

the student's (and the viewer's) intuition.

"Outside In" is the result of collaboration between mathematicians, programmers, and designers. We developed a great deal of custom software in addition to using RenderMan, Softimage, and Mathematica. I want to thank Silvio Levy and Tamara Munzner (the other two directors), Nathaniel Thurston, Stuart Levy, David Ben-Zvi, Daeron Meyer, and all of the other contributors.

"The Geometry Center" is the informal name for the National Science and Technology Center for the Computation and Visualization of Geometric Structures, based at the University of Minnesota.

GEORGE LEGRADY

## Equivalents II

The Equivalents II project has evolved out of an intent to mathematically produce believable still-images that convey the realism of the photographic. The project brings together discussions and references from three distinct but not unrelated disciplines: Iconography; studies in Language and Semiotics; and computer programming. This article discusses the historical references, aesthetic questions, cultural interpretation and technical aspects of a computer program that generates abstract, cloud like images whose tonal characteristics are defined by text typed in by the viewer.

The presentation touches on the following: Alfred Stieglitz' Equivalents, Gerhard Richter paintings and the photographic referent, Iannis Xenakis' mathematics as a base for musical composition, Paul Virilio's infography, Claude Shannon's Information Theory, Mark Poster's The Mode of Information, Brownian motion and Gaussian random behavior models, general users vs specialist programmers, representation and truth, language as an interactive agent, text as a signifying process in the viewing of images (language as anchorage), computer programming practice as art activity, cognitive interpretation and cultural knowledge in the interpretation of images.

PETER BEYLS, ROMAN VEROSTKO,  
STEPHEN BELL, BRIAN EVANS,  
KEN MUSGRAVE, TECHLA SHIPHORST

## Algorithms and the Artist

### Peter Beyls: Introductory note

We address a number of problems related to viewing algorithms as the formulation of artistic statements. We analyze the nature of the algorithmic approach as opposed to direct physical action. Here are some of the basic questions that will be raised. Why do artists choose to express themselves indirectly, by way of formal descriptions of their ideas and what are the sources of inspiration for algorithmic activity. How does current algorithmic work relate to formal methods in an art-historical context. What is the relationship between paint systems and a pure algorithmic approach and is there a way to integrate both. What determines the beauty and effectiveness of an algorithm. What is the relationship between an algorithm and the nature of the physical results it produces i.e. how to externalize (materialize) algorithmic processes. What is the role of interaction in the development of algorithms. Do algorithms allow for progressive optimization or do they require fully pre-conceived ideas? Finally, and most pertinent, does computer programming force a focus on the surface component i.e. perceivable structure, or does it allow for the manipulation of deeper components such as meaning and emotion?

### Brian Evans: The Catalytic Algorithm

With technology it is possible to manifest mathematical ideas as images, sounds, sculpture and even poetry. Artists in all media have found mathematical processes of value in their creative enterprise. These processes are often described using algorithms.

An algorithm is nothing more than a recipe, a finite list of instructions. This recipe will have precise steps to follow, perhaps requiring some initial input (i.e.

ingredients). The algorithm will have a desired outcome, and be considered effective if the outcome is achieved. A tasty apple pie is the result of one algorithm, an image or piece of music derived from a mathematical process, generated from a computer program, is another.

In describing mathematical processes with algorithms, beauty and meaning can be discovered. Numbers are mapped into light and/or sound, and perceived through the senses as objects. It is the mathematical source of these works that has aesthetic worth.

Algorithms, implemented on computers, make it possible for us to see and hear the beauty of mathematical processes. We can explore the inherent beauty of these abstract processes, logical, human-made constructs that initially seem to have meaning only because they can be used to predict natural phenomena. These are processes our culture exploits to myriad purposes, from predicting tomorrow's weather, to navigating and landing a jumbo jet.

When we see a mathematical model visualized, perhaps a model of water resistance over the hull of a racing yacht, a chart of planetary motion, or even the abstract image of a Mandelbrot Set, are we looking at something that, in some metaphysical way exists? Or is the mathematics describing nothing more than an intellectual construct, and the images simply pretty, and sometimes inexplicably useful? Is meaning culturally attributed, or is mathematics meaningful and effective because it describes "grand truths?" We trust our lives on a daily basis to the effectiveness of these mathematical models. What is the basis of our faith? Why do we trust them?

The algorithmic image or composition gives us something to see or hear and begin to ponder. Aesthetic experi-

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ence isn't in the viewing or the listening, it's in the pondering. For me it reduces to a question of divine presence, a point of irresistible curiosity and a source of infinite wonder.

### **Ken Musgrave: Formal Logic and Self-Expression**

Determinism precludes free will. Artistic expression is perhaps the highest manifestation of free will. Yet artistic expression can be obtained strictly through the digital computer, which operates precisely in the realm of formal logic, which in turn is the epitome of deterministic reasoning. The creative act of self-expression directly through a computer program places in unique juxtaposition these mutually contradictory philosophical extrema. My own work entails mapping scientific models, based on the formal logic of mathematics, into the formal logic of computer programs, and using these programs to generate images which (I claim) represent artistic self-expression of a spiritual nature. This bizarre new creative process marks, I further claim, a greater discontinuity in the creative process than any other new medium or process in the history of the visual arts. It's deep and well-developed roots in the formal disciplines of math, science, and logic give it unprecedented conceptual depth.

I propose to present, fortify, and defend these claims in this panel. In the process, I will highlight the serendipitous character of proceduralism in the process, the use of random fractal models in reproducing the kind of visual complexity typical of natural scenes, and the ramifications of the computer's returning representationalism to the "open problems" category in visual art.

### **Stephen Bell: ALGORITHM**

I am interested in producing work which is realised through engaging the audience in active physical participation. In a general sense it can be said that I have been producing work by

proposing rules for the generation of images but leaving significant parameters open to change. The form of the work is defined by the limits imposed by the rules and the degree and manner of control over the parameters afforded to participants.

An algorithm can perform a role in creative activity similar to that of any other constraint used in art practice; the self-imposed limits within which one works in order to free oneself to indulge in creative play and experiment and yet at the same time ensure our focussed and hence enhanced attention. It is in this way that I use algorithms in my work. As I have been using computer graphic workstations the rules are encapsulated in an appropriate computer programming language. Computers are very useful control devices and the programming languages which have been developed to determine how they behave are effective, if somewhat limited, in enabling one to describe rules for the interactive real-time generation of the kind of graphic images which I am interested in; Representations of the interactions of programmed automata with each other and the audience-participants. I would like to hope that we can interpret the word ALGORITHM in a relaxed way.

It is our prerogative as humans, particularly as artists, to interpret language fuzzily, not to define the meaning of a word for eternity but to exploit its value in passing, in a dynamic interchange of ideas and notions with fellow humans in which it plays a significant yet ephemeral part. The word ALGORITHM in the context of the panel will, I hope, be as a catalyst for lively and diverse discussion rather than a straight-jacket. That is, after all, the value that I have found in using algorithms in art practice.

### **Peter Beyls: Algorithms for Conceptual Navigation**

I have always thought of computers as dynamic tools for introspection, explo-

ration and discovery. Computer programming is instrumental in the externalization of ideas and algorithms are formal descriptions of what one hypothesis constitute the production of creative statements. The computer is a playground to speculate on the generative potential of ideas. As a matter of fact, the physical, tangible management of purely conceptual constructs becomes possible. However, the paradox is that while algorithmic specification allows the artist to touch the essence of his ideas it also creates a distance since all specification is indirect and seems to exclude spontaneous action.

The idea is to view computers as partners in the process of creative decision-making. By way of algorithms we can explore various man-machine relations in this partnership: from studying total autonomy in computer programs to systems designed for explicit interaction. The development of personal algorithms is the key to exploration and the gradual specification of objectives from incomplete knowledge, in sharp contrast to view the computer as slave, as a medium for deterministic visualization.

I have characterized the interactive method where man and machine collaborate in a common effort and with common objectives as conceptual navigation; the artist-programmer gets feedback, his expectations are confirmed or contradicted by the program's behavior. Eventually, unexpected results may signal new and promising routes exposing unknown territories. Thus, man and machine contribute both to the creation of a computational climate that favours invention and to the development of a critical attitude towards the often complex relationships between programmed intention and actual result.

Writing algorithms has also forced me to evaluate experience vs. speculation. If one relies on models that have proven to be successful in the past, one

confirms what is already known. Algorithms that use rules reflecting this knowledge produce predictable results. Otherwise, designing processes with the greatest possible freedom in pure speculation is like working outside of any known context making evaluation very hard indeed. The creation of new contexts for growing algorithmic activity mixing memories of the past and an open imagination is, I think, perhaps the most interesting challenge to algorithmic art.

### Roman Verostko: Notes on Algorithm and Art

Almost as if by magic - whatever procedure you dream of - you can probably extend the power of your dream to the computer and let it develop the dream beyond your wildest expectations. You may identify procedures for improvising with color, scale, and position - which is what artists have always done. Given sufficient definition you could develop a form generator and from your new vantage point see new possibilities for further elaboration on your routine. Through trial and error - interacting with the algorithm itself you proceed further into the new frontier.

So what can we learn from this? We learn what artists have always known - that "CAD" programs, paint brush programs, paint brushes and drawing paraphernalia do not make art. Neither do artists or designers simply "make art". The one over-riding essential element to the process, "a developed artistic procedure", is necessarily unique for each artist and for each work of art. The procedure addresses a singular conjunction of elements for which there is no "universal" rule. The "calculus of form" may be placed in the service of such procedures but should not be confused with the art-making procedure. For the artist who writes the code the artistic procedure is the act of "writing the code", pretty much like the creative work of the composer when the com-

poser writes a musical score.

Making art does indeed require a "calculus of form". But the artist's instructions on how to employ the "calculus of form" precede the "calculus". One needs an "artistic procedure" which addresses the entire complex of elements for each specific work. The final form, unique and specific to each work, embraces more than the "calculus". While it embraces and grows from a "calculus" it might employ any of an infinite number of approaches to deliver the form. These may include metaphor, improvisations of the form phenomenon in and of itself, or reference to some other phenomenon or idea - historical, literary, political, mathematical or philosophic.

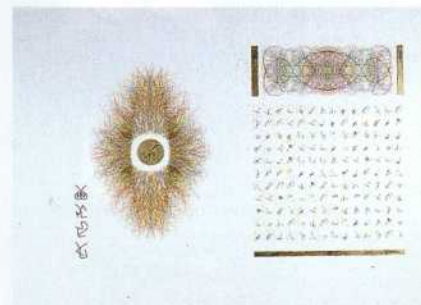
Can an artist write an algorithm then for an artistic procedure? Emphatically yes! Such algorithms provide the artist with self-organizing form generators which manifest his or her own artistic concerns and interests. We are looking to an interesting time ahead of us when artists will be able to exchange and interact with each other's form-generating tools in ways we never dreamed. There are procedures yet to be developed to make this kind of interactive expression accessible - a time ahead when we will literally see an evolution of form including a genealogy associated with its creators.

ROMAN VEROSTKO

### DIAMOND LAKE APOCALYPSE: Illuminated Chaotic Scripts

These works are intentionally made as "precious objects" to heighten their formal relationship to illuminated sacred manuscripts. Chaotic digital scripts have been transformed with an "electronic scriptor", a plotter, following procedures reminiscent of the medieval scriptorium. All works are executed with a multipen plotter using original instructions to generate the entire piece including the scripts, headers and illuminated "initials". The program employs randomly cast control points in its form generating procedures. In several works the illuminated "initials" identify form generators of special visual interest.

These works invite us to savor both the beauty and the mystery of their coded procedures - not so much for their stark logic as for the grace and poetry they yield. The procedures provide a window on unseen processes shaping mind and matter. By doing so they become icons illuminating the mysterious nature of earth and cosmos.



Roman Verostko, Diamond Lake Apocalypse

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