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INTRODUCTION

< This issue >

Craig Harris

This issue includes Roy Ascott's glossary "The A - Z of Interactive Arts", and a view into Clifford Pickover's new book "The Pattern Book: Fractals, Nature, and Art". Clifford Pickover offers us his preface, and includes a reference list and glossary (extracts appear here). In Leonardo Digital Reviews we hear about Siggraph 95 and reviews of other items and events. Several job opportunities appear as well.

Unfortunately I had to miss ISEA 95 in Montreal, but the reports coming in from those who attended are very positive. LEA readers who were able to attend are invited to let the rest of us know what they feel are the peak moments and works presented.

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FEATURE ARTICLE

< THE A - Z OF INTERACTIVE ARTS >

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Art
While traditionally art has been focused on the appearance of things and their representation, the digital arts are concerned with interactive systems, transformation, emergence, coming-into-being.

Art Gallery
If the window onto artspace was the metaphor of art gallery culture, the doorway into dataspace is the metaphor of cyberculture.

Behaviour
Classical Aesthetics dealt with the behaviour of forms, Apparitional Aesthetics deals with forms of behaviour.

Biological buildings
We need a biology of building. Seeding should replace designing, buildings must be planted and allowed to grow.

Connectivity
Connectionism is the way of cognitive scientists, connectivism is the way of the digital artist. Connectionists and connectivists converge at that place in culture where the artificial collaborates with the natural in a new synthesis of being.

Cyberception
We are technologically amplifying our processes of cognition and perception to the extent that a new faculty is emerging. Cyberception means we are evolving a new body, a new consciousness and a new sense of how we might live together in the interspace between the virtual and the real.

Design
Design was always a top down affair with blueprints, master plans, models and maquettes. Now it's becoming a bottom up process with its products growing out of a substrate of communication networks and robotic nodes.

Double gazing
Just as we see, hear, and feel in ways unknown directly to biological man, we also now live in an environment which increasingly hears, sees and feels us. With computer laser tracking of our retina, the artist's gaze is returned. The walls will indeed have ears, and buildings will speak volumes.

Economatics
To halt our social sclerosis, it's not enough to create new jobs, new tools or new investments. Nor can conventional politics, either left or right, solve our problems. It's a matter of accessing the collective telematic consciousness, creating new interfaces to the world net, and constructing new organisms of learning and production.

Feral networking
How quickly computer-based art can be tamed and domesticated! The wild cats are relatively few but their presence in the Internet jungle are our only guarantee against complacency.

Five fold path
- connectivity - immersion - interaction - transformation - emergence

Gaiatronics
The technological amelioration of planetary life

Hermeneutic Error
In the pre-telematic era, we thought the world was full of meaning, a text to be interpreted, a great book waiting to be read. Now we know that reality and meaning are created through the interaction of embodied minds.

Holomatic Principle
The holomatic principle is that each individual interface to the net is an aspect of a telematic unity: to be in or at any one interface is to be potentially in the virtual presence of all the other interfaces throughout the network.

Hypercortex
A post-biological neural nexus of collective cognition! Superthought is a community affair. Neural networks are merging with planetary networks in a new space of consciousness.

Hyperdata
In the Net, ideas converge from scattered sources to become transformed and distributed into many branching pathways of meaning. This darting to and fro of data, colliding, emitting new combinations, absorbing each other is a kind of quantum behaviour.

Interactivity
Trivial and non-trivial. The first is a closed system with a finite set of elements. The second is open ended and infinite in its capacity to accommodate new variables.

Multi Media - FDS and OES
Finite Data Sets: action within pre-designed limits, presented as either a unitary or a so-called "interactive" experience, with the

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artist in control.
Open-ended Systems: interaction within networked, algorithmic or evolutive systems which put the user or the environment in control.

Museum culture
Should be redifined as post-biological horticulture. The net is where we plant ideas in the ground of interactivity and see them grow. This is cybersynthesis rather than photosynthesis: museum as arboretum of new forms and new ideas. Gardens of hypotheses will replace the neo classical temples and post modernist follies of the museum world.

Nano-navigation
Our present multi-media explorations will go progressively further and deeper as we penetrate the nano-field of experience into particle consciousness. Our bodies will host the chips which process these navigations.

Nanotechnology
will give us the tools to re-materialise art from screen-based media to world-based artificial life. Atoms will replace pixels.

Phreno-fractals
Freud is dead and the myth of the unified individual has been destroyed. We are each made up of many selves: de-centred, distributed, and tele-schizophrenic. Our minds have an infinity of phreno-fractals constantly creating alternative realities in which every thread of meaning is woven by us.

Planetary Collegium
New structures of learning, research, and creativity are emerging in the Net. Students deserting the seminar room find that being on-line to a critical community can be more rewarding than in line for infrequent and brief face to face tutorials. The interversity is beginning to emerge.

Psybernetic phenomena
Over the millennia, the human desire for transcendence has taken many forms. We’ ve had telepathy, out of body experience, clairvoyance, ghosts. Now we have telematics, telepresence and the aesthetics of apparition. The Beyond is now over here. It’ s called cyberspace.

Radical Constructivism
Forget representation, think only of connectivity and construction. We are making the body a site of transformation from which we’ ll re-create ourselves and re-define what it is to be human.

Reality - dry, wet, and moist
- Dry Reality is found in the arid and banal spaces of current VR technology
- Wet Reality is the “natural” reality that classically has been sold as the real thing
- Moist Reality is evolving from the technology of artificial life and other post-biological systems.

Smart Architecture
To support the realities of cyborg living, the distributed self, and our digital ecology, architecture will have to become more conscious, anticipatory and responsive. Psycho-therapy for intelligent buildings may be more appropriate than putting ourselves in analysis. Think of all the psychotic and schizophrenic places you know.

Teleprescience
Just as telepresence gives us a new sense of self, so our powers of intuition (clairvoyance) accelerate to a higher state of prescience: teleprescience. It means that we anticipate faster, and foresee further.

Telematic Imperative
When there's no more geographical boundaries, territorial aggression is as irrelevant as polarised politics. The only imperative is to connect. Nowadays even the self is permeable.

Telenoia
Computer-mediated, distributed mind-at-large: asynchronous global connectivity. In celebrating telenoia we reject the individualism of the old industrial culture- solitary, anxious, alienated, neurotically private. Telenoia replaces paranoia in the telematic culture.

T-space
Traditionally, the forms of Art were 2D or 3D. The digital arts occupy telematic space which both collapses classical space and deterritorialises time.

Wormholes
in the quantum foam of hyperspace they allow for time-warps, in the data foam of hypermedia they allow for idea-warps. In both cases the action is faster than light.

Xenoplastic arts
the arts of connectivity and interaction are taking spiritual command of the plastic arts

Zygosemantics
In the computer-mediated systems of interactive art, the viewer and the viewed, the operator and the operated, the public and the artist are yoked together in a semantic synthesis which generates new meaning out of every fresh interaction.

A version of this text was first published in the catalogue of the Interactive Media Festival in Los Angeles June 1995

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PUBLICATIONS

< The Pattern Book: Fractals, Nature, and Art >

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Introduction
"Art and science will eventually be seen to be as closely connected as arms to the body. Both are vital elements of order and its discovery. The word 'art' derives from the Indo-European base 'ar', meaning to join or fit together. In this sense, science, in the attempt to learn how and why things fit, becomes art. And when art is seen as the ability to do, make, apply or portray in a way that withstands the test of time, its connection with science becomes more clear."

- Sven Carlson, Science News, 1987

This book will allow you to travel through time and space. To facilitate your journey, I've scoured the four corners of the earth in a quest for unusual people and their fascinating patterns. From Mozambique, to Asia, to many European countries, the contributors to "The Pattern Book" include world-famous cancer researchers, little-known artists, and eclectic computer programmers. Some of the patterns are ultramodern, while others are centuries old. Many of the patterns are drawn from the universe of mathematics. To start you on the journey, I'll first provide some relevant background material on computers, pattern, science, and art.

The line between science and art is a fuzzy one; the two are fraternal philosophies formalized by ancient Greeks like Pythagoreas and Ictinus. Today, computer graphics is one method through which scientists and artists reunite these philosophies by providing scientific ways to represent natural and artistic objects. In fact many of this book's patterns were generated on small computers using simple algorithms. Other (equally interesting) patterns were generated by human hands, and these patterns often illustrate ornaments of both modern and ancient civilization. Sometimes these patterns consist of symmetrical and repeating designs -- for example Moorish, Persian, and other motifs in tiled floors and cloths.

This book serves as an introductory catalog to some of the many facets of geometrical patterns, and you are urged to explore the ideas in greater depth than can be presented in this compendium. Perhaps I should attempt to define "pattern" before proceeding. You can find many definitions when consulting a dictionary, for example, "an artistic or mechanical design" or "a natural or chance configuration." The patterns in this book have such a great diversity that colleagues have debated whether the shapes should really be called "patterns" at all. However, I take the broad view, and include visually interesting shapes and themes from all areas of human, natural, and mathematical realms. Although the emphasis is on computer-generated patterns, the book is informal, and the intended audience spans several fields. This book might be used by students, graphic artists, illustrators, and craftspeople in search of visually intriguing designs, or anyone fascinated by optically provocative art. In addition, the book may be used by scientists, artists, laypeople, programmers and students. In the same spirit as Gardner's book "Mathematical Circus" or Pappas' book "The Joy of Mathematics", "The Pattern Book" combines old and new ideas -- with emphasis on the fun that the true pattern lover finds in doing, rather than in reading about the doing! The book is organized into three main parts: Representing Nature (for those patterns which describe or show real physical phenomena, e.g., visualizations of protein motion, sea lillies, etc.), Mathematics and Symmetry (for those patterns which describe or show mathematical behavior, e.g. fractals), and Human Art (for those patterns which are artistic works of humans and made without the aid of a computer, e.g. Moslem tiling patterns). I provide a comprehensive glossary to help ease readers into technical or unfamiliar waters.

When deciding how to arrange material within the three parts of "The Pattern Book", many divisions came to mind -- computer and non-computer generated forms, science and art, nature and mathematics. However, the line between all of these categories becomes indistinct or artificial, and I have therefore randomly arranged the patterns within each part of the book to retain the playful spirit of the book and to give the reader unexpected pleasures. Some patterns could easily be placed in either of the three main sections of the book.

The reader is forewarned that some of the presented material in this book's catalog of shapes involves sophisticated concepts (e.g. "The Reversible Greensberg-Hastings Cellular Automaton", by Drs. Tamayo and Hyman) while other patterns (e.g. "Satanic Flowers", by Dr. Harold J. McWhinnie) require little mathematical knowledge in order to appreciate or construct the shapes. Readers are free to pick and choose from the smorgasbord of patterns. Many of the pattern descriptions are brief and give the reader just a flavor of an application or method. Additional information is often in the referenced publications. In order to encourage reader involvement, computational hints and recipes for producing many of the computer-drawn figures are provided. For many readers, seeing pseudocode will clarify the concepts in a way which mere words cannot.

Currently, I know of no book which presents such a large range of patterns and instructions for generating the patterns. There are, however, numerous books available that publish patterns in specific categories. Most are inexpensive paperbacks published by Dover Publications, and many are reprints of nineteenth century books. I think you will enjoy these. Some are listed in the reference section.

Before concluding this preface, I should point out that today scientists and artists seem to have a growing fascination with symmetry and repetition in design. On the topic of art, there are the modern isometric designs of John Locke and the geometrical ornaments of Russian artist Chernikow (where simple forms create complex interweavings), and a variety of popular art deco designs. Also "controlled accident" has found its place in many areas of the modern arts (O'Brien, 1968). For example, Dadaist and Surrealist painters such as Miro, Masson, and Arp capitalized on the elements of chance, and the works they created provide challenges for the mind as well as the eye. In the area of science, researchers are intrigued by the way nature often expresses itself in terms of repeating symmetries -- and the cross section of plants, phase transitions, standing waves on metal plates, muscle striations, snow crystals, and dendritic ice are just a few examples. From the branching of rivers and blood vessels, to the highly convoluted surface of brains and bark, the physical world contains intricate patterns formed from simple shapes through the repeated application of dynamic procedures. Questions about the fundamental rules underlying the variety of nature have led to the search to identify, measure, and define these patterns in precise scientific terms.

One final observation on patterns in nature. Our physical world around us often seems chaotic, exhibiting a limitless and complex array of patterns. However, you should note that our world is also actually highly structured. From an evolutionary standpoint, biological themes, structures, and "solutions" are repeated when possible, and inanimate forms such as mountains and snowflakes are constrained by physical laws to a finite class of patterns. The apparently intricate fabric of nature and the universe is produced from a limited variety of threads which are, in turn, organized into a multitude of combinations. You'll see some of these threads throughout this book.

The World of Fractals and Chaos

Many of the patterns in this book come from the exciting mathematical fields of fractal geometry and chaos. This section is intended as a brief introduction to these fields.

These days computer-generated fractal patterns are everywhere. From

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squiggly designs on computer art posters, to illustrations in the most serious of physics journals, interest continues to grow among scientists and, rather surprisingly, artists and designers. The word "fractal" was coined in 1975 by IBM scientist Benoit Mandelbrot to describe a set of curves rarely seen before the advent of computers with their ability to perform massive numbers of calculations quickly. Fractals are bumpy objects which usually show a wealth of detail as they are continually magnified. Some of these shapes exist only in abstract geometric space, but others can be used to model complex natural shapes such as coastlines and mountains.

Chaos and fractal geometry go hand-in-hand. Both fields deal with intricately shaped objects, and chaotic processes often produce fractal patterns. To ancient humans, chaos represented the unknown, the spirit world -- menacing, nightmarish visions that reflected man's fear of the irrational and the need to give shape and form to his apprehensions. Today, chaos theory is a growing field which involves the study of a range of phenomena exhibiting a sensitive dependence on initial conditions. This means that some natural systems, such as the weather, are so sensitive to even small local fluctuations that we will never be able to accurately predict what they will do in the future. For certain mathematical systems, if you change a parameter ever-so-slightly, the results can be very different. Although chaos seems totally "random", it often obeys strict mathematical rules derived from equations that can be formulated and studied. One important research tool to aid in the study of chaos is computer graphics. From chaotic toys with randomly blinking lights to wisps and eddies of cigarette smoke, chaotic behavior is irregular and disorderly. Other examples include certain neurological and cardiac activity, the stock market, and some electrical networks of computers. Chaos theory has also often been applied to a wide range of visual art.

So extensive is the interest in fractals and chaos that keeping up with the literature on the subject is rapidly becoming a full-time task. In 1989 the world's scientific journals published about 1,200 articles with the words "chaos" or "fractal(s)" in the title.

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< Pickover: Further Reading >

"Some people can read a musical score and in their minds hear the music ... Others can see, in their mind's eye, great beauty and structure in certain mathematical functions ... Lesser folk, like me, need to hear music played and see numbers rendered to appreciate their structures."

- Peter B. Schroeder, scientific consultant, 1986

As you will see in many patterns from this book, mathematical formulas can sometimes be used to simulate natural forms. For example, computer graphics provides a way to represent biological objects. For an excellent book on techniques for simulating nature, see Rivlin (1986). Researchers have explored the use of rules based on the laws of nature, such as logarithmic spirals for sea shells (Kawaguchi, 1982) or tree branching patterns determined from the study of living specimens (Aono, 1984). Other papers describe the generation of plant leaf vein patterns (Kolata, 1987) and woodgrains (Yessios, 1979). Bloomenthal (1985) describes methods for simulating tree bark, leaves, and limbs. Other sophisticated approaches to botanical structure generation exist, for example, beautiful "particle systems" consisting of trajectories of particles influenced by the pull of gravity (Reeves, 1985). See also (Viennot et al., 1989; Prusinkiewicz et al., 1988). For references on symmetry in historical ornaments, see Audsley (1968) and Rozsa (1986). Audsley's book includes illustrations of ancient Egyptian patterns from the painted ceiling of various tombs, interlaced

Celtic designs typical of those used to illuminate manuscripts, and various Japanese ornaments. For a fascinating collection of Persian designs and motifs, see Dowlatshahi (1979). Symmetrical ornaments, such as many in The Pattern Book, have persisted from ancient to modern times. The different kinds of symmetry have been most fully explored in Arabic and Moorish design. The later Islamic artists were forbidden by religion to represent the human form, so they naturally turned to elaborate geometric themes. To explore the full range of symmetry in historic ornament, you may wish to study the work of Gombrich who discusses the psychology of decorative art and presents several additional examples of five-fold symmetry.

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< Pickover: Glossary extract >

This is an informal and brief reminder of the meanings of terms (for more detailed descriptions, see the relevant references in the bibliography).

[Ed: The glossary below is a subset of the full glossary available in the publication.]

Abacus
Instrument for performing calculations by sliding beads along rods or grooves.

Abscissa
The horizontal coordinate of a point in a plane rectangular coordinate system (the x-axis).

Acoustics
The study of sound.

Affine transformation
Loosely speaking, an affine transformation acts by shrinking, enlarging, shifting, rotating or skewing an original pattern, set of points, or object.

Algebraic operations
Operations of addition, subtraction, multiplication, division, extraction of roots, and raising to integral or fractional powers.

Amplitude
(of a wave) The absolute value of the maximum displacement from zero value during one period of an oscillation. The "height" of the wave.

Amino acid
Basic building block of proteins.

Analog-to-digital converter
Electronic device that transforms continuous signals into signals with discrete values.

Analytic function
An analytic function is differentiable throughout a neighborhood of each point. It can be shown that an analytic function has continuous derivatives of all orders and can be expanded as a Taylor series. Functions with a power series expansion are analytic.

Angstrom
A unit of measure corresponding to one ten-billionth of a meter.

Articulation
Movements of the vocal tract to produce speech sounds.

Attractor
Predictable attractors correspond to the behavior to which a system settles down or is "attracted" (for example, a point or a looping closed cycle). The structure of these attractors is simple and well understood. A strange attractor is represented by an unpredictable trajectory where a minute difference in starting positions of 2 initially adjacent points leads to totally uncorrelated positions later in time or in the mathematical iteration. The structure of these attractors is very complicated and often not well understood.

Autocorrelation
For the acoustic applications in this book, the autocorrelation function for data describes the general dependance of the values of the data at one time on the values at another time.

Autonomous
The behavior of an autonomous dynamical system is expressed by an equation which is independent of time. If a time-dependent term is added, this represents an "external influence" which drives the system away from this equilibrium, for example, by adding or subtracting energy. Systems with a time-dependent term are non-autonomous (an unsteady fluid flow is such a system).

Bifurcation
Any value of a parameter at which the number and/or stability of steady states and cycles changes is called a bifurcation point, and the system is said to undergo a bifurcation.

Bilateral symmetry

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The property of having two similar sides. Each side is a "mirror image" of the other.

Cellular automata
A class of simple mathematical systems that are becoming important as models for a variety of physical processes. Though the rules governing the creation of cellular automata are simple, the patterns they produce are complicated and sometimes seem almost random, like a turbulent fluid flow or the output of a cryptographic system. Cellular automata are characterized by the fact that they act on a discrete space or grid as opposed to a continuous medium.

Chaos
Irregular behavior displaying sensitive dependence on initial conditions. Chaos has been referred to by some physicists as the seemingly paradoxical combination of randomness and structure in certain nonperiodic solutions of dynamical systems. Chaotic behavior can sometimes be defined by a simple formula. Some researchers believe that chaos theory offers a mathematical framework for understanding much of the noise and turbulence that is seen in experimental science.

Chaotic trajectory
A chaotic trajectory exhibits three features. 1) The trajectory, or motion, stays within a bounded region -- it does not get larger and larger without limit. 2) The trajectory never settles into a periodic pattern. 3) The motion exhibits a sensitivity to initial conditions. See also Chaos.

Cilia
Minute hair-like projections.

Conservative dynamical systems
In mechanics, conservative dynamical systems, also known as Hamiltonian dynamical systems, are frictionless. These systems do not entail a continual decrease of energy. See also dissipative dynamical systems.

Converge
To draw near to. A variable is sometimes said to converge to its limit.

Cycle
The cycle describes predictable periodic motions, like circular orbits. In phase plane portraits, the behavior often appears as smooth closed curves.

Damp
To diminish progressively in amplitude of oscillation.

Dissipative dynamical systems
These are systems typical of the macroscopic engineering world in which some resisting source causes energy loss. In dissipative dynamical systems the volume of phase space occupied by an ensemble of starting points decreases with time. See also conservative dynamical systems.

Dynamical systems
Models containing the rules describing the way a given quantity undergoes a change through time or iteration steps. For example, the motion of planets about the sun can be modelled as a dynamical system in which the planets move according to Newton's laws. A discrete dynamical system can be represented mathematically as x sub <t + 1> = f (x sub t). A continuous dynamical system can be

expressed as dx / dt = f(x,t) .

Feedback
The return to the input of a part of the output of a system.

Fibonacci sequence
The sequence 1,1,2,3,5,8,13 ellipsis, (F sub n = F sub <n-2> + F sub <n-1>), which governs many patterns in the plant world. Each term is the sum of the last two.

Focus (of a conic section)
A conic section is a set of points for which the distances of each from a fixed point called the focus and from a fixed line called the directrix are in constant ratio.

Fourier analysis
The separation of a complex wave into its sinusoidal components.

Fractals
Objects (or sets of points, or curves, or patterns) which exhibit increasing detail (“bumpiness”) with increasing magnification. Many interesting fractals are self-similar. B. Mandelbrot informally defines fractals as “shapes that are equally complex in their details as in their overall form. That is, if a piece of a fractal is suitably magnified to become of the same size as the whole, it should look like the whole, either exactly, or perhaps only after slight limited deformation.”

Gasket
A piece of material from which sections have been removed. Mathematical gaskets, such as Sierpi&nt.ski gaskets, can be generated by removing sections of a region according to some rule. Usually the process of removal leaves pieces which are similar to the initial region, thus the gasket may be defined recursively.

Gaussian white noise
White noise which is subsequently altered so that it has a bell-shaped distribution of values. In this book, Gaussian noise is often approximated by summing random numbers.

Helix
A space curve lying on a cylinder (or sphere, or cone) which maintains a constant distance from a central line (i.e. a “spiral extended in space”).

Iteration
Repetition of an operation or set of operations. In mathematics, composing a function with itself, such as in f(f(x)), can represent an iteration. The computational process of determining x sub <i+1> given x sub i is called an iteration.

Julia set
Set of all points which do not converge to a fixed point or finite attracting orbit under repeated applications of the map. Most Julia sets are fractals, displaying an endless cascade of repeated detail. An alternate definition: repeated applications of a function f, determine a trajectory of successive locations x, f(x), f(f(x)), f(f(f(x))), ellipsis visited by a starting point x in the complex plane. Depending on the starting point, this results in two types of trajectories, those which go to infinity and those which remain bounded by a fixed radius. The Julia set of the function f is the boundary curve which separates these regions.

Limit

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In general, the ultimate value towards which a variable tends.

Logistic equation
The nonlinear equation x sub <n+1> = k x sub n (1 - x sub n) is called the logistic equation, and it has been used in ecology as a model for predicting population growth.

Mandelbrot set
For each complex number mu, let f sub mu (x) denote the polynomial x sup 2 + mu. The Mandelbrot set is defined as the set of values of mu, for which successive iterates of 0 under f sub mu do not converge to infinity. An alternate definition: the set of complex numbers mu, for which the Julia set of the iterated mapping z rarrow z sup 2 + mu separates disjoint regions of attraction. When mu lies outside this set, the corresponding Julia set is fragmented. The term "Mandelbrot Set" is originally associated with this quadratic formula, although the same construction gives rise to a (generalized) Mandelbrot Set for any iterated function with a complex parameter.

Markov process
A stochastic process in which the "future" is determined by the "present".

Manifold
Curve or surface. The classical attractors are manifolds (they' re smooth). Strange attractors are not manifolds (they' re rough and fractal).

Nonlinear equation
Equations where the output is not directly proportional to the input. Equations which describe the behavior of most real-world problems. The response of a nonlinear system can depend crucially upon initial conditions.

Perfect numbers
An integer which is the sum of all its divisors excluding itself. For example, 6 is a perfect number since 6=1+2+3.

Period
The time taken for one cycle of vibration of a wave.

Periodic
Recurring at equal intervals of time.

Plosive
A type of consonant sound made by sudden release of air impounded behind an occlusion of the vocal tract.

Poincare map
A Poincare map is established by cutting trajectories in a region of phase space with a surface one dimension less than the dimension of the phase space.

Quasiperiodicity
Informally defined as a phenomenon with multiple periodicity. One example is the astronomical position of a point on the surface of the earth, since it results from the rotation of the earth about its axis and the rotation of the earth around the sun.

Rational function
A function which can be expressed as the quotient of two polynomials.

Recursive
An object is said to be recursive if it partially consists of or is defined in terms of itself. A recursive operation invokes itself as an intermediate operation.

Steady state
Also called equilibrium point or fixed point. A set of values of the variables of a system for which the system does not change as time proceeds.

Tesselation
A division of a plane into polygons, regular or irregular.

Trajectory
A sequence of points in which each point produces its successor according to some mathematical function.

Transfinite number
An infinite cardinal or ordinal number. The smallest transfinite number is called "aleph-nought" (written as aleph sub 0) which counts the number of integers.

Transcendental functions
Functions which are not algebraic, for example, circular, exponential, and logarithmic functions.

Transformation
The operation of changing (as by rotation or mapping) one configuration or expression into another in accordance with a mathematical rule.

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Four-dimensional space flowers, spiral chemical waves, And much, much more....

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< Pickover: About the Editor >

Clifford A. Pickover received his Ph.D. from Yale University's Department of Molecular Biophysics and Biochemistry. He graduated first in his class from Franklin and Marshall College, after completing the four-year undergraduate program in three years. He is author of the popular books Keys to Infinity and Black Holes, A Traveler's Guide, both published by Wiley (1995). He is also author of Chaos in Wonderland: Visual Adventures in a Fractal World (1994), Mazes for the Mind: Computers and the Unexpected (1992), Computers and the Imagination (1991) and Computers, Pattern, Chaos, and Beauty (1990), all published by St. Martin's Press -- as well as the author of over 200 articles concerning topics in science, art, and mathematics. He is also coauthor, with Piers Anthony, of the science-fiction novel, Spider Legs.

Pickover is currently an associate editor for the scientific journals Computers and Graphics and Computers in Physics, and is an editorial board member for Theta Mathematics Journal, Speculations in Science and Technology, Idealistic Studies, Leonardo, and YLEM. He has been a guest editor for several scientific journals. Editor of Visions of the Future: Art, Technology, and Computing in the Next Century (St. Martin's Press, 1993), Future Health (St. Martin's Press, 1995), Fractal Horizons (St. Martin's Press, 1995), and Visualizing Biological Information (World Scientific, 1995), and coeditor of the books Spiral Symmetry (World Scientific, 1992) and Frontiers in Scientific Visualization (Wiley, 1994), Dr. Pickover's primary interest is in scientific visualization.

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LEONARDO DIGITAL REVIEWS
SEPTEMBER 1995

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< Conference Reviews: SIGGRAPH 95 >

August 1995
Los Angeles

Reviewed by Annick Bureaud
Paris France
Email: bureaud@altern.com

First Time

It was my first time in California and my first time at SIGGRAPH.

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Everything to discover. One thing I gained is a better understanding of why the Net, VR, etc. are such big topics in California. On my side trips, I found that people in LA are scared to be in their own biological clothes, i.e. living, walking or being outside without technological armor - be it a house, a Convention Center or a car. Mixed with the Hollywood culture, it creates a total fake world in a perfect illusion of a safe and fun reality. No wonder cyberspace generates such fuss, wonder and fear in California. But back to SIGGRAPH. Some veterans said that this year's conference was not all that striking. That was also my first opinion but, as a newcomer, I had a fresh point of view and I hope my comments will not be too naive.

The Art Show
The first discovery was that the SIGGRAPH computer community and the contemporary art community there share the same attitude toward art: art must look like art. Therefore you get the Art Gallery with its old fashioned look, quiet grey space with nicely framed pictures on the walls and spots diffusing a soft light. The most adventurous works here seemed to be paintings (paint put on a canvas) and collages in something which reminds me of artworks from before the second world war, just not as good. Behind this space, and well hidden, were 3 installations, 2 of them related to some mystic experience and one "Mind and Body Environment" by Jason Ditmars showing a huge transparent human head turned into a surveillance and military object. The sculpture makes targets out of its viewers and attempts to locate, analyze and react to the movements and sounds they make within the space. On the metaphor of "seeing is destroying" this work was an interesting counterpart of "Osiris", a simulated night-vision battle presented nearly as a game in the Interactive Communities.

Interactive Communities
I expected a great deal of the Interactive Communities and Interactive Entertainment sections. I was disappointed, at least for the main hall. Although the idea to put together art works, research demos and games was (and still is) truly interesting and challenging, the layout was too gimmicky (why artificial smoke!), packed and did not show that much respect for the works exhibited. The excellent "Frontiers of Utopia" by Jill Scott, showing in interactive films/installations, the combined stories of 8 women and technology at 4 different periods of the 20th Century. It explores the history and nature of idealism, technology and design but was not fully displayed (the leaden suitcases were ommitted) and was exhibited in a small, cramped corner. It is also hard to say anything about "The Tele-Garden: An InterActive Art Installation on the WWW" by Ken Goldberg which I viewed there for the first time because it was too ill-served by the exhibiting context.

Two installations stood out : "Better Living Through Technology" by the Computer Science House which is a student environment combining personal and professional lifestyles, everyday life and high tech equipment. It was, with much humor and inventiveness, the showcase of what a tech-future life in the 21st Century could be. The other one was "T-Vision" by Joachim Sauter and Gerd Grueneis from Art + Com in Berlin. With a real globe as an interface, the viewer visualizes a virtual Earth on the screen, going from outer space to very detailed part of cities (in this case Berlin) and any kind of data related to a geographic region. The virtual globe is modeled from high-resolution spatial data and textured with high-resolution satellite images. This powerful work gives the illusion of flight around the world and is intended to be networked.

But the most interesting parts of the Interactive Communities were

in 2 smaller rooms, quite apart from the main exhibit spaces, under the names of Lounge@Siggraph and Digital Atelier. One was the "ChainReaction" project by Bonnie Mitchell, an interactive collaborative Internet art experience where participants could manipulate images and reintroduce them in the process. In the way of a kind of pictorial "cadaver exquis" this work was addressing issues involved with image manipulation, copyright ("who" is the "author" of "what" in such a case?) and collaborative works world-wide (on the Net, here it seemed that world-wide was mostly North-America-wide). A second compelling piece was the "Anti-rom: The Antidote to Multimediocrity" presented by Andrew Cameron from a group of British artists. This simple-looking CD ROM was a refreshing, ironical and critical review of "the state-of-the-art" in multimedia and interactivity. All of the works displayed in those 2 spaces were not high-end technology pieces but more modest projects and often more interesting, like one unpretentious (I could never find out who created it!) interactive work where you follow a bat from one room to another, trying to find your way in some weird spaces

Conferences and Courses :
Another important part of SIGGRAPH is clearly the conferences and courses. From my experience, these were mostly "performances" by the lecturers but I obtained the proceedings and written material! A couple of snapshots from the panels: it was interesting to follow the "Museum without Walls, New Media for New Museums" panel where Doug McLeod stressed the fact that we know little and in the end use new technologies with old ideas. He focused part of his talk on the constraints of space and architecture in museums and the necessity of a "liquid architecture", with more flexibility both in the physical and digital spaces where the cartesian space is embedded in the software, orienting therefore the creation. McLeod also mentioned the gap between the museums and the electronic art community. It was somehow amazing to see all those museum people among the SIGGRAPH crowd and to listen to some marketing people behind me thinking out loud "that museums will start being a market". Help !

Other fruitful talks were given in the different panels I followed, among them in the "Interactive Multimedia: a new creative frontier or just a new commodity" one, where it was acknowledged that if programming has been the great winner of the past few years, it is time to think about content because it is content which makes the piece (whatever it may be: art, entertainment, etc.). This was also the common idea stressed in the special effects session where someone said that the computer images alone were not enough anymore to make a movie. But, if the computer community is aware of the necessity to have the collaboration of artists, they still think that "needing a programmer behind every artist" and the lack of cutting edge skills of artists are problems but they seemed blind to the fact that needing an artist behind every programmer is also a problem. In "Archeology of Media", part of the Artist/Designer Sketches section curated by Eduardo Kac, Machiko Kusahara brought a challenging issue to the whole discussion of originality and cultural diversity by explaining the way that Japanese deal with art and culture by defining originality as locating oneself in relation to other ideas.

Trade Show:
A real discovery to me was that the "Exhibition" at SIGGRAPH is more than just a trade show. It is there that the products and the trends are shown and there that you can get an idea of what the computer business is preparing and how it envisions and therefore shapes the future. VRML and 3D vision were what I saw most, but I must admit

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that I missed a lot of it because of the exhibition of photographs of Moholy-Nagy at the Getty. Moholy-Nagy advocated the use of technology to expand the boundaries of the arts and widen perception of the world. This exhibition of his photographs made during the 20's was a challenging experience during the rush of SIGGRAPH -- teaching us lessons from 70 years ago in our nowadays world, bringing art, content and aesthetic construction where they belong: at the heart of human perception. See you next year in New Orleans for SIGGRAPH 96 where a collaborative exhibition is planned with the Contemporary Art Center.

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< Exhibition Catalog Review: El Rastro >

El Rastro, Presencia Remota Insinuada
The Trace, Remote Insinuated Presence
Installation by Rafael Lozano-Hemmer,
in collaboration with Will Bauer

ARCO 95 International Art Fair
February 1995
Madrid,Spain,

Reviewed by Paul Hertz
Email: paul-hertz@nwu.edu

The Trace consisted of two identical interactive stations linked by an ISDN connection. Within the enclosure of the stations, overhead projection, positional lights, positional sound, and computer displays provided cues to participants holding a tracking device. On the overhead display, a floating disc corresponded to the position of the remote participant, while a floating ring corresponded to that of the local participant. Similarly, two beams of blue light from robot-controlled lamps intersected at the position of the local participant, while two beams of yellow light intersected at the position of the remote participant. Ten loudspeakers provided a cue to the position of the remote participant, while their sound grew louder as the relative positions of the two participants came closer together. Finally, a large vertically mounted monitor in each station provided a constantly updated stream of statistics on the positions of the two participants, with a diagram of their current positions.

When the two participants reached the same relative position in space--i.e., when they coincided in an act of "telembodyment"--the lights would all coincide, the disc and the ring, the one fit within the other, would play a spinning animation with a sound of machinery, and the two stations would be inundated with sound. This telembodyment was presented as a "technological metaphor" of the many ways in which human beings may be inside each other, physically and virtually. It was also possible, though perhaps contrary to the elaborately constructed outcome of the Trace, for participants to purposely avoid one another or to play cat and mouse.

It is impossible to know with any precision what the actual experience of this work was, judging purely from a catalog. There can be no doubt of its sophistication nor of its purposeful attempt to pare down the space and the stimuli it presented to essentials, hiding the technology and creating an environment with multiple points of reference, without overwhelming the participant. Telepresence and VR in general too often reduce participants to disembodied ghosts, virtual voyeurs. By incorporating the physical self within a virtual space, the Trace lends a kinetic and hence an emotional dimension to this medium. Furthermore, each participant interacts with another human being, however intangible. While events

planned by the artist may be triggered in the Trace, it also functions as a bi-directional medium through which participants create their own events. Evidently intended to function as an open symbol, with sufficient structures and cues that the author's intent could be read by those who cared to investigate it, as an installation the Trace understates its purposes enough to leave interpretation to the subsequent musings of each participant. In particular, such a work might hope to involve the senses before involving the mind, and so plant ideas about its meaning in immediate experience. All these virtues please the gods of design, touch the imagination, and suggest that the experience of this piece at the very least was a lot of fun. Yet the underlying technology and model of interaction of the Trace beg several questions, particularly in light of other art that incorporates the body. Since the conflict of technological wealth versus economy of means is probably familiar to anyone who has drooled over high tech only to reflect that the most modest of means are sufficient to create great art, let's leave that issue, and examine the model of interaction in the Trace. The constitution of the physical self within cultural and social space involves a constant process of negotiation and exchange with other members of one's society and culture, within the parameters of identity assimilated through the process of education and socialization. Through this process the human body is constructed as a symbolic presence with culturally determined codes of interpretation. In effect, my body becomes the embodiment of my identity, of my memory and the memory others have of me.

Additionally, the body of the other becomes for me a source of behavioral cues, but cues that are rarely unambiguous, for they too operate as signs within a cultural matrix. In particular, these cues negotiate the instrumental use of the body, the mutual accomplishment of tasks. We may nominally each possess our own body, but the space between us must be physically and semantically bridged at every step. Space acts as a medium where every sign of the body (including the fundamental act of physical presence) is mediated by the totality of signs within our culture. Like the physical space through which we move, this semantic totality never fully enters into our comprehension. For the most part, we have so thoroughly assimilated its codes that we don't even stop to consider their existence. Telepresence casts this same social/physical space into the virtual realm, and redirects both our instrumental acts and our messages to each other through electronic media. The question arises, can a shift in the medium bring about a shift in consciousness?

We hold it for a truism that every shift in viewpoint brings about a shift in insight. But to point to the human body, by whatever means, is only the first step in clarifying or dismantling its accrued symbolic functions, or in constructing new ones. Indeed, the creation of new symbols often necessitates the destruction of earlier ones. Traditional views of how communities construct their identity have focused on the instrumental and economic relations of their members--on what people do for each other and why. But this model fails to explain the ways in which communities develop a symbolic representation of their identity. The symbols that we use to identify ourselves may not even jibe with our actual relations. When symbolic representations are perceived to be manifestly false with respect to economic or instrumental relations, social identity enters into crisis. Within the realm of art production, the artist assumes the power of naming, ritual enactment, and symbolic transformation. Often this role arises precisely from a critical perception of society and estrangement from accepted representations of its integrity. Artists such as Helio Oiticica or Lygia Clark, active in Brazil during the 60s and 70s, engaged the body as an

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element in their art through wearable objects and ritual actions. As an example of extreme simplicity, their single collaborative work "Dialogue of the Hands" (1966), consisting of a series of actions of the artists' two hands linked together by an elastic Moebius band, would be hard to surpass. In their work the spectacle of estrangement becomes a source of identity. By acknowledging distance and dispossession they raise the hope of overcoming them and reconstructing our subjective identity--or at least they raise the specter of the other who can construct with us an intersubjectivity where we are cognizant of fragmentation and distance, a domain where they are no longer hidden. Oiticica and Clark's work contrasts with another stream of work that incorporated the body during the same period, the productions of the Groupe de Recherche Visuel, based in Paris. Artists such as Julio LeParc constructed installations exploring sensory stimuli of light and sound, often in a minimalist style, to which participants might respond. While there is an element of play in both streams of inquiry, their models of interaction are very different. Where Oiticica and Clark are concerned with how participants incorporate symbolic representations, LeParc's work (for example) ushers participants into a stimulus and response game. Both streams continue through the present, with the "behavioral" model of the Groupe de Recherche Visuel seeming to predominate in many technological artworks.

One could consider the ring and disk in the Trace as ritual vestments, but the model used to bring about their union seems inadequate to fully realize the "technological metaphor" of the ways human beings may be inside each other, as announced by the catalog. A ritual where the human body attains a symbolic presence differs from a stimulus and response game, such as the Trace offers. Even though a ritual may appear to be a game, its implications point beyond rules of behavior to symbolic transformations of perception. An economic, stimulus-and-response model is inadequate for analyzing the symbolic construction of identity in society, and it cannot adequately engage our complicity in a symbolic action either. Indeed, the model itself may function as a symbol, displacing other possibilities. Cause and effect, in linear progression, become the overarching paradigm of how things happen, dampening symbolic actions that point to other states of mind such as synchronicity, conflict, ambiguity, and paradox. The fact that the outcome of the game in the Trace is a machine-like animation only contributes to this muting of possibilities. Unless the intention is ironic, it is hard to derive sex, pregnancy, or satori from clockwork. Perhaps we accept or perhaps we reject the interpretation offered by the catalog's straight-faced prose--or perhaps we heave a sigh that artists are obliged to provide interpretations at all, lest the critics beat them to the punch. It hardly seems a flaw that a work may not fulfill the grand scheme its author seeks to reveal, when the work is playful and open to many avenues of exploration. When the work is realized in a technological medium for which codes of interpretation have yet to be established, any attempt to provide symbolic content is bound to be tentative. Perhaps all we can ask is that it be engaging and thoughtful, and bring technology to a human scale. Judged from afar, the Trace appears to succeed in doing just that.

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< Journal Review: InterCommunication >
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Reviewed by Curtis E.A. Karnow
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The Nippon Telegraph and Telephone Corporation (NTT) sponsors the InterCommunication Center (ICC), a cultural facility planned for physical completion next year. Not yet wholly embodied, the ICC is up and running through (among other things) the quarterly journal reviewed here. The folks at ICC seem to have the quasi-governmental backing they need to fund their interesting publishing, symposia schedule, and research work. It would be interesting to have an in-depth report on the work of NTT and ICC.

The ICC focuses on the arts, communications, information and sciences - just the menu "Leonardo" readers will most enjoy. I was sent a few issues of Intercommunication in Japanese, but my Japanese not being much good, I asked for an issue in English. I was sent their 1994 Annual compendium, the experimental first in English, which presumably pulls together some of the best from 1994. Past issues have concentrated on themes such as organisms as information systems, artificial life, "Tuning forks- Technologies of Sound and Music", body performance, interactive art, etc. The latest, Issue 13, is titled "Political Economy of the Internet."

The Annual is a wonderful issue. It begins with remarks from a symposium including Edmond Couchot and Paul Virilio among others, and moves on to articles on intelligent agents; hypermedia museums; landscapes and vehicles of the future (landscapes in Velo-City), virtual reality (but of course); George Coats and others on >>ars metaphysicia<< and so on. One issue included a CD-ROM database of artists. Items swirl over and around art and information/ electronic/ technology. The editors of the Annual decided to imitate the dance in their text layout. Perhaps they thought to invoke the U.S. publication 'Wired.' Too bad.

In the Annual, text is more or less legible depending on the color backgrounds. Perhaps they lightened the contrast for articles the editors don't like? Most pages are conveniently readable, although the editors from time to time succumb to the modern diseases of fontitis, colorclash and textmixis. It's hard to follow three different articles rushing at each other across the page. Being enticed by the cute metaphor//suggestion of mutating texts isn't an excuse. [At least they resisted that temptation for the individual theme issues.] I'd also hope for better binding next time- the pages fall out and the cover comes off. Perhaps time online destroys long term memory of the physical behavior of glue and paper?

Actually, the collapsing pages and cover are a tribute to the number of times I've picked this volume up and read it. I've cited a couple of its sources in a paper I'm preparing on law and intelligent agents, and I tend to browse the dense paperback over lunch. Architects, media-fiends, and photographers and disciples of Baudrillard will find it just as worthy. This Annual exhibits the value in the collection of items from many different disciplines; this would not be found in the individual theme volumes. But together here, the dazzling shifting topics strengthen and play off each other, sparking ideas in the mind of the reader that no author may have considered. It is this mix that emphasizes InterCommunication's focus on the relationship between culture and technology.
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< Reviewer's Bio: Kevin Murray >
Dr. Kevin Murray is a narrative psychologist working as a freelance writer and curator, engaged in developing a critical writing appropriate to multimedia. He is editor of "Judgment of Paris: Recent French Theory in a Local Context", a collection of essays about the influence of writers like Derrida and Foucault at a local level.

He has been writer in residence at the Crafts Council of Victoria, Adelaide Festival and RMIT Key Centre for Design Winter School. Lately, he has been investigating the fate of the material world left behind by the digital revolution. This was also the subject of his latest curated exhibition "Symmetry" which can be viewed from his web site at http://werple.mira.net.au/~kmurray/key.html

< END LEONARDO DIGITAL REVIEWS SEPTEMBER 1995 >

ANNOUNCEMENTS

< Technology Links - New Images Through New Tools >

Cambridge Art Association
25 Lowell St.
Cambridge, MA 02138 USA

Date: Oct. 5 - Nov. 17, 1995

This juried exhibition is open to all NEW ENGLAND area artists whose work utilize new technological mediums, i.e. computer generated or altered art, collage art utilizing computer produced elements, manipulated photographs, CAD/CAM sculpture, computer plotted lenticular glass art, holography, electrography and vacuum molded plastic sculpture. The exhibit will be held at the Cambridge Art Associations University Place Gallery in Harvard Square from October 5 - November 17, 1995.

MEDIA AND SIZE LIMITATIONS:
Limited to those mediums listed above. No size limit. Additional requirements/restrictions are as follows:

Relective Holography must be framed. Holograms must have own integral point source lighting. Own pedestal if applicable. CAD/CAM Computer sculpture may not have live lasers.

ENTRY AND FEE INFORMATION:
Work will be judged from actual artworks only! No slides or disks. Artists are responsible for delivery and pick up of artwork. Each entrant may submit up to two entries and must include a completed entry form (see below) and entry fee for each piece submitted. The non-refundable entry fees are as follows: CAA members: $7.50 for one artwork and $10.00 for two. Non-members: $10.00 for one artwork and $15.00 for two. Payable by cash or check.

Shipping: We prefer that all work be hand delivered. Shipments must be packed in accordance with United Parcel Service standards. CAA will assume no responsibility for artwork. Insurance for shipping is the responsibility of the artist while in transit to and from the gallery. All shipped artwork will be returned in its original packaging. Return postage and shipping fees must be prepaid. No COD in either direction.

ENTRY FORM:
To receive an entry form, send S.A.S.E. to the address listed above.
Cambridge Art Association

IMPORTANT DATES:
SEPT. 29-30: Work may be dropped off for juring on Friday evening September 29 from 4 - 7pm and Saturday September 30 from 9am - 5pm at 25 Lowell Street, Cambridge, MA. Work must be framed, wired, and ready to hang (ABSOLUTELY NO CLIP FRAMES). Sculpture must have a pedestal.
OCT. 2: Artists will be informed of jurors decision on Monday, October 2, late afternoon/early evening by telephone.
OCT. 3: Work not chosen for the exhibit must be picked up at 25 Lowell Street on Tuesday, October 3 from 11am - 7pm. There will be a $10.00 per day storage fee for each piece not picked up at this time.
OCT. 5: The show will be open to the public on Thursday October 5.
OCT. 13: The reception is on Friday, October 13 from 5:30 - 7:30.
NOV. 17: Last day of exhibit is Friday November 17.
NOV. 18: Exhibited works must be picked up at the University Place Gallery on Saturday, November 18 between the hours of 9:00am and 12:30pm. There will be a $20.00 per day storage charge for each piece not picked up at this time.

This exhibit is sponsored in part by Kinko's Copy, Bortman Design Group, Frame King, and Millennium Productions.
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JOBS/OPPORTUNITIES

< Faculty Vacancy - University of Illinois at Urbana-Champaign
School of Music Composition-Theory Division >

Don V Moses, Director
School of Music
University of Illinois
1114 West Nevada
Urbana, IL 61801
Telephone: 217-244-2676

Jim Beauchamp announces a faculty vacancy in music technology at the University of Illinois School of Music. The position has not been formally approved, but they expect approval by October 1. Proposed Starting Date: August 19, 1996

+ Rank and Salary: Assistant Professor, tenure-track, salary negotiable, based on qualifications.
+ Duties: Teach composition, theory, and courses involving music technology at the undergraduate and graduate levels.
+ Qualifications: Demonstrated excellence as a composer, preferably with expertise in interactive computer music applications or systems. Demonstrable skill in and dedication to undergraduate and graduate teaching. Doctorate or equivalent experience.
+ Application: Send letter of application with curriculum vitae, 3 scores, and 3 cassette tapes (if available), a published article (if applicable), and arrange to have 3-5 letters of recommendation sent to the address listed above.
+ Deadline: For full consideration, applications should be received by December 1, 1995. Interviews may take place before the deadline, but no final decisions will be made until after December 1, 1995.

The University of Illinois is an Affirmative Action, Equal

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Opportunity Employer. Applications from women and minority candidates are especially encouraged. Current faculty in the UIUC Composition-Theory Division are: James Beauchamp, William Brooks, Zack Browning, Judd Danby, Eric Lund, John Melby, Heinrich Taube, Sever Tipei, Heidi Von Gunden, Scott Wyatt, and Paul Zonn.

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< San Francisco State University Art Department, Conceptual Design/Information Arts (Sabbatical Leave Replacement) >

Mail materials to:
CD/IA Sabbatical Positon, Art Department
San Francisco State University
SF, CA 94132
Tel: (415) 338-2176
URL: http://userwww.sfsu.edu/~swalters

Steve Wilson announces a vacancy to fill a sabbatical leave at San Francisco State University for the Spring and Fall semesters 1996.

Rank: Assistant/Associate Professor (negotiable)
(** Fall continuation is contingent on state funding although present indications suggest likely refunding.)

The Conceptual Design/Information arts area offers studio courses that integrate theoretical studies on topics of culture, new technologies and art as research. Possible examples of courses to be taught include: Conceptual Strategies, Robotics & Electronics, Interactive Media & Conceptual Art, Biological Systems, Explorations in Word in Image. Practice and Theory in Emerging Technologies, Computer Programming and Narrative, Telecommunications based Art. In addition, particular courses can be adapted to candidate's expertise.

Responsibilites also include running the area, participate in departmental committees, undergraduate/graduate advising, assist in area development and fund raising. The candidate is expected to have both practical and theoretical knowledge in the field of emerging technologies, cultural theory and contemporary art.

*MFA or Phd in relevant area
*Knowledge of digital technologies and relevant art theory
*Experience teaching courses in art & new technologies
*Knowledge of digital technologies and relevant art theory
*Experience teaching courses in art & new technologies
*Exhibition record of recent artworks exploring art/technology/culture (** Note the area is searching for candidates whose knowledge and interest go beyond use of new technology merely as presentation format).

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< CCRMA Faculty Position >

CCRMA Search Committee
Attn: Annie Sultan
Department of Music
Stanford University
Stanford, CA 94305-3076

The Center for Computer Research in Music and Acoustics (CCRMA) at Stanford University hopes to fill a junior faculty (tenure-track) position in computer music*. Teaching responsibilities at the undergraduate and graduate levels will include seminars and lecture courses in the candidate's areas of expertise. Stanford University is an affirmative-action employer and actively encourages women and minority candidates to apply.

Candidates should send a letter of interest containing a brief description of relevant experience, a current curriculum vitae, and names and addresses (physical, e-mail, and FAX, if possible) of three referees. The preferred date for receipt of the above materials is on or before November 1, 1995. Please do not send any supplementary materials at this time.

*Computer music is a multidisciplinary field drawing on more traditional fields such as Music, Engineering, Psychology, Computer Science, Physics, and Applied Mathematics. Qualified candidates may have doctoral degrees in any of these or related areas. An overview of CCRMA research and teaching programs is available online via World Wide Web at http://ccrma-www.stanford.edu/

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LEA WORLD WIDE WEB AND FTP ACCESS

The LEA Word Wide Web site contains the LEA archives, including all back issues, and the Leonardo Electronic Gallery. The Profiles and Feature Articles have been extracted from the back issues, and reside in their own sections of the site. It is accessible using the following URL:

http://www-mitpress.mit.edu/LEA/home.html

Back issues, submission guidelines and LEA Gallery files are available via ftp anonymous, using the following method:

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ftp mitpress.mit.edu
login: anonymous
password: your_email_address
cd pub/Leonardo/Leonardo-Elec-Almanac
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