C-11, O-15 and F-18 are most commonly used isotopes for labelling molecules or drugs. After administrating these labelled compounds in tracer amounts molecular pathways can be studied by taking dynamic image series of various organs in animals or humans. The input of the molecule is derived from arterial or venous plasma data. Dedicated scanners for small animal research have been developed but they are not applicable for brain studies. The HRRT (High Resolution Research Tomograph, Siemens Molecular Imaging, Knoxville, TN, USA) is the state of the art scanner for small animal as well as brain studies. It is developed for research use and only 18 of them will be installed to PET research centres around the world. Main physical parameters are listed in Table 1. The crystal is made of two 10mm layers. The fist is Luthetium orthosilicate (=LSO) and the second Yttrium doped LSO (=LYSO). Main performance parameters of the new scanner were measured as close as possible according to NEMA NU-2001

(2001) (National Electrical Manufacturers Association) standard and are compared with commercially available scanners.

Table 1. Physical parameters of the HRRT PET scanner

Detector material	*LSO/LYSO dual layer crystal*
Dimension (mm)	*2.15x2.15x10 both layers*
Ring diameter (cm)	*46.9*
Number of detectors	*59904 in both layers*
Axial Field of View, FOV (cm)	*25.3*
Transaxial FOV (cm)	*35.0*
Image planes	*207*

RESULTS AND DISCUSSION

Comparison of NEMA performance is shown in table 2. The commercial scanner value is the best value of three commercial scanners on each performance parameter. The values show that the new scanner has great potential for brain imaging. Series of human studies were also performed to compare the image quality of the HRRT against commercial scanners. Most commonly used ligand is F-18 labelled F18-FDG (Fluoro-deoxy-Glucose). Brain structures are clearly seen better with HRRT than other scanners when keeping other imaging parameters constant (Fig. 1)

Table 2. Comparison of main performance parameters

		HRRT	*commercial PET*
Spatial resolution (mm)			
transaxial	*1 cm*	*2.5*	*4.6*
axial	*1 cm*	*2.5*	*5.1*
transaxial	*10 cm*	*2.6*	*5.3*
axial	*10 cm*	*2.5*	*5.9*
Sensitivity (cps/kBq)		*14*	*8.5*
Scatter fraction (%)		*45*	*34*

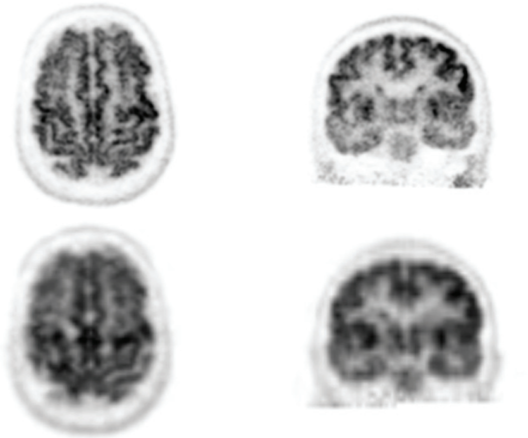

Figure 1. FDG brain study of the same subject scanned with the HRRT (top) and a commercial PET scanner (below). The difference is clearly visible and HRRT reveals more structural information.

CONCLUSIONS

PET has proved to be valuable tool in brain scanning. The new dedicated brain scanner HRRT further improves the value of PET method and can provide invaluable information about the potential of a new therapeutic principle in drug development as well as brain research and clinical diagnosis.

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F9: INDIVIDUAL FUNCTIONAL IMAGING AND MEASUREMENTS ON NORMAL TISSUE RESPONSE IN RADIOTHERAPY

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Keywords: MEG, scintigraphy, laser Doppler method

INTRODUCTION

Radiotherapy (RT) has greatly been benefiting from various imaging methods such as magnetic resonance imaging (MRI), digital subtraction angiography (DSA) and positron emission tomography (PET) in defining cancerous tissues and target volumes for radiation. Apart from PET , which is gaining increasing popularity in RT, functional imaging of normal tissues has not been widely utilized to optimize normal tissue sparing. Moreover, data of functional measurements on normal tissues during radiotherapy is few. There is still not enough knowledge of how to apply those results in RT planning, e.g. in fractionation.

In this presentation we present three techniques that we have made to approach these topics, with each of the author working in one of the projects described.

METHODS

1) To localize normal tissue with critical function we used MEG (magnetoencephalography) with anatomical MRI (magnetic resonance imaging). Important primary visual or sensomotoric areas on the cortex were determined before high dose stereotactic radiotherapy. The patients (n=4) were given either a stimulus or a task and the response of the cortex was registered by MEG and localized in MRI, which was then used in RT planning.

2) To study the effect of radiotherapy on salivary function in the treatment of head and neck cancer patients we made both a direct measurement of saliva production and salivary scintigraphy. Both parotid (stimulated) and submandibular (unstimulated) functions were determined in scintigraphy. Radiotherapy was carried out by intensity modulation in 36 patients to a total dose of 50-72 Gy.

3) Radiation-induced cutaneous hemodynamics was measured by a self-constructed HeNe laser (_=632 nm) Doppler device in 194 patients receiving radiotherapy with various fractionations (table 1). The amount (RBA) and the velocity of red blood cells (RBV) as well as DC level describing the redness of the skin (direct current) were measured prior, during and after RT.

Table 1. Description of the patient material.
X refers to photons (MV) and E for electrons (MeV) from the linear accelerator.

Patients	*Radiation*	*Fractionation*
24	*60Co/X4*	*20 x 2.4 Gy*
130	*X6/E9*	*25 x 2 Gy*
19	*X6*	*4 x 5 Gy*
21	*120 kV X-ray*	*5x 0.2/0.6/1.0/1.2 Gy*

RESULTS AND DISCUSSION

1) MEG/MRI: On a reconstructed model it was technically feasible to determine the activated areas to be avoided in radiotherapy planning. The patient cases will be presented to demonstrate the benefit of image fusion in stereotactic radiotherapy treatment planning.

2) Both parotid and submandibular gland function can be spared after radical RT of head and neck using IMRT. The response is of sigmoidal shape. The calculated D50 for one year after RT is 27.2 for stimulated salivary secretion and 34.2 Gy for unstimulated. As a consequence there will be a trial starting to investigate the correlation between clinical symptoms and results of the functional tests and imaging.

3) Laser Doppler studies: The results demonstrate peak changes up to 215% in RBV. It also correlates both with skin dose and biologically effective dose (BED). Great individual changes were observed. The results also demonstrate that early response in cutaneous microvasculature within 2 weeks of RT indicated by the DC level is prognostic for patient outcome, studied in a small sample of patients. The finding suggests that both normal tissues and tumours share the same individual radiosensitivity.

CONCLUSIONS

Instead of relying mainly on animal studies or on human studies demonstrating the observed complications (often severe, i.e. reaching the tolerance dose) - or on visual scoring or symptom grading it is possible to use functional data obtained from normal tissues. Functional imaging and measurements provide an objective assessment of normal tissue response and their more optimized use in further RT treatment planning.

Our results demonstrate that functional measurement of normal tissues can provide valuable information for RT treatment planning in order to avoid irradiation of structures with critical functions. It can be used when outlining the planning target volumes and designing the irradiation technique and fractionation. Studying the response of normal tissues also helps in establishing individual dose response relationships, which may predict the clinical outcome.

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F10: MEDICAL PHYSICS IN DIAGNOSTICS OF MUSCULOSKELETAL DISEASES

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Keywords: Articular cartilage, bone, diagnostics; osteoarthritis, osteoporosis

INTRODUCTION

Bone and cartilage are elementary components of our locomotory system. Both tissues have adapted to carry body weight and enable smooth locomotion of the body. For their important mechanical function, tissues have unique mechanical properties. For example, cartilage-cartilage contact shows minimal friction, not obtainable by engineered materials

Musculoskeletal diseases, such as osteoarthritis and osteoporosis, are examples of chronic diseases with continuously increasing incidence. These diseases are the major threats of our musculoskeletal system. Osteoarthritis (OA) is a severe disease of the joints, in which articular cartilage is damaged and worn away. Majority of population over 65 years suffers from this condition that causes pain and discomfort as well as restricts daily activities. In osteoporosis, compositional and structural tissue changes reduce bone strength exposing it to fractures. For both diseases, early diagnosis is essential for the successful treatment. Unfortunately, the present clinical diagnostic techniques, such as joint radiographs for OA, provide only insensitive diagnostics of early cartilage degeneration. Osteoporosis diagnostics also exhibits some limitations that reduce the diagnostic performance. A current golden standard for osteoporosis is dual-energy X-ray (DXA) technique.

DIAGNOSTIC TECHNIQUES

As both cartilage and bone are weight bearing tissue, evaluation of their mechanical properties may provide sensitive ways to diagnose their pathology. Based on laws of physics, mechanical and acoustic techniques can bring information about material properties of these tissues. We have developed mechanical and ultrasound methods that can be used to determine quantitative parameters that are directly linked to tissue material properties.

In cartilage, indentation technique during arthroscopic examination of the joint indicates compressive stiffness of articular cartilage, sensitively impaired in early cartilage degeneration. Visually undetectable tissue pathology may be determined with this mechanical technique. Combination of ultrasound and acoustic measurements, i.e. mechano-acoustic technique called ultrasound indentation, gives even more information on tissue pathology and enables diagnosis of the type of tissue degeneration. This information could guide the further treatment to optical alternatives. These technologies and instruments developed by our research group have been applied in many theoretical, experimental and clinical studies which have highlighted their diagnostic strength (see, e.g., Töyräs et al. (2002), and Laasanen et al. (2003))

For osteoporosis, we have developed noninvasive diagnostics using techniques based on ultrasound (US) backscatter measurements (Hakulinen et al. (2004), (2005), and (2006)). Laboratory measurements have demonstrated that backscatter measurements reveal diagnostically valuable information, in a more flexible way than the existing clinical transmission US techniques. Bone mechanical strength can be predicted with the backscatter technique, possibly improving accuracy of the prediction of fracture risk. Both backscatter and transmission US techniques necessitate elimination of the effect of overlying soft tissue, a great challenge to perform successfully. Our experimental and theoretical analyses suggest that this elimination can be possible even during in vivo measurements. However, more work is still needed before the US backscatter techniques can be taken into clinical practice.

DISCUSSION

Development of novel diagnostic tools is only successful if experts in physical, medical and engineering sciences work together to combine the theoretical expertise of a medical physicist with the experimental and clinical skills of the other professionals. By active collaboration a significant contribution to the prevention, diagnostics and therapy of musculoskeletal disease is possible.

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2A:
Technology & Music

F11: THE HISTORY AND FUTURE OF COMPUTER MUSIC

Otto Romanowski

ABSTRACT

What kind of computer did Mozart use? Do we need people to compose and perform? Do we need instruments? Composer Romanowski will give audible answers to these questions and will predict the future.

F12: COMMODORE 64, INSTRUMENT OF COMPUTER MUSIC THE CULTURAL HISTORY OF SOUND INTERFACE DEVICE (SID)

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INTRODUCTION

Nowadays the importance of computer music in popular culture is undisputable. Usage of computers or more commonly information technology have made possible to create new kind of music culture. More widely this phenomenon is a part of digitalization of our culture. As we examine the present changes in cultural existence, we also need to find ways to make new interpretations of our cultural past. (Gere 2006) In my presentation I will concentrate on the cultural history of SID-music, better known as the reference for hardware used in Commodore 64 home computer. It's mainly a part of my research "The Lure of the Machine. The Personal Computer Interest in Finland from the 1970s to the mid-1990s" (Saarikoski 2004).

THE RISE OF GAME MUSIC

In 1982 Commodore computer company, founded in United States by Jack Tramiel, released a new and revolutionary home computer model, Commodore 64. In early 1980s home computers were extremity primitive if you compare them to modern PCs. But in those days Commodore 64 was one of the very few affordable home computers, which could be used for creating multimedia. Technical features included real time colour computer graphics, sounds and music. (Bagnall 2005) And because of this Commodore 64 could easily be used for game programming. One of the most important hardware used in Commodore 64 was sound chip called SID (Sound Interface Device). This tiny little device enabled the making of four channel music. Designer of SID, Bob Yannes have recalled that the majority of computer sound chips available in markets had been designed by people who knew nothing about music. Although this might be a strong generalization, SID was still in many ways a serious attempt to create a sound chip as good as available in professional synthesizers. (Barton 2004)

Commodore 64 was a huge international million-seller. This home computer remained in production for over ten years (1982-1993). In Finland, Commodore 64 was the most popular home computer ever used in 1980s. During it's hey days in 1985-1987, almost 75 per cent of finnish home computer market was dominated by this machine. (Saarikoski 2004) Breakthrough of Commodore had also a strong international impact on the social and cultural formation of home computer hobby. SID computer music culture, mainly mainted by the computer hobbyists became first active in early 1980s. In 1980s computer music culture was also in some way connected to the rise of electronic music industry.

Commercially SID-tunes were used mainly in computer gaming industry. In many ways, the SID-music marks an important turning point in history of game audio. It's quite interesting that almost all of the professional SID-composers began their careers as computers hobbyists. Most SID-composers came from Europe (especially from Britain and Germany). Perhaps the best known composer was Rob Hubbard, but alongside with him you can also mention composers like Martin Galway, Ben Daglish, David Whittaker, Jeroel Tel, Mark Cooksey, Chris Hülsbeck, just to mention a few.

SID-composers were also very talented programmers, because SID -music-files had to be squeezed in couple of kilobytes of computer memory. Actually quite many of the composers worked under hard stress, work schedules were usually almost inhuman. Music had to be created in couple of weeks, at worst in couple of days. Because of this SID-composers can usually be classified as a part of "hacker" culture. This refers to the quite idealitic view of computer hobbyist ("geeks") as unselfish pioneers of computer culture. (Saarikoski 2004)

In Finland there was a handful of SID-composers, but there are only a few commercial tunes available. Some of them have also been active in demoscene, subculture of computer demos. Some have also been composers of electronic music. In an interview Otso Pakarinen, who was also game programmer and pioneer in electronic music, told me that working with Commodore 64 was quite fun but challenging. Before they could even start to create games and music they actually first have to program all software tools! (Saarikoski 2004)

So how can you describe the sound of SID-tune? First of all, it's very simply but usually tune is catchy and it include some complicated variations. No samples or any modern data storage technics can be used. SID-music was played of course during the game play, but there was also a special style of music called "loaders". In those days the loading of a computer program could take painful 5-10 minutes. Because of this "loaders" were usually played together with a graphic display while the game was being loaded from cassette or disk drive.

THE LEGACY

As the commercial market for Commodore 64 -games was shrinking in late 1980s and 1990s, the composing of SID -tunes was more and more a part of computer subcultures, for example demoscene. From 1990s to 2000s SID-music have also influenced several new computer music genres, such as "chip tunes", which refers to music written in module formats, where sounds are created in realtime by a computer. During the late 1980s saw the first climpse of nostalgia for the old SID-tunes, when computer hobbyists started to convert SID-music and games of Commodore 64 to the new computer platforms. This was the starting point for the cultural phenomenons now known as "retrogaming".

According to the SID-music archives, especially The High Voltage SID Collection, there are over 30,000 SID tunes available (<http://www.hvsc.c64.org/>). More tunes are added regularly. Best examples of SID tunes have endured time and they can be regarded in many ways as "classics" of computer music. Primitive but still enchanting soundscape of SID can be a reason why there are so many free remixes of SID-tunes nowadays available (for example <http://Remix.Kwed.Org>. For many of those who started to play computer games in 1980s, SID -game tunes are clearly a living part of their computer history. This also explains how there so much humor and nostalgia linked to old Commodore games and music in popular culture today.

RESULTS AND DISCUSSION

To conclude there are several factors for the rise of SID music culture. First was the early rise of computer gaming industry and secondly the formation of home computer culture. This also partly explains the longevity of SID music culture. This can not be solely explained to be a part of nostalgia. Still SID music awakes warm feelings, which can be read from this paper too.

But SID-music is still used in new and creative ways even by the users who didn't have the opportunity to play with Commodore 64 in their childhood. It's also interesting to notice how SID music can now be heard for examples in music videos or TV-commercials. At least in Finland Commodore game tunes are widely used in mobile phones. This also raises several interesting questions. How can SID be classified as a part of popular culture in wider point of view? And in which direction is today's game music culture developing? In many ways the cultural history of SID demonstrates how boundaries between human and computer are not simple and technologically oriented as many might think.

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F13: TOWARDS THE NEXT GENERATION DIGITAL PIANOS

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Keywords: Musical Acoustics; Piano; Electronic Music

INTRODUCTION

The piano is probably the most popular instrument in western music. It has established its status since the first piano, which was built in 1709, when Bartolomeo

Christofori of Florence modified the harpsichord in order to make the instrument capable of variations in tone (Fletcher and Rossing (1991)). Today many people live in apartment buildings, and thus there is a demand for high-quality instruments that do not disturb the neighbors. Digital sampler-based pianos have become popular, mostly because they sound and even feel astoundingly natural, but do not produce structural noise. However, the drawback is that the need for memory is heavy, since the sound production mechanism of the instrument is based on recorded tones that are played back from the memory of the instrument. Moreover, the physical couplings between the tones are inadequate.

Physics-based modeling of musical instruments has gained popularity during the past decade (Välimäki et al. (2006)). The idea behind this technique is that the sound production mechanism of the instrument is modeled instead of the sound itself. This can be done in a computationally efficient manner with digital signal processing. The advantages are the reduced memory consumption and the possibility to take the physicality of the instrument into account better. In addition, by changing the parameters of the synthesis algorithm, it is possible to model a high-quality Steinway grand piano or a poor upright piano with the same algorithm. It is also possible to scale the algorithm to meet the required computational complexity and sound quality. This, however, usually requires knowledge about the human perception of the piano sound, which can be studied by means of properly designed listening tests.

ACOUSTICS OF THE PIANO

In this section, the acoustics of the piano is briefly overviewed. The discussion is mostly concentrated on the grand piano, but the presented features are also applicable to the upright piano. The grand piano consists of five main parts: the keyboard, the action, the strings, the soundboard, and the frame (Fletcher and Rossing (1991)). The keyboard consists of 88 keys of which 52 are white and 36 are black. From the keystroke the energy is transmitted to the action, which controls the hammer. The hammer hits the string and sets it into vibration. The energy is transmitted into the soundboard via the bridge. The cast-iron frame, positioned to the upper part of the wooden case, keeps the instrument together, and it is designed to withstand the high tension of the strings. The strings are attached to the tuning pins at the player end and to the hitch-pin rail at the other end. There are 243 strings in a concert grand piano; the first eight strings are single strings and the rest of the strings corresponding to the 80 highest keys are in groups of two or three strings.

The main features of the piano sound are inharmonicity, complicated decay, and beating. In addition, the soundboard and usage of sustain pedal amplify and color the sound. The inharmonicity in piano sound is caused by stiffness of the vibrating strings. It causes the higher partials to travel faster on the piano string, which means that their frequencies are a little higher compared to those of an ideal string. The complicated decay process is due to frequency-dependent losses in strings. As the strings preserve most of the energy transmitted by the hammer and the action, the decay rate of the tone depends on how rapidly the energy is leaking out from the strings. Another important phenomenon in the piano sound is the beating, which results from unison groups of strings (Weinreich (1977)). When the hammer excites a tricord, that is, a set of three unison strings, the strings begin to vibrate in the same phase. Due to small differences in frequency between the strings in the tricord, the tone starts to beat soon.

PHYSICS-BASED MODELING OF THE PIANO

At the moment, the most popular physics-based sound synthesis technique is the digital waveguide modeling (Smith (1992)). It is based on the traveling-wave solution of the wave equation. The solution can be written as a superposition of two traveling waves (one traveling to left and the other traveling to right) propagating along the piano string. The solution can be discretized by sampling the values of the traveling waves at certain, discrete moments. Since one spatial unit corresponds to one temporal unit and the wave propagates through the whole string, the wave can be simulated with a digital delay line. The result is a periodic signal whose fundamental frequency depends on the length of the delay line. In order to fine-tune the fundamental frequency, a tuning filter is inserted in series with the delay line. Figure 1 presents the basic string model.

The losses can be modeled with a specific digital filter, which adjusts the decay times of the partials as a function of frequency. In general, the trend is that the lowest frequencies decay slower than the higher frequencies, but in the case of the piano some of the higher frequencies may decay slowly as well. This fact makes the filter design problem difficult, as simple lowpass filters are not capable of producing enough variation in the decay of a tone. However, specific loss filter design techniques have been proposed recently; see Rauhala et al. (2005), Lehtonen et al. (2005a) and Lehtonen (2005b). These techniques are able to imitate the main features of the decay process efficiently.

The inharmonicity phenomenon means that the delay of the string model should be smaller for the high frequencies. Hence, it can be simulated by inserting a dispersion filter, which causes the delay of the string model to depend on the frequency in a desired way, to the string model. An example of dispersion filter is introduced by Rauhala and Välimäki (2006a).

The string model requires an excitation signal, which simulates the effect of the hammer hitting the string. The purpose of the excitation signal is to provide the correct amount of energy at certain frequencies so that the produced tone has the desired timbre. Moreover, the excitation model should be able to produce dynamics in the resulting tone depending on the key press velocity. A parametric approach for producing the excitation signal is proposed by Rauhala and Välimäki (2006b).

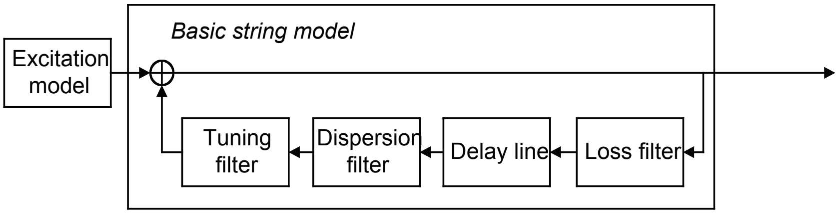

Figure 1. Illustration of a piano string model using the digital waveguide technique.

APPLICATIONS

The parametric piano synthesis algorithm can be used in various applications. The most obvious use case is the replacement of the acoustic piano in performances or at homes. In this case, the parametric digital piano will offer the user advanced ways to modify the timbre of the instrument, since several physical parameters, such as the degree of inharmonicity, are directly controllable. Some years ago mobile phones obtained possession of a music synthesizer, which is used for generating ring tones, alarms, and background music for gaming. The quality improvement of these electronic sounds calls for more sophisticated technology than the wavetable synthesis used in current phones and other mobile devices. Parametric synthesis would be a wise choice, since it does not require much memory and the sound-generation algorithms are simple enough to operate in real time. The enhancement would be dramatic even for an everyman. Finally, parametric synthesis can be useful in various pieces of music software, in which the user occasionally wants to play musical material, such a melodies or chords encoded in the MIDI format, but without having to obtain a full-scale sampling synthesizer to do it. In such software environments, the parametric piano synthesizer can be included as a short text file containing a few hundred lines of program code.

CONCLUSIONS

In this paper, physics-based modeling of the piano sound is discussed. The advantages of this scheme over current digital pianos using the sampling technique are the reduced demand for memory, the controllability through parameters, and the scalability of computational complexity and sound quality. It is likely that physics-based modeling technique will become a serious competitor for the sampling technique in future digital instruments. In addition to this, many other applications exist in restricted environments, such as in mobile devices. Sound examples and more information about parametric synthesis of the piano sound can be found at http://www.acoustics.hut.fi/research/asp/piano/.

ACKNOWLEDGEMENTS

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2B: Modern Techniques in Health Care II

F14: WIRES AND ELECTRODES INSIDE THE HEAD – INTRACRANIAL RECORDINGS IN THE COURSE OF EPILEPSY SURGERY

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Keywords: Epilepsy, Intracranial recordings

INTRODUCTION

Epilepsy is a disorder of the brain that results in recurrent, unprovoked seizures. Seizures originate in the brain as a result of excessive or disordered electric discharge of brain cells. The most common treatment option consists of one or more medications. However, some patients with epilepsy continue to seize despite the best medical management. If the seizures of such a patient are localization-related, the patient may benefit from epilepsy surgery. Localization-related seizures originate in a particular area of the brain and then spread to involve other brain areas. Removing the epileptic focus surgically may stop the seizures.

Epileptic foci are frequently due to architectural abnormalities, for example, such as cortical dysplasia. While modern anatomic and functional imaging can identify these anomalies, the areas that are responsible for the generation of seizures may be more extensive than the lesions found in the imaging studies. As a result, to further define the seizure focus, particularly in relationship to normal, eloquent areas of cortex, the recording of electrical activity directly from the brain is often required.

The information about the exact position of implanted electrodes in the brain with respect to relevant brain structures is essential for the correct interpretation of the electroencephalographic data and for the planning of the subsequent surgical procedure. This paper illustrates the visualization of electrode locations based on volume rendering of three-dimensional magnetic resonance imaging (3-D MRI) and/or computerized tomography (CT) data taken before and after electrode implantation.

Studies performed during evaluation for epilepsy surgery represent a valuable resource for scientific research (Engel, 1998). Such research can help not only the current patient but also future patients with epilepsy or other brain disorders. It can also give insight to functions of the brain structures that are difficult to reach without invasive methods. This paper presents some results of such a study. We were able to record electric responses to a change in sound in the human hippocampus and amygdala using depth electrodes aimed at these structures.

ELECTRODES

The choice of recording electrodes depends on the size and location of the suspected epileptogenic focus. There are three main types of electrodes, i.e., strip, grid, and depth electrodes, for recording brain electrical activity, as well as for electrically stimulating the cortex to determine underlying function. Invasive electrodes are usually placed in the subdural space or in some cases within the brain parenchyma.

Grid and strip electrodes differ mainly in shape. A strip electrode is a single linear array of usually 4 to 8 electrode contacts, whereas a grid electrode has parallel rows of electrode contacts. Both are designed to contact the cortical surface directly. In most cases, they are placed in the subdural space. Strip electrodes are implanted surgically through a small hole that is drilled through the scull under general anesthesia. Grids require craniotomy to be implanted. The craniotomy is centred over the suspected epileptogenic focus and should be large enough to sufficiently sample surrounding brain. Depth electrodes are multicontact tubular probes that penetrate the brain to record from structures below the cortical surface. For example, recordings directly from the hippocampus and amygdala may be needed in cases of difficult temporal lobe epilepsy.

VISUALIZATION OF ELECTRODE LOCATIONS

For the planning of surgical resection it is necessary to know exactly the locations of the electrodes with respect to precise anatomical structures. Visualization of the locations is also needed for the correct interpretation of electroencephalographic data. A number of methods have been used to estimate the position of intracranial electrodes after implantation. Three-dimensional reconstructed MRI is considered superior to plain scull radiographs or CT imaging.

Kuopio epilepsy group has used the 3-D reconstructed MRI for visualization of electrode locations since 1999 (Immonen et al, 2003). The reconstruction has been based either on coregistration of preimplantation MRI and postimplantation CT images, or on coregistration of pre and post-implantation MRI. Fig. 1 presents an example of visualization of subdural electrode locations.

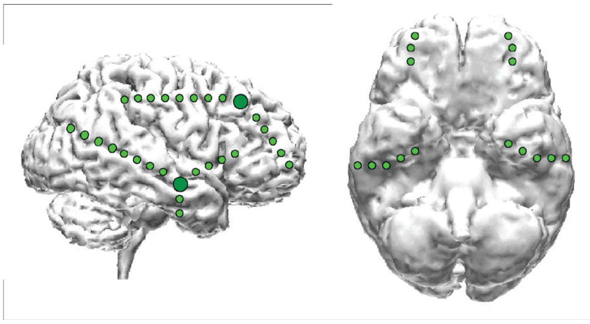

Fig. 1. Visualization of subdural strip electrode locations (small green circles) on the cortical surface in 3-D reconstructed MRI images (right side view on the left and bottom view on the right). Large dark green circles show the locations of the drill holes through the scull.

REACHING DEEP STRUCTURES OF THE BRAIN

We were able to record event-related potentials to non-attended auditory stimuli in candidates for epilepsy surgery with depth electrodes aimed at the amygdalo-hippocampal area. We found significant differences between responses to frequent and infrequent (or deviant) stimuli. Most of the differences were the larger the closer the electrode contacts were to the hippocampus and amygdale (see an example in Fig. 2). This shows that preattentive deviance detection also produces local electric activity in temporomesial structures, in addition to previously known neocortical areas.

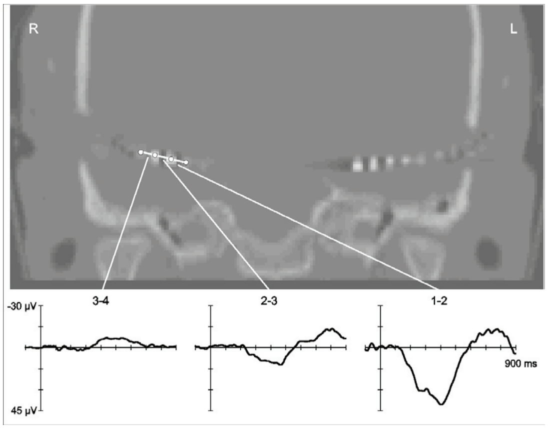

Fig. 2. Responses to deviant stimuli recorded from a depth electrode in one of our subjects. A coronal CT reconstruction demonstrates the temporomesial locations of the tips of the depth electrodes. The four deepest contacts (1, 2, 3, 4) of the right electrode are marked in the figure. The responses are presented as voltage differences between the contacts (3-4, 2-3, 1-2). The amplitude of the waveform increases when the recording site moves closer to the hippocampus

CONCLUSIONS

The accurate visualization of implanted electrodes with respect to relevant brain structures is of paramount importance for the correct interpretation of the electroencephalographic data and for the planning of the surgical procedure. Even though the patient's best interest are always the first priority, implanted electrodes can and should be used for research both on epilepsy and normal functions of the brain.

ACKNOWLEDGEMENTS

Even though the list of authors of this paper contains only the physicists of the Kuopio epilepsy group, all the work presented here is a result of the co-operation of the group. We thank all the members of the group in the departments of neurology, neurosurgery, radiology and clinical neurophysiology.

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F15: NAVIGATED MAGNETIC STIMULATION OF THE BRAIN - A NEW BRAIN MAPPING MODALITY

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Keywords: Transcranial magnetic stimulation, Stroke, Brain mapping, Brain tumour

INTRODUCTION

The basic principle of brain stimulation with inductive eddy currents has been known for hundred years, although the clinically successful transcranial magnetic stimulation (TMS) investigations have been performed only since mid-eighties (Barker et al, 1985). Its earliest and currently the most common clinical application is a non-invasive measurement of nerve impulse conduction from the motor cortex through spinal cord to peripheral muscles. However, through targeted and navigated stimulation of the cortex and recording responses, e.g., from muscles, functional brain mapping is possible. Furthermore, by measuring EEG and evoked potentials during navigated magnetic stimulation, gathering information e.g. on connectivity between cortical areas is possible. This may provide important information when judging health and normal functioning of the brain, e.g., after mechanical trauma, stroke or surgical operation.

Importantly, TMS can demonstrate causality. For example, if activity associated with a certain cortical region, e.g. speech or motor task, can be suppressed or distracted with TMS stimulation it is a strong evidence that the region is actually used during task. In an earlier study a subject's performance in a character identification task was impaired when single magnetic pulses were administered between 60 and 140 ms after the onset of the visual stimulus (Amassian et al. 1989). Furthermore, applying repetitive TMS (rTMS) to language areas in the dominant hemisphere has been shown to cause speech arrest (Pascual-Leone et al. 1991). These studies indicate that TMS or rTMS can be used for creation of targeted virtual lesion on the cortex. Obviously, this technique provides a unique tool for neuroscience and for clinical medicine.

METHODS

In principle, TMS uses electromagnetic induction to get electrical currents across the insulating tissues of the scalp and skull non-invasively and with minimal discomfort. These currents are induced by driving intense pulses of current through the coil located at the surface of the head. In practice, discharge of a large capacitor induces a rapidly changing current (5-10 kA) to the coil windings and produces a magnetic field oriented orthogonally to the plane of the coil. The generated magnetic field passes through the skin and skull inducing a current in the brain flowing tangentially with respect to skull. Naturally, this current activates nerve cells in the cortex effectively in the same way as if applied with traditional cortical electrodes.

During stimulation, a plastic encased coil is held against the head over the cortical area of interest. However, brain function mapping and creation of targeted virtual lesions requires accurate and reproducible targeting of the stimulus. This is achieved by acquiring a structural MR image of the subject's brain and using the image to guide positioning of the coil in real time (Hannula et al. 2005). However, for optimal targeting and controlling of the stimulus it would be essential to be able to model accurately the current flow in the cortex. Since the brain is a non-uniform conductor with an irregular shape, the modelling is a complex task.

The experiments described in the following have been conducted in the TMS unit at the Department of Clinical Neurophysiology in Kuopio University Hospital. The unit is equipped with an eXimia TMS/NBS system (Nexstim Ltd., Helsinki, Finland). The system enables navigated TMS and rTMS experiments with simultaneous registration of 60-channel EEG.

EXAMPLES OF APPLICATIONS

1. Mapping motor functions around tumour for the planning of surgical operation
In this study our aim was to map the motor cortex around a tumour to assist the planning of surgical resection. The cortex was stimulated extensively around and within the tumour (Fig. 1). Motor responses were recorded from facial and upper limb muscles. Motor cortex was accurately located so that the tumour could be removed surgically without any symptoms of paralysis.

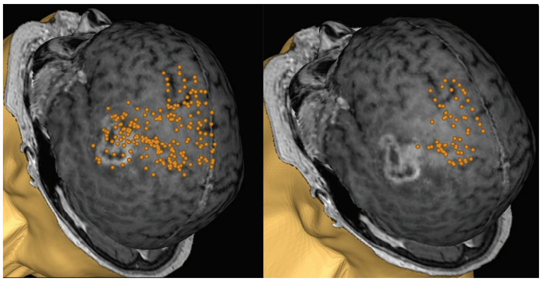

Figure 1. The motor cortex was mapped around and within the tumour. All the stimulated locations are marked with small orange dots on the left. The locations at which the stimulation produced a muscle response are displayed on the right.

2. Hand representation areas outside M1 observed by navigated brain stimulation
In this study we aimed at mapping the motor cortical representations of upper extremities and at finding out whether muscle responses can be elicited by stimulations outside the primary motor cortex M1. Fourteen healthy subjects were examined using a navigated brain stimulation system. The stereotactic navigation was based on three-dimensional T1-weighted MR-images of the cortex. The mapping surface was at a depth of 25 mm from the exterior skull surface. The motor area and the resting motor threshold (MT) were determined for the opponens pollicis muscle. Cortical areas anterior and posterior to M1 were mapped extensively at MT intensity. EMG was recorded from four different upper limb muscles. Motor responses ≥ 50 μV were accepted for further analyses. Only the motor responses that could not be caused by simultaneous stimulation of M1 were included in the analysis.

Motor responses could be elicited in all subjects by stimulating the superior frontal gyrus areas anterior to M1. Latencies of these responses were the same as those evoked by the stimulation of M1. This indicates that there are significant motor areas outside M1 that react to magnetic brain stimulation, and provide direct input to peripheral muscles. This kind of motor capacity may play a role in the rehabilitation of motor deficits. Navigated brain stimulation provides a method for direct observation and testing of cortical motor representations, and thus a tool to plan and adjust individual rehabilitation strategies (Teitti et al. 2006).

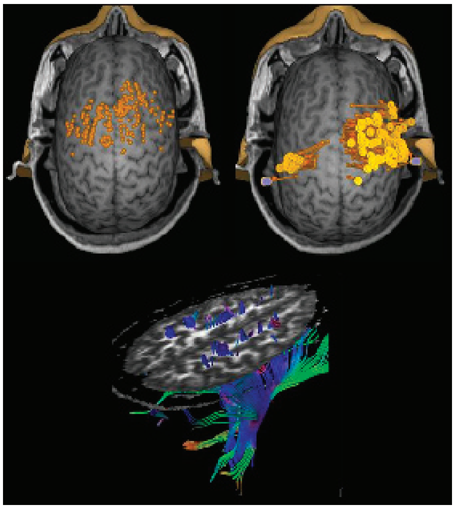

Figure 2: Stimulations outside the motor cortex can elicit motor responses. All stimulation points are shown in the upper left image. The upper right image shows thenar targets on M1 (light blue cylinders) and the stimulation sites that produced motor responses. The bottom image is produced by MR tractography from one of the subjects in the study. It shows that there exist corticospinal tracts that originate from the frontal lobe.

DISCUSSION AND CONCLUSIONS

In the light of existing literature and the application examples presented here navigated brain stimulation may provide a valuable tool for both clinicians and basic researchers. It provides a powerful tool for examining cortical excitability and connectivity. On the other hand, rTMS has shown potential in treatment of several psychiatric disorders, for example as an alternative to electroconvulsive therapy.

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F16: INTENSITY MODULATED RADIO-THERAPY IN THE TREATMENT OF HEAD AND NECK CARCINOMA

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Keywords: Intensity modulated radiotherapy, head and neck carcinoma

INTRODUCTION

Intensity modulated radiotherapy (IMRT) is a method that utilizes automatic optimization of radiation dose distribution followed by dynamic (= intensity modulated) dose delivery. The essential prerequisite for this technique has been the development of computer controlled multi-leaf collimators (MLCs) in the linear accelerators. Thereby it is possible to produce even complex forms of beam modulation calculated by the treatment planning optimization software. The treatment planning of IMRT is considered as "inverse" and that of the conventional one as "forward" process. In the latter the process starts with a selection of a suitable set of radiation fields and adjustment of all treatment parameters according to the clinical situation and experience of the planner. Thereafter the dose distribution is calculated and evaluated, and the required corrections made accordingly. Usually the conventional planning process takes a few iteration cycles of this kind to achieve a clinically feasible result.

In the inverse planning process the optimization constraints are defined in the beginning of the planning process for the optimization software. The constrains are usually expressed as maximum or/and minimum dose values for the target volume and as maximum doses for a set a healthy structures to minimize the complication probabilities. The target volume covers clinical and subclinical tumour + necessary margins to achieve control of the disease. The optimization software then finds the balance between different constraints and produces modulations for each individual radiation field. In this process the number of adjustable variables is remarkably higher than in the manual planning process with static beams. In IMRT each beam is typically modulated with a resolution of 0.25x0.25 cm2 – 1.0x1.0 cm2. Thus, for a 10x10 cm2 treatment field there may be even 1600 different and adjustable intensity (beam pixel) values compared with the single beam weight of the manual process with static beams.

The clinical advantage of IMRT is based on the possibility to produce even concave dose distribution and thereby achieve better dose conformality for the target volume of complex shape. In the head and neck area the advantages of IMRT relate to the possibility to protect salivary glands and spinal cord, which are usually partly or totally surrounded by the target volume. The dose coverage of the target volume may also be better with IMRT compared with that of the conventional technique where several adjacent photon/electron fields result in dose gaps in between them. This may even improve the control probability of the tumour. The published clinical results also support this assumption. The disadvantage of IMRT is the increased volume of healthy tissue irradiated to a low dose.

METHODS

From July 2000 we have been treating over 100 patients with tumours of head and neck region with curative intent in Helsinki University Central Hospital, Department of Oncology. The inverse planning has been performed with the Cadplan Helios inverse planning software (Varian Medical Systems). The patients have been treated with Varian Clinac 600CD or 2100CD linear accelerators using 6 MV photons and a dynamic MLC method to produce intensity modulation. The methods and results for implementing the IMRT in clinical environment and for the quality assurance for the first 15 patients have been described by Van Esch et al (2002).

The patients have been immobilised using a stereotactic head and neck mask system (BrainLab). The treatment technique has been described in detail by Saarilahti et al (2005).

From a selected group of patients (n=36) we have measured an unstimulated and stimulated salivary secretion rate before radiotherapy, as well as 6 and 12 months after radiotherapy, to see the clinical effect of the protection of major salivary glands. In this group one or both parotid glands and 0-2 submandibular glands could be spared for each patient depending on the site and spread of the primary tumour. The follow-up of the patients for possible tumour recurrence was performed according to the normal practice. The presented material includes patients with a minimum of 2 years follow-up time.

RESULTS AND DISCUSSION

The dose response of the salivary glands has been verified. It seems that both for the parotid and submandibular gland the dose response can be described with a sigmoid curve with D50 between 25-30 Gy. It seems also that there is some recovery of the salivary function from a minimum level at 6 months to the value at 12 months.

The tumour control results are still preliminary. However, the number of local recurrences in this material has been very low and no recurrences have been observed in the vicinity of the spared salivary glands. This implies that the clinical judgement of the target volume has been correct and the impact of dose inhomogenity in the borderline between protected and treated volumes is insignificant.

Our results with more clinical details have been presented by Saarilahti et al (2005, 2006).

CONCLUSIONS

With IMRT it is possible to spare a clinically significant amount of the salivary function. We have also got a preliminary evidence that IMRT also results in at least a similar, but probably a better local control of the head and neck tumours compared with conventional static beam radiotherapy. Further studies are warranted to show the potential of IMRT in sparing other important healthy structures in the head and neck region, like larynx (speech, swallowing function), mandible (teeth, prevention of osteoradionecrosis) or reduction of the irradiated area of mucosa (minor salivary glands).

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3A: Future of Technology & Society

F19: MOORE´S FUTURE IS MORE

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Keywords: Electronics; Moore ´s Law; Miniaturization; Nanotechnology

ABSTRACT

Gordon Moore (1929--) observed in 1965 that the number of transistors on the silicon chips doubles inside fixed period time. This so called "Moore´s law" has helped us to foresee the future development of microelectronics during the last 50 years by predicting the number of transistors on the silicon chips in the future. Because of the economical and technical reasons it is not yet possible to integrate everything on the silicon; therefore the alternative solutions must also be used to decrease the size of the portable devices. One possible way is to go from two dimensional world to three dimensions. This means that we concentrate more to total volume of the devices instead of the area of silicon chip itself. New technological solutions to use all three dimensions effectively electronic devices are coming more strongly to the market. However the CMOS technology must be replaced depending on the physical aspects when the minimum size is 30 nm. So we need the future technologies to solve many problems we are going to meet. Maybe we find the solution in nanotechnology.

INTRODUCTION

How the art, science and technology can serve the mankind to survive and toggle the big challenges, we will meet. Can we really predict what is going to happen in the future? In the past the great inventions has always been done by individuals and very locally. In historical point of view there have lived persons with great talent in art, science and technology. For example Leonardo da Vinci (1452-1519) was a great artist but also a skilful scientist and inventor. He was the first one who used the technical drawing as a help in designing. The development work in science and technology is nowadays done in larger groups and means more co-operations between the people globally.

PREDICTIONS

To predict the future trends in technology has been very difficult with one exception. One of the inventors of company Intel, Gordon Moore found in empirical observation a special rule in 1965, in which he predicted that the number of transistors the industry would be able to place on a computer chip would double every year 1. In 1975, he updated his prediction to once every two years but later on it was found out that it doubles every 18 months. In Figure 1 the development of the new memory chips follows very well the Moore´s law during last 40 years 2. A system where all the functions are integrated within a chip is called SoC (System on Chip) technology. In order to integrate so many transistors as possible on one chip, the dimensions of single transistor must go down (so called top-down approach). This means problems in lithography processes, when dimensions meet the diffraction limit (one half of the wavelength of light).

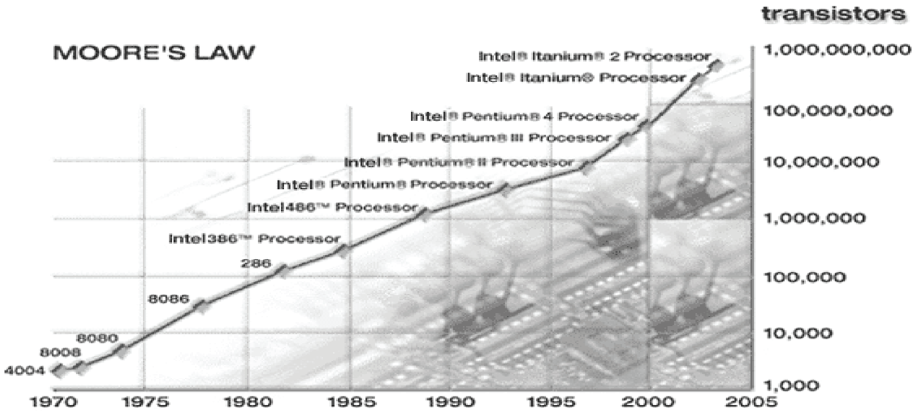

Figure 1. Number of transistors in processor circuits vs. time 2

But what happens when CMOS technology reach its physical limits (year 2016?). Moreover the production cost will increase exponentially when the feature size becomes less than 50 nm. To decrease the dimension of the transistor on the silicon chip by 20% in size means 36% decrease in surface area. Since the active area of the silicon consists only the surface the silicon chip, it can be thinned from 800 μm to 20μm and therefore the volume could decreased to only 2,5% of the original volume. This approach is used especially in memory circuits; the total volume can be as small as possible, when using stacked solutions. What the Moore ´s law doesn´t predict is the development with "heterogeneous technologies" used for example in portable devices. There is a lot of technologies like RF (BiCMOS,III/V), high-voltage/power, SIP, passives, sensors, actuators, microfluidic, biochip,...etc.

POSSIBILITIES & ALTERNATIVES BEYOND MOORE ´S LAW

The man is always found a solution to continue the development for smarter, cheaper and smaller electronic devices, which are produced of recycled materials. The need from application side needs similar functions like the eyes, ears, noses, arms and legs of human-being and the brain is provided as microprocessor and memory. How we can meet these challenges. There are two developments going on: 3D miniatuzation and nanotechnology. Maybe both are needed to fulfil the future needs to miniaturizate the electronics for portable devices. A system where the different functions are implemented on many chips using different technologies and all these pieces will be integrated in same base substrate is called SIP (System in Package) technology.

NANOWORLD & NANOTUBES

What is beyond Moore´s Law? When the channel length of the transistor will be 10 nm, the problems with short channel effect and instability of the transistor will a big problem. This could be the limitation for "top-down" development. But the man finds always the new solutions to continue the development. For example taking in use new materials like carbon nanotubes or so called "bottom-up" nanotechnology. In Fig.2 is picture of carbon nanotube, which consists of carbon atoms in regular and rigorous arrangement like the morphology in "chicken wire". The structure can include single wall or several walls. The diameter of single wall carbon nanotube is starting from 2 nm and the length can be 100 μm or more. They have interesting properties depending of the structure. The most of nanotubes produced are semiconductors. They have good conductivity and high mechanical strength. Carbon nanotubes can be used also as sensors or containers for hydrogen. In Fig.3 the carbon nanotube is used as conductive channel in transistor demonstrating the possibility for new solutions in order to follow Moore ´s law in the future.

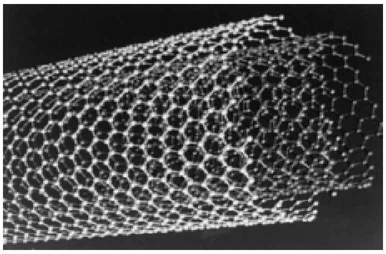

Figure 2. Structure of carbon nanotube 3

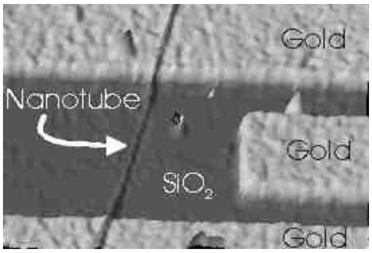

Figure 3. Transistor structure using nanotube4

If we compare the capacity and size of NEC Supercomputer (top down technology) to human brain (bottom up technology) we can understand the enormous possibilities of nanotechnology in the future (table 1.) 5

Table 1. “Top-down” vs “Bottom-up”

	Weight	Power	Capacity	Technology
Human brain	1,4kg	10W	>100 teraflops	bottom-up
NEC supercomputer	tns	>500kW	40 teraflops	top-down

The capacity is coming closer the human brain, but the drawback is the size and the power consumption. In future the size will go down, when using 3D–miniaturisation and the nanotechnology will help to spare energy.

CONCLUSIONS

“Small is beautiful” and “there is lot of space at the bottom”, said famous prof. Richard Feynman (1918-1988) already 1959 6. But actually the development of the nano-technology is still in the beginning phase; therefore it will take several years before the level of silicon technology is achieved. Nanotechnology means more co-operations between different sciences like physics, chemistry, material science, biosciences, mechanics, electronics, and communication and information technologies. This all means a new era for co-operation between sciences, which has not been possible earlier. There is also space for art to describe the new nanoworld with fancy structures of atoms and molecules and give inspiration for many years.

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F20: NEOREALITY – PARALLEL PHYSICAL AND ELECTRONIC REALITIES

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Keywords: Neoreality, Mixed reality, Information society

INTRODUCTION

Information society has changed the way of living and doing, mostly during this decade. Most technological innovations behind this development are quite trivial. However, the procedures and customs as well in everyday living as in work have changed. Most probably we will see several social innovations utilizing the information society in near future.
In the beginning of this decade and millennium it was realized that Finland is a forerunner and ideal test environment for the information society, as stated by Statistics Finland (2001) and Castells and Himanen (2001). In 2001 a wide five-year knowledge society program eTampere (2001) was started. It operated in social, economical and technological fields with a total budget of 130 M€. The goal of the program was to increase the information society skills of the citizens and to create basis for new kind of business. One of the six sub-programmes, the Technology engine programmes, recognized five technology areas to be developed. One of these technology themes was neoreality, a combination of physical and electronic realities.

The word “neoreality” was a translation of the author for a Finnish term “uustodellisuus” launched by Reijo Paajanen (2000), who is also known as the father of Nokia communicator: “ Earlier we had only the reality and dream world. The computers brought us the virtual reality. Games and the computers as everyday things lead to mixing of reality and virtual reality and create the neoreality. One consequence of neoreality is that one cannot always identify whether being in reality or virtual reality”. In context of eTampere neoreality was characterized as a combination of two realities, the physical reality and the virtual reality. Mixed reality was found to be an interesting technology application of neoreality.

The electronic world lives every hour of the day by messaging, ordering, asking and processing, while we are acting in the physical world. Neoreality can overload our work and free-time, but it may also give us more time to intellectual and creative work or liberate us from tight office hours.

The purpose of this paper is to analyze the present state of neoreality. It gives examples of neoreality technologies as well as points out the necessity to recognize the neoreality for improving the quality of life.

METHODS

For a more detailed determination and discussion on neoreality a special workshop was organized in May 2004 by eTampere program. Six specialists of information technology, innovation research, hypermedia and economy were invited to the workshop to discuss and determine the term neoreality.

The analysis of neoreality presented in this paper is based on personal experiences of the author in a role of the manager of a sub-programme of eTampere and a director of Digital Media Institute, an information technology research center in Tampere University of Technology.

RESULTS AND DISCUSSION

As a conclusion of the workshop the concept of neoreality was determined more precisely as new kind of culture in working, business and social life, where the electronic reality operates parallel with the physical reality, providing new opportunities and creating new threats. According to this determination the neoreality is a dual reality concerning everybody continuously.

One example of problems in neoreality is the coupling with email, especially at work. We are filling the calendars and work lists with meetings and duties in physical reality, while our email boxes are filled by new messages both during the office hours and also between working days in electronic reality. Processing of emails takes time in the physical world, and activity in electronic mailing may lead to increasing amount of responses. The fact that the total number of junk mail has exceeded the number of other mail in 2004 increases the challenges of handling email.

However, email implies one of its original benefits in saving time and paper consumed in ordinary mail. It also enables the offline communication during the optimal periods of time. To enjoy these benefits, avoiding the drawbacks of email listed above would be of high importance both in work and on free-time.

Maybe the most important way of coupling with email is to recognize the existence of two realities, both of which demand their time. Therefore one should allocate time for each reality. Junk mail filters are useful for decreasing the amount of unnecessary emails. Additionally each email user should obey certain email etiquette to speed up the processing of emails. This includes, for instance, entitling the emails with the essential information of the message and signing each mail by contact information of the sender.

The neoreality is also present in everyday social relations. Mobile phones and internet online contacts can replace physical meetings. However, mobile phones also tend to interrupt normal discussions. This can be avoided by appropriate rules or etiquette.

The electronic communication has also changed the culture of normal business. Today also small-size Finnish companies have replaced faxing by email, desk phones by mobile devices and brochures by home pages. Also many financial routines are handled automatically by appropriate software. E-business has replaced conventional business with surprisingly few problems.

Health care has also faced the transfer to eHealth. Electronic patient records, internet services and telemedical applications have become a part of our health care system. To save expenses especially the quantity and quality of home health care should be increased by applying information technology as described by Eskola (2005). In health care applications the replacement of physical services by electronic ones faces several challenges. The systems should be safe and they should be easy to use both for personnel and patients. Finally, the e-Health applications should not diminish the time spent in physical reality between the personnel and the patient. Although the discussions and visual contacts can take place in electronic reality, they should be applied only to produce added value to the health care process. According to numerous reports, the presence of health care personnel and touch are basic needs of most patients.

CONCLUSIONS

The technological development has brought the electronic reality to us. The peripheral human sensory and motor systems would be able to cope with the two realities even simultaneously. However, this seems not to be the case with the human brain. The electronic reality can be used to speed up and advance the efficiency of several processes, thus improving the quality of our work, health and everyday life. However, it also tends to increase the rush, stress and absence in our physical reality. To avoid this, one should simply recognize the concurrent existence of two realities.

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F21: STAR WRECK

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Keywords: Movie Making, Science Fiction; Internet; Community

INTRODUCTION

In 1998, five students from Tampere, Finland, started on a voyage into the unknown. Their plan was to make a movie parody of the popular science fiction series Star Trek, Paramount Pictures (1966-) and Babylon 5, Warner Brothers (1993-). The movie, Star Wreck: In the Pirkinning, Energia Productions (2005), gained major interest in online sci-fi communities during its seven years of production. 300 volunteers participated in the production, and the movie was finished in the summer of 2005. Later that year it was released online for free download, gaining a wide audience with over 4 million downloads in less than 6 months. Star Wreck blazed a trail for Internet and community based movie productions and Internet movie marketing and distribution.

METHODS

Star Wreck: In the Pirkinning was the sixth episode of the Star Wreck movie series. Samuli Torssonen, the creator of Star Wreck, made his first animated Star Wreck short film in 1992 using a home PC. The movies that followed grew longer, more visual, and the plots became more complex. In 1997, Star Wreck movies 1 to 5 were released on-line. They attracted a growing crowd of supporters that started following the production of the next movie from its early stages.

The beginning of Star Wreck: In the Pirkinning in 1998 was very humble. The crew used a simple Sony HandyCam, a Pentium III PC, a blue-colored curtain as a blue-screen, some props from the previous movies and the knowledge they had accumulated during the production of the earlier episodes. The goal was to make a short sci-fi movie with fine visual effects and distribute it online for free.

The production can be roughly divided in three chronological parts based on the technology used and the nature of the production. During the years 1998 and 1999, there was very little production planning and scheduling. The equipment was modest and the whole production was characterized by hobbyism. From 2000 to 2002 the skills and ambitions of the crew started to grow. Make-up, proper costumes, lighting and digital filming was taken up. From 2003 to the end of the production, a new, professional attitude led to streamlining the screenplay, re-filming and re-editing. Post production such as visual effects, image compositions, audio editing and final video editing was mostly done during this phase. The premiere for the movie was held on 20 August 2006 for all the volunteers who took part in the filmmaking. The movie was then released on DVD, and online for free download 6 weeks later using direct downloads and Bit Torrent.

RESULTS AND DISCUSSION

The release attracted worldwide attention in the media. During the months that followed, TV, radio, newspapers and Internet sites published a multitude of articles and interviews about the movie, the crew and the phenomenon they created. In less than 6 months, the movie had already been downloaded 4 million times. A major factor that attracted general interest was the communality aspect of Star Wreck. Many sections were produced using the assistance of an Internet community created around the film, and the way the Star Wreck crew boldly took advantage of the possibilities of the Internet was widely found interesting. Major movie companies are now slowly realizing the possibilities of free Internet distribution, and communally produced movies are considered the next important advancement in the movie industry. Once the technology develops to support the new ideas, the entire movie culture will be facing a change in both production and consumer levels.

CONCLUSIONS

High quality movies can be produced with reduced costs in pre-production using communities as an idea source. Cost effectiveness in marketing and distribution can be increased by utilizing the Internet. The creators of Star Wreck: In the Pirkinning see the Internet as a tool, not an enemy that jeopardizes their income. The film industry is about to go through a great change, and Star Wreck is one of the pioneers, leading the way to the future.

ACKNOWLEDGEMENTS

The Star Wreck crew would like to thank all the fans of Star Wreck all over the world for their sincere support and efforts towards the completion of In the Pirkinning. They carry the spirit of Star Wreck throughout the Internet.

4A: Science, Technology & Experience

S2: MUSIC GENERATED FROM PICTURES

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Keywords: Pictures; Generative Music; Algorithmic Composing; Psychology of Music

INTRODUCTION

The most common way to generate music from pictures has been the "Piano player method". The vertical positions of pixels are interpreted as pitches and time goes from left to right. The results using this simple method have not been impressive. The method presented here uses pictures to generate music in a different way.

METHOD

The Synestesia method I have been developing generates music (midi files) from any pictures. Sculptural work is a good metaphor for the method: the sculptor starts from a block of stone which inspires the artist towards a certain final result. Synestesia Method is based on filtering pixels "away" and on using several selectable parameters. Using parameters is like looking the sculpture from different angles or in diffeernt lightings and environments. The picture and the list of parameters together form the metascore of the composition. The challenge is to find pictures generating interesting music. But why does this method work?

The Synestesia method will produce complete compositions, modern art music. By selecting specific parameter sets one can build quite different styles or composer profiles. The pieces composed have lasted from one minute to 10 hours. The generation itself will take about 5 seconds. Link for the full presentation of the method is shown in REFERENCES section.

Many people interested in Synestesia method have been asking about the inverse process, generating static pictures from midi files. By going back and forth in this

way one could get a kind of generalized cell automaton creating music and pictures forever. That is possible because those mappings are irreversible.
Most philosophers of music think absolute music has no semantics. The noun “cat” refers to things called cats but sad music has nothing to refer to. Sad people walk slowly and sad music is slow but that is only an isomorphism or a cliché. Pictures on the other hand have semantics. The mapping from pictures to music is always more or less artificial, there is an infinite number of possibilities.

PICTURES

On the site synestesia.fi one can find about 200 mp3 pieces which have been generated by using many kinds of pictures, landscapes, drawings, barcodes, cash receipt, ruins of WTC, falling space shuttle, hand writing, portraits, dogs, Aurora Borealis and so on. The main question here is this: how can Synestesia Software using Synestesia method generate so interesting music that month after month 5000-6000 files are downloaded from the Synestesia Internet site?

MUSIC

One might postulate the following paradigm set: absolute music, titled music, picture music, program music, songs.

Absolute music doesn’t tell a story. It is more like ornaments in art. The titles give listeners a kind of context for listening the piece. Changing the name moves the listener to a different listening context and the piece may create new impressions. Many listeners erroneously think that the piece “represents” something. Even in art the name of a painting may be important. One can see the sunset over a lake only after hearing the name of Turner’s painting “Sunset over Lake”.

Pictures correspond to the titles of “normal” compositions. Generating music from pictures creates the contexts for listening. Using both a picture and a name may even magnify the effect. Because of the parameters it is possible to influence the piece to be generated in a pseudo-synesthetic way. Quite often the generated music seems to have its own character “asking” the user to go to a certain direction. The “picture music” is a new and unmapped area of music, connecting art and music. But one must always remember that pictorial representation of music is not possible because music doesn’t have semantics..

Program music is based on descriptive texts. Film music may be a kind of program music, or film “on the background” can make absolute music programmatic in the ears of film lovers. Good examples of this are Stanley Kubrick’s films “Eyes Wide Shut” and “Space 2001” using extensively György Ligeti’s music.

COMPUTER CREATIVITY

Can computers be "creative"? It is a well known fact that some of the most original moments in Beethoven's Ninth Symphony have been the result of printers' error. Also the Finnish composer Einojuhani Rautavaara has reported that he has got some of his ideas when hitting a wrong piano key during composing. So it seems that live composers may use randomness or serendipity as a creativity tool. It is a kind of a paradox that computer music based on randomness has not been so successful. The Synestesia Software does not use randomness at all, all pieces are deterministic.

Many creative composers have developed sets of algorithms for creating their compositions. Good music must move on midway between the expected and the unexpected. Synestesia music typically does something else than expected without randomness. Professional musicians may experience this negatively as if the music would be trying to fool them. However, the pieces are not based on old clichés that are so typical especially in film music. Even professional creative composers could profit from Synestesia Software as a creativity generator.

COMPOSITIONS

Synestesia music doesn't use the model of tension/release/resolution but many pieces are still highly emotional. The structures and rhythms of Synestesia pieces are mainly based on the structures and colors of the pictures used for generations. Anybody can use Synestesia Software for generating music and the music will always be coherent when compositions of amateur composers may be less coherent.

According to an old myth Beethoven composed his pieces in his head before writing on paper. That myth has been proved to be false. The documents show that Beethoven wrote his pieces tens of times on paper before the final version. When using Synestesia system one starts from the chosen picture and one is able to listen to the generated piece after only 5 seconds. Some parameters can be changed and after additional 5 seconds the piece can be listened again. The process is very interactive and rewarding.

Sometimes Synestesia music may be like semi-repetitive tapestry still having inner variability. The method is based on gravity of pitches. Perhaps that is one of the secrets of the system.

Much of the enjoyment of modern art music is based on rehearing the music many times. Synestesia pieces can be perceived during first hearing.

Older art music has the feature of persistence of illusion, the same music can be enjoyed again and again. Synestesia music creates the same illusion.

It is well known that musical notation is only part of the truth and musicians playing the piece create their own version the piece. Synestesia midi files can be printed as preliminary scores and processed into full scale scores with articulation etc. Synestesia Software creates the control codes to be used by the software instruments used for playing midi files, but the notation or the sequencer programs don't understand these articulations. On the other hand it is possible to use instruments in such a way that normal instruments can't follow, unplayable rhythms and piano glissandos are good examples of this.

FUTURE

One interesting tool for research (and fun) is under development as an application of Synestesia method: Snapshot Music.What you see is a camera lens and loudspeakers on a side of a box. If the camera detects some change on the view the system will wait until the view is nearly static and then the system will generate music using up to 16 instruments and after a few seconds one can listen to the music. The piece will last about one minute and the process will start from the beginning. This tool could be used for experimental musicology in many ways and for music therapy for example.

The main problem at the moment for using Synestesia music is the price of the software instruments used for playing the midi files. Also the software instruments call for a powerful computer having a lot of ram. Synestesia Software (Java applet) itself can be used in any computer, PC or Mac. My guess is that in a year or two the situation will be quite different and the opportunity window will be widely open for the approaches like Synestesia method. Many new applications will be developed for “emotion conversions” from pictures to music – even for mobile phones.

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S3: BEAUTY MAKES SENSE: A PSYCHOLOGICAL AND AESTHETIC VIEW OF ENJOYMENT WITH INFORMATION TECHNOLOGY

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Keywords: aesthetic; emotion; computers

INTRODUCTION

The model of optimal experience or flow experience created by the psychologist Csikszentmihalyi has similarities with the aesthetic views of Langer, Dewey and Beardsley, who have been interested in the enjoyment inherent in the experiencing of beauty. I aim to look at digital user interfaces from these two viewpoints: one aesthetic and one psychological.

THE FLOW OF AESTHETIC EXPERIENCE

This paper examines the role of aesthetic experience in the emergence of enjoyment and knowledge in interaction with information technology. A starting point is the model of flow experience by Csikszentmihalyi (1982, 1988, 1991, 1996, 1997). In his model Csikszentmihalyi proposes that the enjoyment in experiences universally arises in situations that offer enough challenge to make the experience engaging in stead of boring, but not too much, so as to avoid frustration. In this kind of setting any action or experience can become a flow experience. In a state of flow experience a person is so fully concentrated on whatever it is, they are doing that nothing else enters the mind. No disturbing thoughts or worries, not even stimulations to senses that are not related to the task at hand. This kind of intense concentration leads to a state, where cognitive processing exceeds that of a normal state enabling enhanced learning. At the same time usually a sense of enjoyment and satisfaction are present.

A similar experience has previously been described in aesthetics by several scholars. Dewey (1934) gives a description of what he calls the aesthetic experience and describes it in much the same ways as Csikszentmihalyi does talk about the flow experience. Dewey (1934) states, that in an aesthetic experience the recipient has an active role in processing the information she is receiving in the accounter. This information is emotional. Unless there is an active participation of this kind, the experience can not bring enjoyment and hence cannot be described as aesthetic.

Beardsley (1981) makes a more analytic approach to aesthetic experience and carefully lists the features of this kind of experience and also the consequences they have on recipients. Basically he sees the aesthetic experience in much the same way as Dewey does. Like Dewey he sees the essence of aesthetic experiences in emotional states and receiving emotional information through them.

In accordance with Dewey, Langer (1953) says the main purpose of art is to create and present information and in this way further understanding. If art is seen, as Langer does, as means to create and present objects in order to further understanding of emotions and to create a wider world view, art becomes research into these topics that makes suggestions about their nature. Seen like this art is one way to present information. Through art one learns about the subjective experience in much the same way than in propositional interaction one learns about the objective world. Thus aesthetic enjoyment is principally a similar kind of enjoyment that is caused by finding the truth. (Langer 1953.)

Langer (1953, 1972) says that all experiences that bring enjoyment and satisfaction are aesthetic. She sees that this enjoyment comes from the triumphant realization of having been able to learn something new. This learning in Langers view is emotional by nature and is not expressed in words or symbols. Rather this information is acquired through direct experience of the interaction with the entity – be it an artifact or some other stimulus - that causes it. Langer and Csikszentmihalyi & Robinson conclude that aesthetic enjoyment and aesthetic experience are caused by the intellectual triumph of having understood something. (Langer 1953; Csikszentmihalyi & Robinson 1990.)

Csikszentmihalyi and Robinson (1990) say that aesthetic experiences and flow experiences are basically the same thing. Only when one has this kind of experiences with art, they are called aesthetic experiences. In all other contexts the same experience is called a flow experience. Aesthetic experiences bring new information into the mind and they also affect the information already there causing this information to be reordered and these together amount into learning.

Csikszentmihalyi (1982, 1988, 1996) has done extensive research on enjoyable and satisfying experiences. According to him such experiences can arise in almost any kind of context ranging from watching TV to doing sports and working. He has found that enjoyable experiences have exactly the kinds of consequences on human mind as Beardsley and Dewey have earlier described. Like they do also Csikszentmihalyi (1982, 1988, 1996; Csikszentmihalyi & Rochberg-Halton 1981; Csikszentmihalyi & Robinson 1990) describes the accumulation of knowledge and skill through experiences and he also describes the mechanisms that lead to the enjoyment related to these experiences.

AESTHETIC INFORMATION TECHNOLOGY

The state of flow or optimal experience is perhaps not that rare in the context of computer games or Internet-surfing, but all kinds of interaction involving a digital device could perhaps allow flow to occur. There has been some research on a variety of issues related to information technologies that has made use of the flow construct as defined by Csikszentmihalyi (Chen, Wigand & Nilan 1999, 2000; Finneran and Zhang 2002, 2003; Ghani & Deshpande 1994; Koufaris 2002; Pilke 2004; Woszczynzki, Roth and Segars 2002).

All these scolars approach the issue of flow and information technology use from different viewpoints, but they all seem to support the hypothesis that flow experiences do occur in information technology use when task performance is at a proper level, i.e. that there is a reasonable amount of success, but still a good amount of challenge. Chen et al. (1999, 2000) even conclude that the World Wide Web would be especially suited for flow experiences. In addition to this Hoffman & Novak (1997) state that designing for flow would be highly recommendable for commecial applications, since it creates a positive impression of the products and services. If indeed flow experiences are aesthetic experiences by nature, this would indicate that aesthetic experiences are an essential part of information technology use.

These assumptions seem to be supported by an interview study (Pilke 2004) that asked 20 Finnish frequent computer users whether they did experience flow at all and specifically if they had such experiences at information technology use. Indeed they did. Flow experiences with information technology were almost as frequent as were flow experiences in general. This perhaps is an indication in the direction of one of the main sources of flow experiences for these people being information technology.

When asked, what they thought facilitated the occurrence of flow experiences, among other things a lesser cognitive load caused by the application and a pleasurable interface were mentioned. The factors that these informants saw as hindering the emergence of flow were among others excessive simplicity so as to make the task boring and slow feedback. Also having to put effort into finding out how an interface works was mentioned hindering flow experiences. These findings are well in line with the flow construct. They also are in line with what is generally seen as good usability.
These findings could also be interpreted in support of the kind of definition of aesthetic information technology Gelernter (1998) talks about. He says a combination of simplicity of structure with powerfull functioning that would allow an effective and unobscured access to the use of the technology at hand would amount in an aesthetic end result.

CONCLUSIONS

It seems evident that aesthetic experiences are an integral part of interactions with information technology. In addition it seems that features that have been regarded as good design in regard of usability could also be interpreted as aspects of aesthetic when referring to interactions with information technology. From all this it could be concluded that designing for flow experience would mean designing for aesthetic experience and designing for aesthetic experience would also be in line with what is regarded as good usability.

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S4: PHYSICALISING THE DIGITAL: DIGITAL ART IN THE PHYSICAL AGE

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The discussion of the institutionalisation of art is by far not a new one. Since most notably the 1960s, writers such as Arthur Danto and George Dickie have been debating and examining the elements of what makes object 'A' a piece of art, when object 'B' although identical in every way, is not even considered within the 'world' of art. Intention and branding are some core elements within a process of selecting and prioritising certain objects above others. Further, as we see through what Robert Yanal describes in his 1998 essay The Institutional Theory of Art, art valuing and distinguishing is no longer based on the aesthetic. This by all means should be emphasised within our current commodified environment, whereby serious debate is taking place in terms of whether or not broadcast commercials and advertising campaigns, with larger budgets than independent feature films, should be classified as art or not. However, in the case of today's topic of digitisation and the limitations of the digital, we as an audience are presented with a vast array of examples of websites and installations, aesthetic and anti-aesthetic, and the issue here does not lie in whether it is classified as art or not, but whether it is seen. The following paper seeks to problematise the notion of total virtualisation, or in other words, the total digitisation of our daily lives, through highlighting key concerns with this assumption as evidenced through the web based art scene. I will take you through notions of the virtualisation of our reality as mentioned by Paul Virilio, as well as seen in mass media and government policy, which will subsequently lead us to the point of discussing the artists' positioning within this digital age. Following this I will briefly describe two art projects which exist in the realm of the virtual and I will discuss their relationship to the world of a physical institutional reality. These projects are the current Nordic Institute for Contemporary Art's (NIFCA) *Rethinking Nordic Colonialism: a postcolonial exhibition* *project in 5 acts (1)* (March 24th-November 25th, 2006) and Australian cybernetic performance artist Stelarc's *Prosthetic Head* (2) (2003) Finally, I will conclude by adding some thoughts in regards to the limitations of the digital.

With the rate of artists who specialise in creating digital pieces ever increasing and the ever increasing digitisation of lives of the audience who view these pieces, there is a tendency for theorists and consumers alike to assume an inevitable totality within the medium. Paul Virilio in his book The Information Bomb (2000) describes how not only people's material reality but also their mental process is in transformation from analogue to digital. He compares examples of what he considers the similarities between areas such as sport to life itself within an arena of extreme science. He discusses how a change in nature has taken place from human competition to a sense of scientific fragmentation, whereby physiology alone is not enough to cope with what is expected within the sports industry. He uses the example of the abuse of "pharmacopoeia" through reliance on steroids, to compare with the nature of extreme science within other areas of life. He does this by describing research that has moved away from the "patient", or human, and towards an area of "general virtualization" (2). With the view in mind of a complete numeric breakdown of our physical realities, as generated by extreme science, no matter how pessimistic, we see an overall tendency throughout media and technological enthusiasts alike, to read our material world as rapidly transforming from the continuous into the discrete (Manovich, 1996; Manovich, 2001). Classic examples of this can be seen in movies such as The Lawnmower Man (1992) and the Matrix Trilogy. The latter subsequently has a virtual reality, multi-user domain (MUD) website by the same name (3) , whereby players are invited to become absorbed in the world of the digital. This is not the only MUD which beckons the user to immerse themselves in the world of numeric coding; other sites include Finland's own *Habbo Hotel (4)* , *Second Life (5)* , and the notorious *Sims (6)* . Of which, all can be seen as a form of escapism, yet none the less can also ultimately be seen as reinforcing the 21st century ideology of a global Information Society (7) .

Moreover, it seems little surprising that more artists are utilising the means of digital technologies within their arts practice. Whether it is due to material reasons, as digital media and exhibition is the cheaper alternative to what we have witnessed within other media such as photography, or whether this is for subversive reasons, using the social nature of the technology as a platform for political commentary. In addition to web specific artists, it is almost a given criteria that anyone who considers themselves a professional, in any field including the arts, be attached to the web in some way or another, whether through resume pages or industry organisation websites. The World Wide Web is now considered the one stop spot for professional information, advertising, and preview based aesthetic experience. Therefore, with this demand for virtual visibility created by an economically rationalised global society, and a cultural industry that is fraught with resource extremes, there is not so much wonder as to why it is becoming more and more difficult to distinguish one website from the other within this sea of information. The problem of the user in attempting to find specific sites and artists of interest is one thing, yet the struggle of the artist to be seen amongst the masses of information is another.

There seems to be a dual pull towards the necessity of artists in maintaining their ‘material’ world reference. One is that the audience they are seeking exist within the material world; these are human beings no matter whether represented as private cultural consumers, or multi-national corporations. They are physiological beings who possess only a limited capacity to read and sort through the piles of electronic information placed before them. Secondly, whether artists like it or not, or whether they claim to conform to the ‘establishment’ of art society or not, in order to be seen, to receive funding or in fact to effectively reach an audience, they need some point of contact to the physical art world. There is still as Danto (1964) described a need for instrumentals which enable the receivers to be able to distinguish what is artwork as compared to other things. There is also still a need to acknowledge the promotional qualities of the physical environment of the art institution in which crucial contacts between the artist and the receiving public are established.

Therefore, it is now time to briefly describe Rethinking Nordic Colonialism and Stelarc’s Prosthetic Head. In Rethinking Nordic Colonialism we see a transnational multidisciplinary exhibition project which seeks to discuss the history of colonialism within the Nordic countries, in addition to questioning the current legacies of colonialism within the Nordic countries’ contemporary reality. This project is devised through a series of exhibitions held in Iceland, Greenland, The Faeroe Islands, and the Finnish Sápmi, from March until November 2006. A bulk of the project material exists online through a web catalogue and numerous links to the pages of participants. The closing party of this project will take the form of a DVD launch in Helsinki, Stockholm and Oslo. Whilst this is an example of a large-scale collaborational exhibition involving numerous artists, curators and scholars, Stelarc’s Prosthetic Head, through the collaboration of several technical teams, is a 3D animated interactive art project designed to be a virtual extension of Stelarc’s own persona. The head which closely resembles that of Stelarc’s own, is designed similarly to projects such as the online Eliza generator and websites such as the *John Lennon Artificial Intelligence Project (8)* , whereby viewers are given the opportunity to ask the artworks/textual generators questions (through typing). Yet, what we can observe in both of these examples is that the fact they are attached to various physical art institutions through the means of exhibition is in no way a coincidence. In fact, whilst the five act exhibition project of Rethinking Nordic Colonialism is designed to connect the cultures of some of the Nordic countries’ key geographical locations via the means of a multi-faceted online arena, Stelarc’s Prosthetic Head in its nature of being virtual, relies on a combination of institutional installations and artist talks to ‘survive’ in both physical and conceptual terms.

Through reading Stelarc’s selected list of performances and presentations on his official website, it can be seen that this artist who argues that the human body is becoming obsolete within the wave of mass information and rapid technological development (9) is in fact heavily relying on this so-called Obsolete Body to transfer information from one geographical location to another. In 2004 alone, Stelarc was in contact with physical cultural institutions, both universities and art venues, through presentations and installations at least ten times according to his website, and more than this considering his Honorary Professorship at the School of Contemporary Arts, Edith Cowan University, in addition to experimental performances such as Schizoid at the Perth Institute of Contemporary Art, Western Australia. What is more is that these presentations occurred through Stelarc's physical presence and the environmental installation of his virtual material in at least four different countries around the world. Therefore, in order to validate the artificial significance of his virtual Prosthetic Head Stelarc, we can assume, must exist in the 'material' environment and thus make contact with other 'material' beings to emphasise the nature of virtualisation possibilities. In other words, Stelarc's Prosthetic Head lives through its interaction with living, physical human beings and the way in which Stelarc's presence is projected by his virtual representation is through live, institutional encounters which facilitate the meeting between artist and audience.

Equally, Rethinking Nordic Colonialism may just as easily have existed within the sea of cyberspace. Nothing would have prevented the groups of artists from making contact with one another, and the DVD box set which will be launched at the end of the exhibition could have existed easily and inexpensively online. However, this example of a project which extends physical (conceptual) geographical borders and is enacted physically on actual land sites bares witness to the persistence of importance that the material world holds for the interaction of humans beings, and their encounter with pieces and practitioners of art. It is through these physical spaces that not only people are joined together, and are significantly affected by the ultimate concreteness of face-to-face confrontation, but also the concepts discussed within the works are anchored to the human being's concept of existence.

Therefore, it is my opinion that whilst the economic rationalism of our times make digitisation and the virtual existence on the World Wide Web a more prominent phenomenon, the mass of information in itself is re-validating the human need for a physical, or experience. In fact, I feel that with the unregulated nature of the Word Wide Web and the realisation that it is an accessible medium, penetrable by all, the significance of the traditional art institution is becoming re-charged within the professional art environment. Naturally, the two go hand-in-hand; within this digital age it is fair to assume that the art institution is unviable without its publication on the Web. However, the field of the digital can be seen to be limited through the very nature of humans who are, in essence, material beings.

Footnotes:

(1) Find the main World Wide Web site for Rethinking Nordic Colonialism at: http://www.rethinking-nordic-colonialism.org/index.html
(2) See Prosthetic Head at: http://www.stelarc.va.com.au/prosthetichead/
(3) Find the Matrix website at: http://whatisthematrix.warnerbros.com/
(4) See Habbo Hotel at: http://www.habbohotel.fi/habbo/fi/
(5) See Second Life at: http://secondlife.com/
(6) See The Sims at: http://thesims.ea.com
(7) For information on political strategies towards an information society in Finland please see the e-finland website at: http://e.finland.fi/
(8) Please find the John Lennon Artificial Intelligence Project at: http://johnlennonproject.com/
(9) Please see Stelarc's notes on the Obsolete Body at: http://www.stelarc.va.com.au/obsolete/obsolete.html

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S5: TOWARDS A VIRTUAL OPERA

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ABSTRACT

Opera is one of the oldest forms of multimedia art, involving instrumental music, human voices, visual sets and lighting, and real-time acting. Today, information technology brings various new possibilities to realize such performance. This paper reviews existing technology that has been utilized experimentally or in public productions. These include still or live images projected on video screens and used as virtual sets, manipulation of voices and theatre acoustics by digital signal processing, synthetic instrument sounds, and animated characters as virtual performers. A particular question for discussion is adequate modeling of human behavior - how far is it possible

and what technical and psychological research is still needed? Another interesting problem is the control of the digital effects and their synchronization to live actors, which is usually done manually by a technical director. Possible alternative technologies are score and conductor following, as well as tracking of actors'9 movements on stage. Such automatism requires, besides reliable detecting hardware and software, also careful score structuring, in order to avoid inadverted triggering of actions, and to allow smooth recovery from such accidents. Yet another possibility is interactive narrative, which forms through audience participation. Many of these technologies are already used in computer games, but further research is still needed. The presentation includes demonstrations of experiments, and visions for the future.

4B: Applications and Methods in Science & Technology

S6: WHY MULTIPLE GOALS IN FINANCE?

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http://www.jaapspronk.nl/
Master in Financial Management
(4th Edition in progress)
(5th Edition will start in September 2006)
Details on www.ecft.nl/mfm/

ABSTRACT

For people working in finance, either in academia or in practice or in both, the combination of 'finance' and 'multiple criteria' is not obvious, However, we believe that many of the tools developed in the field of MCDM can contribute both to the equality of the financial economic decision making process and to the quality of the resulting decisions. In this paper we answer the question why financial decision problems should be considered as multiple criteria decision problems and should be treated accordingly.

S7: INTRODUCTION TO MULTIOBJECTIVE OPTIMIZATION WITH SOME APPLICATIONS

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We describe the basic concepts of multiobjective optimization where several conflicting criteria are to be optimized simultaneously. In addition, we introduce some methods and the interactive NIMBUS method, in particular. Finally, we demonstrate the usability of interactive optimization with some real-life applications.

S8: NEW COMPUTATIONAL TECHNOLOGIES FOR RELIABLE COMPUTER SIMULATIONS

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Keywords: Computer Simulations, Computational Error Control

The present work is devoted to one of the most challenging problems in mathematical modelling and numerical analysis, which also has great importance for most of applications in industry: reliable verification of accuracy of approximate solutions obtained via computer simulations. This task is strongly related to the so-called a posteriori error estimates, giving computable bounds for modelling errors of various types and detecting zones, where such errors are excessively high and some mesh-refinement algorithm should be used. On the base of a model boundary value problem of elliptic type we present effective technologies and discuss relevant implementation issues on how: to obtain two-sided (upper and lower) a posteriori error estimates for verifying the overall accuracy of computed solutions to derive two-sided (upper and lower) a posteriori error estimates aimed at control of local errors to develop parallel numerical procedures for computing the above types of a posteriori estimates The estimates derived in the paper are capable of giving bounds independently on the technique used to obtain approximate solutions.

S9: DOES MONEY MAKE THE WORLD GO ROUND?
The journey of Euro coins and banknotes as a diffusion process

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In the beginning of 2002 the Euro became the legal tender of twelve countries in the European Union. The design of the banknotes featuring bridges, gateways and windows symbolises the European spirit of communication, co-operation and openness. Whereas the design of the banknotes and the front of the coins is the same everywhere, the backside of the coins is unique for each country, usually presenting a work of art, architecture, a legend or a national symbol. This means that the spreading of the coins between the countries also spreads knowledge about the European cultural heritage. In this study the spreading of the coins and banknotes is viewed as a physical diffusion process. However, the indistinguishability of the coins makes it practically impossible to empirically retrace the diffusion. In this sense the banknotes make a difference. Besides a unique serial number, each Euro banknote has commonly known codes by which the origin of the note as well as the country of issue can be found out. There exists a volunteer community called EuroBillTracker (EBT), whose 80000 members enter the serial numbers and location information of each note they obtain, making it possible to track the route of individual banknotes. A numerical model has been developed to illustrate the diffusion process. The model is based essentially on the residence-time Monte Carlo algorithm. The diffusion of both the coins and the banknotes can be predicted by the model. In the case of banknotes the model results have been compared with the EBT data.