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The Sound of Silence in Spaces of Many Dimensions

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Abstract. We explore three-dimensional space by re-generating it as a body-mind experience. Our mind has invented even more dimensions. We experience them as purely mental constructs, far from any immediate sensory perception. We connect the sensual perception of three-dimensional space with noise, and the mental construction of multi-dimensional space with silence. Its beauty would then be the sound of silence. We show the visually exciting silence of that world in studying art work by Manfred Mohr. He has developed his distinct style strongly connected to the cube and hypercube in four and more dimensions. His art is not visualizing those structures but rather deconstructing their symmetry as an act of creating concrete aesthetic objects. We have designed a software tool, deviceX, to support the observer in developing an idea of the silent processes behind the algorithmic patterns governing the appearance of lines, shapes, and colors. deviceX allows to manually transform the geometric appearance of a Mohr picture into its equivalent topology. We provide a general theoretical background by linking our example to the view of the computer as semiotic machine, and of software as algorithmiuc sign.

Keywords: semiotic machine, algorithmic sign, algorithmic art, hypercube, deviceX

Introduction

Is „computers in art education" to be understood as art education enhanced by computers brought into the classroom? Or, perhaps, as an introduction to Adobe Photoshop in preparation for a cooperative student project on collage? It could go either way.

Art education is different in so far as it (*i*) is about perception *and* conception, and (*ii*) relies on doing much more than many of the other subjects. Art education helps develop a feeling for the concreteness of materials. Computers, programs, data, and interfaces are of a different kind. Starting in the early 1970s, the material status of software was heavily discussed. Is it of an immaterial or pseudo-material kind? The position we take on such issues influences the use of computers (or digital media) in art education. What is the right time to allow for computers in art education, was a hot topic but got run over by facts. What are subject matters from aesthetics and fine art that *need* computers for a proper treatment, appears to be a more appropriate direction to go.

In this paper, we introduce a view of the computer and of software that supports an independent position on the issue of computers in art education. We identify the computer as the semiotic machine, and software as algorithmic signs. The semiotic concept leaves behind as fruitless debates like „computers in the classroom – yes or no?" The paper first studies an example of the algorithmic art of Manfred Mohr which we use to demonstrate a specialized software tool. It allows for an insight that is otherwise impossible to gain. We, second, explain the two concepts and interpret the example in the light of that theory. We hope that the strange title will become clear by reading the text.

Algorithm and art

A small number of exhibitions in the USA and Germany in 1965 started a movement that came to be called *computer art*. Those earliest and rather innocent manifestations were often belittled and, with exceptions, widely ignored by the art establishment. A few more events were put up by prestigious places like discovery trips into the relation of art, science, technology, and culture. In their time, none of them was a great success. But in retrospect, each one of them left behind a legacy.

During the last decade or so, art historians have finally started to research and interpret the phenomenon in depth. The general literature in the fields of digital art and digital imagery has exploded over the last few years. We list but a few for the interested reader: Spalter 1999, Wilson 2002, Paul 2003, Grau 2003, Rush 2005, Alexenberg 2006, Altena 2006, Gere 2006, Grau 2007, Reck 2007, Herzogenrath and Nierhoff-Wielk 2007.

Researchers in art history or cultural studies are at times surprised to realize that an entirely new image science has emerged. The *algorithmic revolution*, as Peter Weibel calls it in a remarkably successful exhibition at ZKM (Karlsruhe, October 2004 to January 2008), happened without people noticing but with greatest effect. There are virtually no images any more that would not carry some algorithmic traces within.

We decided, for this paper, to concentrate on one particular case. We hope thus being able to demonstrate a principle, the *principle of inherent capability*. What is it? One of McLuhan's most celebrated slogans was, „the medium is the message" (McLuhan 1964, 23ff). Simply put, this says that a new medium gets used with an old medium as its contents (e.g., theatre – cinema). The message is reduced to stating „look here, I was done by whatever the new medium is". The principle of inherent capability, however, claims that a medium becomes more than its own message when its inherent capabilities are used for new kinds of expression.

The inherent capability of the computer is computation. When the machine for computation started to reveal its media qualities, it first generated pieces of art that often looked like contemporary art. The challenge is to use the computational machine such that it does not just automatically compute what was done by hand before. The search was for the genuine expression.

We want to demonstrate this principle in the case of Manfred Mohr's art. Manfred Mohr is a New York based artist of German origin who started using the computer in 1969, shortly after a few others had demonstrated the feasibility of writing computer programs to generate aesthetic objects and put them up in galleries. To avoid the term „computer art" (which had gained some limited popularity by the time), Mohr for some years spoke of his art as „algorithmic art". As it turned out, his effort was in vain. For many, the term „algorithmic" may have been too alien. Outside of mathematics or computing it was simply unknown. But when you started to understand what it entailed, the term *algorithmic art* seemed to be a contradiction in terms.

For *algorithm* is more or less synonymous to *computable function*. Could art be generated by computable functions? Not really, general opinion would have it. Art came out of deep feelings, intuition, from the guts and not the brains. You knew how to do it or you left it. Following this train of thought, algorithmic art would have to be a result of computation without mercy, of automatic descent, but at the same time of aesthetic value. The world of algorithms is a mathematical world, a world of general laws and rules, of strictly logical derivation, of hard work to follow a proof. The world of art is a world of immediacy, a world of specifics and unique decisions, of judgement, critique, and contradiction, of quarrel and acceptance. Where mathematics defines, art interprets. Where art is subjective expression, mathematics is general law.

It may turn out now, a generation later, that the rejection in the 1960s of the term *algorithmic art* was an unconscious reaction against first signs of a development in culture that has meanwhile taken on form and gained tremendous momentum. The development and influence of digital media requires people to be capable of thinking algorithmically and aesthetically at the same time. The fact that new study programmes, centered around digital media, have started to be offered at many places is an overt proof of the trend.

In the word „algorithm“ the first paradigm of computing appears: *computability*. It is still of lasting importance and influence, and will prevail. But it has become second to a new paradigm: *interactivity*. Interactivity had been a topic of research for a long time with some erratic achievements during the 1960s by Ivan E. Sutherland, Doug Engelbart, Ted Nelson, and, starting into the 1970s, Alan Kay and his Learning Research Group at Xerox PARC. With the appearance on the market, in 1984, of the Apple Macintosh, twenty years after the beginnings of algorithmic art, interactivity became the second paradigm of computing. Prix Ars Electronica, the most prestigious award available to artists of the digital era, soon adopted „interactive art“ as one of its prize winning categories.

There is quite a diversity now of genres in digital art. They could as convincingly be used for a demonstration of the principle of inherent capability. They all rely on algorithms, in some cases in the most beautiful and inventive ways. It is, therefore, justified to stick to the more traditional approach of studying a piece of canvas covered with paint, digitally printed.

Cube and canvas

Manfred Mohr began painting in the mid 1960s in the *Informel* and Hard Edge traditions. The chaos component of his creative spirits also surfaced in his jazz improvisations on the saxophone. Rather early, however, the algorithmic structure component gained priority over the chaotic one when he was allowed to use an automated drawing machine in Paris in 1969. In 1973 he conquered his life’s topic when he started to break the cube’s symmetry (Figure 1 is an example).

Just using the computer (instead of, or besides, other devices) would not turn his work into art. He had to turn the newly available technology into his instrument for an expressive purpose. Mohr’s idea was to use the computer as an algorithmic instrument to break the cube’s symmetry. The three-dimensional cube is arguably the most fundamental element of space. It definitely stands solidly for the Cartesian idea of space. Breaking symmetry would create a source of visual complexity. Mohr’s work of about 40 years is proof of the potential of this first intuition.

Mohr paints canvases (or has a digital printer do that for him). So he restricts his creative output to the flat 2D-image. But the 3D cube is not a *physical object* to him. It has rather become a *mental concept*. The mental concept, in order to be turned into the stuff of computation, must take on the form of algorithm and data structure. In the algorithmic world, this is not a voluntary decision. It is a necessary step. Nothing exists here unless it is made computable. In order that humans may be sensually affected by the computer’s results, the object of computation must be turned into perceivable form. This is the most trivial, yet fundamental lesson of computing: Computer things and processes must be sensually perceived by the human, and electronically computed by the computer. Everything on and in the computer exists in duplication. This will turn out to be the *raison d’être* of the algorithmic sign, and the peculiarity of the computer as medium.

Whether Mohr was aware of this theoretical insight, doesn't matter. He did what he did with a good deal of secure intuition. From Max Bense, one of the founders of information aesthetics, who had a strong early influence on Mohr, he had learned that the work of art may be described as a sign. When such signs are generated by the computer, they become algorithmic signs (Nake 2001b). The art is to create creatures that traditional drawing or painting does not dream of. Traditional painting appears as immediate, direct, haptic experience: brush on canvas, pencil on paper. Algorithmic art, in comparison, is painting from a distance, with the brains, and eyes shut. Not the individual piece occupies the artist's thinking. It is rather the entire set (or class) of pieces that this particular one belongs to.

The voluminous book by Keiner et al. (1994) tells Mohr's story. Two catalogs (Nake 2001a, Herzogenrath et al. 2007) are on his more recent art. After having been an addict to the 3D cube for some years, his art was in need of greater complexity. He turned to four and more dimensions. In *n* dimensions, the hypercube is a purely mathematical structure. Its defining components are hypercubes again, but of reduced dimension, *n*-1.

Geometry and topology

We have designed an interactive software tool capable of transforming the geometry of a particular class of Mohr's paintings into the corresponding topology. The tool works only for the space.color class of Mohr's art. We here indicate what the tool is supposed to do.

We must outline the algorithmic generation of an instance of the space.color class. Take a hypercube in six dimenensions. Choose two opposing vertices, say A and B. The diagonal from A to B cuts through the interior of the hypercube. A *diagonal path* is a path from A to B running along edges of the hypercube. Each such diagonal path consists of six edges. Between two given vertices, there are 6! = 720 different paths.

The program randomly chooses four of those paths. They are ordered from first to fourth. A straight line connects the first bends of the first and second path. This applies equally to the third and fourth paths, and back to the first. Analogously, connections are established between the sequence of second bendings, etc. This procedure creates 24 quadrilaterals cutting through part of the hypercube. Each one of them is randomly colored. This way, a complex situation of colored quadrilaterals in space is constructed. The construct is purely mental. It can easily be described algorithmically and carried out computationally.

Mohr's interest is not visualizing the space situation. He rather projects the colored quadrilaterals down to the flat image plane (in some pre-assigned sequence as to avoid problems of hidden faces). This projection creates the image (Figure 2). In our implementation, the hypercube rotates in space, creating incessant changes of color-form in the image plane.

This is the starting point for deviceX. It can be used to explore this sort of image. In its current form, deviceX (Figure 3) appears on the screen as a slider without having the typical visual form of a slider. It is a miniature replica of Mohr's algorithmic space.color image. You move the slider by moving the mouse. Ist position between the geometry and topology of Mohr's picture is turned into an interpolation of the two extreme views. The slider *itself* shows the state of the object or process it is applied to. Contrast this to the typical slider to control the volume of your radio set. It is used to physically reset the value of the volume, and to change the radio state accordingly.

Similar in our case of a semiotic (or semantic) slider. When you move it, you immediately observe on the slider the change of state. So the slider stands for the control position *and* the controlled state variable. This collapsing of the two sides of a control (setting the scale and changing the state) is only possible in the semiotic domain. Figure 4 shows a series of twelve states of deviceX applied to a particular 6D-situation.

The device allows for a few more functions to help understand some of the relations in Mohr's paintings. You can select colored areas, or their border lines. When selected, an objects starts to flicker. Flickering helps you concentrate on selected parts.

Mohr offers a little computer and LCD screen running one such situation in permanent rotation in very slow motion. He can almost guarantee a situation never re-occuring during a collector's life time.

Semiotic machine and algorithmic sign

Art education has always been manual and mental, material and form. This may in part be changing. A semiotic transformation is the necessary pre-condition before anything can be processed by computer. Objects lose their materiality when substituted by signs. The semiotic transformation emphasizes operations and structures: operations to be applied to, structures to organize, the resulting signs (really this refers to the representamina of signs).

deviceX can help develop a deeper insight into a complex image. What is the trick? We observe that the image exists as an algorithmic sign, i.e. a sign resident on the computer. As such we observe its visual appearance, while the computer is manipulating the structure of that appearance. Our action is moving the slider. Our observation is that the slider's content leans more to the geometry or more to the topology of the image. The immediacy of this semiotic (quasi-immaterial) situation is due to the actual manual movement of the slider's physical device and its computational interpretation by the software. This immediacy is of high educational value. In the semiotic realm it figures *in place of* the application of a physical tool to some physical material. The tool literally becomes a mediator.

Our lesson is that immediacy in handling an interactive device and perceiving the semiotic changes, may substitute for the physical immediacy of tool and material. In the material world, when we apply a tool to a physical object of interest, we change the state of that object irrevocably, and in parallel observe the change. In the semiotic world, we change the state of a physical device and in parallel observe the change of the *representation* of the object of interest. It is changed because the computer intermittently reads the device's changed state, interprets it according to the currently active software, and thereby changes the state of the representation. This is possible only because the object appears visible to us and manageable to the software: it has become an algorithmic sign!

At the same time, the computer has become the *semiotic machine* (Nöth 2002). This type of machine changes the semiotic, rather than the physical, state of objects. As the semiotic machine, the computer has over the last two decades revealed its media qualities. It has made objects and processes grow semiotic skins before they can be manipulated by algorithms. Those skins create a distance, they remove us from the objects, allowing only for mediated encounters. Some of that mediation may be gained back in immediacy – in a more abstract immediacy, of course. That would become the sounds of silent spaces.

Space and silence

Since stillness is the motto of this conference, instead of a conclusion we end on stillness. Thinking of it brought up the following thoughts. We see, in all honesty, connections between algorithmic travel in abstract space, silence, and noise.

To Immanuel Kant, *space* was an inner subjective imagination and yet a formal condition *a priori* of our experience (Kant 1956, 270). The naive idea of space is a box surrounding us: we go to a building, enter it, and leave again. Kant's concept of space is, of course, not as simple as this but he supports it.

Space as a container to be filled was the idea of Aristotle. To Descartes the physical world was out there with all its myriads of things: *res extensa.* The soul and thinking were in here with all the names and concepts: *res cogitans*. Thus he created the utterly successful split of body and mind. (Descartes 1647) It was needed to invent abstract mathematical spaces: axiomatically defined space became a sign.

Three dimensions became a mathematical concept, and once that had been introduced, it was easy to have any number of dimensions. The abstract concept was clear, clean and powerful. You don't *see* those dimensions. You *think* them.

Can we think of time and space without noise and silence? Does not all our experience result from our bodily movement in the world? From home to work, from day to day, through dark and light – all forms of time-space experience are tied up with noise and silence, with sound and stillness.

Silence is the „complete lack of noise or sound" (Oxford Dictionary). Stillness is „the quality of being quiet and not moving". Moving creates space, not moving is location; their parallels are noise and silence. Silence is the zero extreme in the auditory domain: total absence of any audio signal. Noise – as in *white noise* – at the other extreme stands for the mixture of all possible audio signals. Sound is what we perceive most of the time.

Sounds are events in space traveling in time. Each one tells us of near and far, out and in, left and right, front and back. Space is not empty of sounds. *Real* space is also sound.

What about abstract space then, imagined, mentally constructed, mathematical space? There is clearly no sound there. Metaphor doesn't sound. Yet, in older times, the stars and planets screeched, squeaked, rumpled along their eternal mechanical paths because the metaphor for outer space suggested so.

To the extent that space is void of matter, it must also be void of sound, we believe. Space out there is governed by silence. And yet – is it not a pleasant idea to listen to silence? John Cage's composition comes to mind. Listening to the sound that we cannot hear, and after a while we discover it, the sound of silence.

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Figure 1: Manfred Mohr, P-202-f (Cubic Limit II) 1977 (artist's permission) – 6 stages from a 3D development

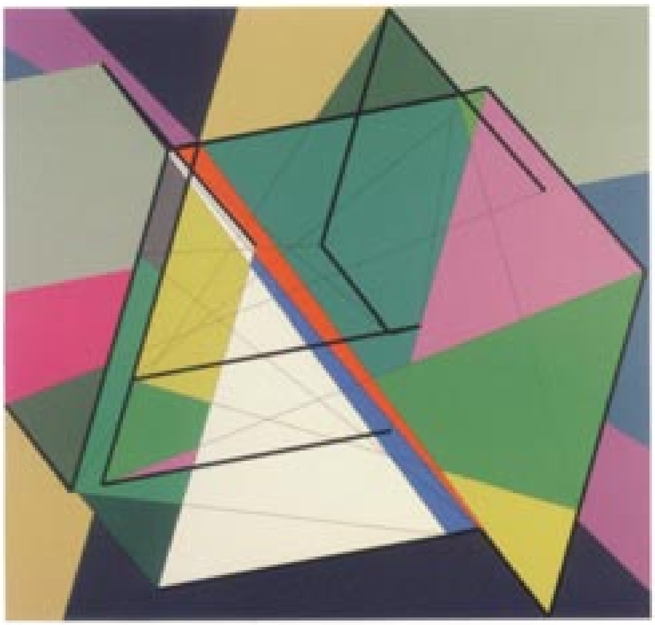

Figure 2: Manfred Mohr, P-707-f (space.color) 1999-2001 (artist's permission) – diagonal paths in 6 dimensions

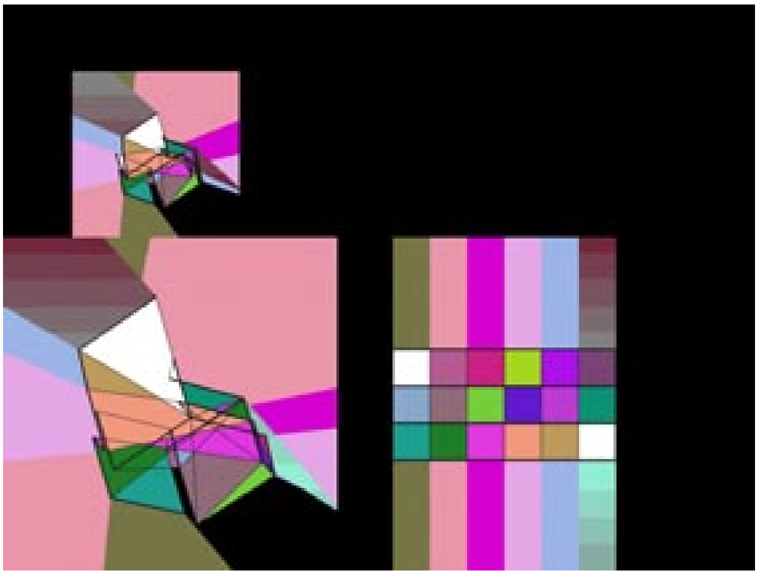

Figure 3: deviceX. Lower row, geometry (left) and topology (right) of typical Mohr image from space.color program. Upper row, small replica of geometry, slightly moved top the right.

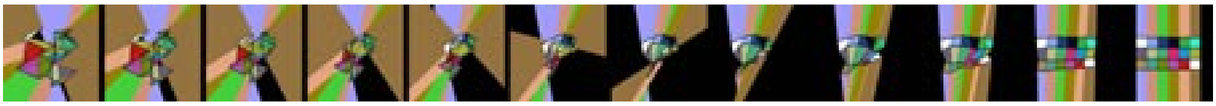

Figure 4: deviceX. Twelve stages of moving the slider from geometry (left) to topography (right). Image different from that of Figure 3.

Authors' Short Biographies

Frieder Nake is a professor of interactive computer graphics at the computer science department, University of Bremen, Germany. His academic degrees are in mathematics but he moved into computer science at a time when the field was still developing into a well established formal discipline. He started his academic career in Stuttgart, then moved to Canada (University of Toronto, University of British Columbia), and returned to Germany in 1972 to teach in Bremen. His current interests are digital media theory and design, algorithmic and interactive art, digital media in education, and the theory of computer science.

Matthias Krauß holds a degree equivalent to an M.Sc. in computer science from the University of Bremen. He worked there as a lecturer and researcher for four years, and is currently with the research and development group eCulture Factory of Fraunhofer Gesellschaft. There he is heading an international project in e-learning. His interests are digital media, computer art, and complex programming.

Susanne Grabowski graduated in media pedagogy from the University of Augsburg, with a specialization in digital media. She was a lecturer and researcher with the computer graphics group at University of Bremen for eight years. Currently she is with the University of Education at Weingarten. She has recently finished her Ph.D. on digital media in study environments with an emphasis on computer art.