

# PROCEEDINGS

## 9th symposium on small computers in the arts

NOVEMBER 2-5, 1989  
PHILADELPHIA, PENNSYLVANIA

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**Proceedings  
of the  
Ninth  
Symposium on  
Small Computers  
in the Arts**

November 2-5, 1989

Philadelphia, Pennsylvania

# **The Ninth Symposium on Small Computers in the Arts**

## **Organizer:**

Small Computers in the Arts Network, Inc.

## **Sponsors:**

Small Computers in the Arts Network, Inc.

Computer Society of the IEEE

Philadelphia Area Computer Society

Delaware Valley Chapter of ACM/SIGGRAPH

## **Support:**

Pennsylvania Council on the Arts

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Dick Moberg

Julie Shay

## **Proceedings Committee:**

Mark Scott, Editor

Julie Shay, Coordinator

## **Published by:**

Small Computers in the Arts Network, Inc.

Box 1954, Philadelphia, PA 19105

**ISSN 0748-2043**

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**Cover Design:** Jennifer Wolf

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## The S.C.A.N. Story

The Small Computers in the Arts Network (SCAN) originated from a computer music concert held in 1978 in Philadelphia as part of a Personal Computer show and sponsored by the Philadelphia Area Computer Society. The concert was so successful that its organizers have repeated the event every year. It is now the Annual Philadelphia Computer Music Concert. We realized at that first concert that the audience was not there because of the high quality music (it wasn't), but because of the novelty of the techniques involved in producing the sounds. Since some people didn't quite understand what they were listening to, during the second year of the concert, lectures on computer music were added for those interested in the technology involved. Another problem experienced at that first concert was, what does the audience look at during the performance? Normally the audience follows the movements of the musician or singer on stage...but here was a box sitting on a front table with, at best, a few blinking lights. So, for the next year's meeting, we added talks on computer-generated graphics and video and, since then, have incorporated them into the evening concert.

Interest continued to grow and, in 1981, the organizers decided to hold their own three-day event called the Symposium on Small Computers in the Arts which consisted of lectures, demonstrations, exhibits, and workshops. The subject matter was expanded to include all the arts and included some talks on dance and sculpture. The event was co-sponsored by the Institute of Electrical and Electronic Engineers (IEEE) Computer Society which published the Proceedings of the event. To keep in touch with interested persons the organizers formed an informal non-profit, group, the Personal Computer Arts Group and published a small, irregular newsletter. As interest grew further, it became clear that the group could better serve its purpose by incorporating as a non-profit, educational organization. This led to the formation of the Small Computers in the Arts Network, Inc., or SCAN, in August of 1985 and the obtaining of its tax-exempt status in 1987.

Today SCAN is an organization which provides information for those interested in using computers and related technology in the arts. This includes music composition, music synthesis, music performance, graphics design, animation, video, textile and fashion design, sculpture, dance, writing, and other aspects of the arts. SCAN performs its services partly by means of a resource guide to the field, entitled Small Computers in the Arts News. Current subscribers are located across the country, in Canada, and in several European countries. In addition, the annual Symposium on Small Computers in the Arts is organized by SCAN and provides a forum for those working in the field to present new works, developments, and techniques. Courses and workshops are offered at both beginning and advanced levels. Demonstrations, film and video shows, a computer art gallery, and the computer music concert are also part of the Symposium.

SCAN has operated for the past nine years as a volunteer organization with a minimal budget. We have a mailing list and data base of over 2300 people across the country and internationally who work in the arts with new technology or are interested in learning about the field.

More information on SCAN can be obtained by writing to SCAN, Box 1954, Phila., PA 19105.



# Introduction

This is a year of consolidation, if the following papers reflect the representative experiences of those out art-making on small computers.

I remember when our work was technically complex beyond belief. When we showed it to 'regular' people we would need to use a disclaimer, like: "But it was done on a computer." or "But the machine cost less than \$5000." or "But we could only use four colors to make the images.", etc. We all remember this prehistoric time period, which only ended two years ago!

The world is realizing the usefulness of our irstwhile toys and inventions. When the world employs them, though, they don't make a loud statement, or stick out from the crowd, the way they did way back then. They are invisible now.

What the world wants out of these electronic do-dads is to get the job done cheaper, faster, more flexibly than what could be achieved by conventional methods. Whether we are using a paint system, fitting type for an advertisement, writing code to move objects around on a screen, digitally sampling a TV show or mixing in a drum track, we are now equipt with equal or better tools than the guy without a system.

Our gadgets are getting the job done, it was only a matter of time. Being in control of one aspect or another of this electronic meta-media makes **us** valuable as well. Many of us have been able to cut our own way in the world on the strength of our familiarity and/or facility with these tool-creating tools.

New centers of socio-economic development are forming. A school that has state-of-the-art equipment can attract more electronic media students, and can potentially produce more competitive graduates, which encourages on-going relationships with local corporations, who may even contribute financially to the institution, creating self-perpetuating spirals of higher technology.

We as graphic artists, musicians, sculptors, animators and programmers are both creators and chroniclers of society's latest panacea. Do we have a model of what it is that's being built? Are we pushing or being pushed? Or do we merely provide commentary for this new dominant infra-structure as it leaps from its digital cradle?

What kind of a future would you project for the person who hopes never to use or work with an electronic system? On the other hand, where do **you** personally want to get to through the creative use of these systems? And in what direction would we ideally like to wag the dog, given the opportunity?

Start thinking up some answers, but don't stop asking more new questions.

Mark W. Scott, 10/89

# **Proceedings of the Ninth Symposium on Small Computers in the Arts**

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## Implementing a MIDI Laboratory and Curriculum in Electronic Music at Brookdale Community College

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Lincroft, New Jersey

### ABSTRACT

Computer technology usage in the arts is proliferating rapidly. It is increasingly becoming commonplace and, in certain commercial applications, expected that artists be able to express themselves in this domain. The useful and artistically attractive options that the technology represented, lead to the founding of the computer music facility and accompanying curriculum at Brookdale Community College.

The use of computers in the arts is proliferating at a pace few thought possible or probable. We see technological breakthroughs occurring on an almost daily basis. This is the result of an evolutionary process, a process that, while representing only an instant in the overall context of historical time, has seen proliferation so rapid as to be almost unbelievable.

We witness the manifestation of this phenomenon in a wide assortment of endeavors. Certainly it is extremely noticeable in the media-related fields. Computer-generated graphics are pervasive, used in everything from soap suds ads to network logos. Electronic music scores currently dominate the commercial music field in advertisements, regular programming on commercial television and Top 40 music. Non-commercial artists of great competence are embracing these mediums as well.

The proliferation has had far-reaching effects. Educators in all but the most deeply traditionalist colleges offer courses in, and keep their curricula abreast of, new technology. But the cost of implementing a high-technology program can be prohibitive. Educators also have to temper their classroom time against the amount of time spent researching new equipment and theoretical

breakthroughs, and the actual time spent learning the mechanics of the equipment and incorporating it into an existing program. Professionals in the field must also spend considerable time learning about and keeping abreast of new equipment which offers technological superiority. It has, in fact, become one of the "nightmares" of the techno-industries that a rival will incorporate the latest dream machine before you even hear of it, leading to loss of clients. The brochures of the professional recording studios proudly tout one piece of "hot" equipment after another in their quest for attracting new clientele. The artist is now increasingly involved with the vast web of technological options that were once, with a few noticeable exceptions, strictly the domain of science and industry.

Much of the present situation I describe, as it relates to the music industry at large, is the result of implementation of the MIDI (musical instrument digital interface) standard. MIDI is a universal protocol language that allows computers to communicate with synthesizers and other devices similarly equipped. The entire procedure is accomplished by way of a binary communication link that exists between computers and electronic music peripherals (sound synthesizers, samplers, processing gear, recording equipment, etc.) that are equipped with the MIDI standard. When using MIDI and a computer to realize a musical work, the keyboard of an electronic musical instrument acts as the keypad does on a computer; to input data. The synthesizers communicate musical information (note names, volume of notes, durations, etc.) in binary number codes which are then stored by the computer. Because music is an art that exists through real-time, the data is sent in reference to a real-time base, which is usually the internal clock of the computer or some related peripheral.

Once the information is accepted by the computer it



can then be edited by manipulation of material (moving sections around, replacing one item with another, etc.), much in the same way as it is done with word processor software. The computer, at any time, can initiate a "performance" of the work. The data is sent via the computer, based on a real-time reference (the internal clock) back to the synthesizers. The synthesizers understand MIDI, which means they can re-interpret the binary number stream being sent by the computer and yield the appropriate notes, durations, volumes, etc., all in a correct real-time reference, thereby providing a "performance" of the piece which is metrically and rhythmically accurate. One needs only to visualize an old fashioned piano roll. The mechanism deciphers the code on the roll and results in a performance. In this case the computer is the mechanism and the roll -- but infinitely more sophisticated.

A specific type of software was developed by manufacturers (for all major brands of pc's) to accomplish the tasks described above. "Sequencing" software has made it possible for a musician to develop an entire score (notes, orchestration, dynamics etc.) over MIDI, onto the pc, and then save the entire work to disk. Other types of MIDI software provide other functions, such as converting a performance played on a MIDI keyboard into standard music notation.

Adoption of the MIDI standard has revolutionized the attitudes, activities and working processes of a majority of musicians working in a commercial venue. Within the past five or six years a substantial amount of musical activity has moved from a real time performance situation (musicians recording "live" in the recording studio) to the composer-technician-performer spending most of the preparation time for a recording project at a home computer and then realizing the better part, if not the entire work on electronic synthesizers. The amount of time spent actually recording a piece has in many cases been cut down considerably. Decisions such as mix levels, balance and sometimes orchestral sonorities are all worked out on the pc and saved to disk, prior to the actual recording of the work.

This is the current state of affairs in the commercial music industry. A good majority of music tracks for television programs (Miami Vice for instance), jingles and Top 40 songs are produced in exactly this way.

For composers whose music is suited to applications on electronic instruments (a good majority of commercial

composers and academic computer musicians), the incursion of technology is a positive and stimulating influence. A composer working with these systems has control of virtually every aspect of the piece through editorial decisions made on the pc.

The astounding technological breakthroughs that have occurred during the past decade have to be viewed in light of several very real factors, such as:

- (1) the tremendous commitment of time on the part of the musician necessary to master these techniques;
- (2) the expensive financial realities of assembling a professional electronic music studio;
- (3) the expectations of the commercial music industry at large that the composer/musician be well-versed with these skills.

The potential power of the new technology as a viable, fresh and dynamic way to create art, along with the three basic premises stated above, were the ideological justification for the founding of the Brookdale Community College Electronic Music Facility, and the accompanying course curriculum that was devised to support it. The initial idea for a facility and program came about as the result of my "conversion" to electronic music, about five years ago. As a composer with a traditional background, I initially approached the new technology with a good degree of trepidation and skepticism. After a number of firsthand experiences I was convinced that MIDI held a great potential for musicians and that the techniques involved in the production of MIDI-related music would soon dominate the commercial music field. MIDI would be of great benefit to those students at Brookdale Community College whose primary musical interests are in popular and commercial music.

I also realized from my own initial experiences that the vast amount of material that had to be learned (sequencing software, how to program sounds on synthesizers, how to synchronize computer music scores to video, etc.) would not easily be mastered by those musicians with little or no computer experience and little or no experience with electronic music systems. As a person teaching on the college level for many years, I approached the material with a fairly high degree of musical sophistication and still had to spend literally hundreds of hours familiarizing myself with computer techniques, the properties of different music

software and a general working knowledge of integrated MIDI systems. Many of the incoming students have a limited musical background and little or no computer experience. For them to tackle the material "head on," so to speak, without guidance, would be an extremely difficult and frustrating experience. Under the best of circumstances it requires a tremendous effort to master a discipline. In this case it is even more difficult. This is a relatively new discipline. The accumulated body of writings is inconsistent (in fact, in some cases, nonexistent) and the research material is sketchy at best and lacks specific organization. The material has not had the benefit of vigorous academic scrutiny, it is not yet a time-honored discipline.

Therefore the main thrust of my program was to organize the material in a way that it would be presentable from a pedagogic standpoint. I wanted to save the students a lot of the trial and error time I had devoted to mastering the basic skills, such as working with sequencing software. The software is a wonderful tool but requires vigorous demonstration with concrete musical examples so that students with lesser musical experience recognize its potential. It was necessary to distill the vast amount of material into an organized, graduated presentation so that students could assimilate it within the context of a college course of studies.

I felt the program should also stress strong traditional music theory and compositional skills. Students should come away from the program with strong compositional skills combined with the technical know-how and experience to bring these skills to fruition in an electronic music lab -- exactly what the commercial music industry is demanding at this moment. We want our students to be able to walk into production houses in New York, L.A., Nashville etc., be strong compositionally, be well-versed with their systems, and have the technical prowess and experience to learn and operate a good part of the technical gear. In a sense, we are training artist-technicians.

As a result we have a core curriculum that stresses commercial composition and electronic music techniques. Three sections of commercial composition are offered concurrently with three sections of electronic music. The first section of electronic music concentrates strictly on mastering a sequencing software package (Sequencer Plus Mark III) while covering some basic concepts of electronic music. The next two courses have students working with

fully-implemented, professional MIDI systems (see equipment list) on projects they could encounter in the industry. The three commercial composition courses include a concentration of writing assignments in varied types of commercial endeavors (songforms, jingles, writing for video, etc.). Harmony and arranging techniques are part of the core curriculum as well. As students gain proficiency in their compositional skills, they realize their original compositions in the electronic music lab, and gain many of the benefits that a "live" performance gives to a student composer of a completed work or a work in progress. The feedback and gratification exacted from this process is virtually instantaneous -- one can have a reasonable facsimile of a work in about the time it takes to play the individual parts at the keyboard. The benefits to the musical experience are obvious. The user can make accurate revisions and experiment with such things as the orchestration. If the piece is intended for live performance, the revision process will save valuable rehearsal time. There is no doubt in my mind, from the results I've observed, that the process of instantaneous feedback on original compositions as a result of working with MIDI systems motivates the learner and accelerates the learning curve.

The facility itself is the result of a very positive, progressive and forward-thinking administration at Brookdale Community College, and of an innovative grant program that the State of New Jersey implements and supports. The New Jersey Board of Higher Education runs a grant program titled "Computers in the Curricula". It is an extraordinary program that allows colleges to submit proposals for computers and computer related equipment that can be implemented into innovative curricula. When a proposal is funded, the institution then provides the necessary facilities and manpower to implement it. Over the past three years I (and my assistant, Barbara Baron) have applied for and been awarded three consecutive grants under this program.

Phase I enabled the integration of the computer and related technology into existing and newly developed music courses. Phase II provided for expansion and integration of computer-generated video graphics within the program, allowing for collaborative interactive projects between the students of three different departments: Music, Telecommunications, and Visual Arts. An entirely integrated program is now in place. Phase III allowed for an entire computer based music notation system to be added to the facility. The

dollar amount awarded from the three grants was in excess of \$185,000. Brookdale has contributed a like amount in appropriate facilities. The net result is a well-equipped, well-housed facility that is one of the most foremost of its type in the nation.

The grant proposals and equipment purchases were the result of hundreds of hours of careful research and planning. All equipment purchases had to be considered in terms of their cost-effectiveness, flexibility and ability to integrate with other pieces within each workstation.

A program of such dimensions in the arts is usually not within the grasp of an institution, especially within such a relatively short time period. In this respect the New Jersey Department of Higher Education's grant program is an invaluable resource -- the program and facility at Brookdale would not have been possible without adequate funding. Likewise the support and cooperation I have received from colleagues and the administration alike is equally invaluable.

The Electronic Music Facility is one of the pilot programs to be housed in the new \$12 million Advanced Technology Center, located on the Brookdale campus. The facility includes fifteen workstations -- six beginner, three intermediate, two advanced and four music notation systems. Equipment choices were made on the basis of which would best simulate and replicate a professional environment. Those chosen include: eleven IBM computers, six Macintosh computers, synthesizers and samplers from most of the major manufacturers including two Kurzweil 250 samplers, an entire line of professional mixing consoles and recording equipment and a vast array of MIDI software (see accompanying equipment list).

Our program is already beginning to produce the results intended. For instance as the result careful course offerings and selected computer software tutorials, students are gaining a working facility on the systems and software much more quickly than if they were working on their own. Brookdale students are obtaining valuable "hands on" experience at professional electronic music workstations. As a result of that experience, our graduates are finding jobs in the industry or becoming very satisfied, qualified hobbyists.

As a result of working with the systems in the lab, students are much more familiar with MIDI equipment

in general. This knowledge is very valuable when they purchase equipment for their home studios; it saves them from making many costly mistakes. Students are composing, synthesizing, orchestrating and realizing their own music in the lab and receiving instantaneous feedback on their work. Some of the music is quite good and has found its way into various professional projects. It is now possible in the lab to exact an engraver quality score of a work using the appropriate MIDI software.

The overall level of musicianship of our students has increased significantly. Students enrolled in the program realize through careful guidance that these high technology instruments are simply valuable tools -- a means to an end. They are only as valuable as the inherent musicianship brought to them. For instance, the sequencing software assumes a high level of musical sophistication on the part of the user. If the software is capable of inverting a melody diatonically at an axis of C#5, one must understand that concept musically before being able to use it or ask the computer to perform that function. When these situations arise, students enrolled in the program realize they are in need of a stronger theoretical foundation and seek it in our traditional harmony and theory courses.

In the spring of 1988 and 1989, Statewide Electronic Music Conferences were held at Brookdale Community College. All college music faculty from New Jersey were invited to attend the conference. College educators and professionals from four states attended. As a result, project information and technical procedures have been shared with colleges and colleagues throughout New Jersey and the northeastern part of the country.

In summarizing, I have to say that what started as a casual encounter with electronic music has become an obsession of the first rank. The commitment to keeping the program and facility running is almost all encompassing. It seems (for better or worse) that all my time and energies as an educator, composer and administrator are presently devoted to electronic music. For instance as an educator I'm continually learning new hardware and software. I must then decide if the piece is to be implemented into the program and then make all of the pedagogical decisions germane to its use.

As a composer, electronic music systems are more and more becoming the genre of choice because of the very



powerful advantages already cited. If I am working on a project or have the urge to write a piece requiring the intimacy and breadth of a Beethoven string quartet, I can still do so -- I do not in any way advocate the abandonment of the Western European or live performance tradition. I can, however, obtain a reasonable facsimile, at any stage of the work, using the above described sequencing techniques.

As an administrator I am involved in decisions concerning the physical logistics of the studio, deciding on and purchasing equipment and overseeing of the operation of the Brookdale Community College Electronic Music Facility in general. I am confident that, as time goes on, some of these duties will be delegated and some aspects of the operation will "run themselves" which will allow me to resume some of my more traditional activities. Be forewarned, however, if you are contemplating starting a program, you must be prepared to devote a great deal of time for the first few years if you want to see your efforts reach fruition.

At this stage I feel the results and recognition received as a result of these efforts have more than offset any necessary shift in priorities. Activities in electronic music will remain a permanent part of my lifetime musical activities. Dr. Thomas Rhea, a noted member of the faculty at Berklee College of Music and the leading national expert on the history of electronic music, best sums up my thoughts and sentiments in an evaluation he did of the Brookdale program and facility for the New Jersey Board of Higher Education:

In summary, the Electronic Music (and Commercial Music) offerings at Brookdale are testimony to the positive results that can occur when a few hard-working individuals receive enlightened, focused support from local administrators, and state officials of Higher Education. In my estimation, the excellence of Brookdale's program may become a standard against which other institutions of its kind will be measured. I also believe, with continued support, this program could become the envy of many four year institutions whose programs are chronologically more advanced.

## Brookdale Community College Electronic Music Facility - Equipment List

- 7 IBM Model 30 Computers
- 4 IBM Model 25 Computers
- 6 Macintosh SE Computers w/Radius 25 Accelerator cards
- 11 Voyetra OP4001 MIDI Interfaces
- 6 Opcode Studio Plus Two MIDI Interfaces
- 1 Opcode Time Machine
- 4 DaynaFile DOS to MAC/OS interpreters
- 1 Hewlett Packard Laser Printer
- 1 Apple Postscript Printer Model NTX
- 2 Kurzweil 250 Digital Samplers
- 1 Kurzweil RMX Module
- 2 Kurzweil PX 1000 Modules
- 1 Emax Digital Multi Sampler
- 4 Yamaha DX 27 Synthesizers
- 2 Yamaha DX 11 FM Synthesizers
- 6 Yamaha KM 602 keyboard mixers
- 1 Yamaha DX 7 Synthesizer
- 1 Ensoniq Mirage Sampler
- 2 Yamaha DX 100 Synthesizers
- 1 Oberheim Matrix 6 Synthesizer
- 1 Roland D 50 Synthesizer
- 3 Korg M 1 Music Workstations
- 2 Roland D 550 LA Modules
- 6 Roland D 110 LA Modules
- 1 Roland VP 70 Voice Processor
- 1 Yamaha TX 802 FM Module
- 3 Yamaha TX 81Z Modules
- 1 Oberheim X-pander Module
- 1 Oberheim Matrix 6R Module
- 1 Oberheim Matrix 1000 Module
- 6 Roland MT 32 LA Modules
- 4 Yamaha FB01 Modules
- 1 DigiSound 16 Digital to Analog Music workstation
- 1 TASCAM MS 16, 16 track deck
- 4 DBX Noise Reduction Units
- 4 JL Cooper MSB+ MIDI Bays
- 2 Roland GK 1 Guitar/MIDI pickups
- 2 Roland GM 70 Converters
- 2 Fender Squire Guitars
- 3 Fostex Model 80, 8 track decks
- 1 Fostex Model 20, 2 track deck
- 3 Fostex Model 450 Mixing Consoles
- 1 TAC Scorpion Mixing Console (30 in, 16 out)
- 1 Aries Mixing Console
- 1 Sony 5850 Video Tape Deck
- 1 Sony PVM 1910 Monitor
- 1 Fostex 4030 Synchronizer
- 1 Fostex 4035 Autolocator
- 2 Crown Microtech Amplifiers
- 4 Tannoy Speakers
- 1 Yamaha P2075 Amp w/speakers
- 1 Roland SBX 80 SMPTE/MIDI converter
- 1 TASCAM RS 208 Reverb Unit
- 1 Yamaha SPX 90 Effects Processor
- 1 PCM 70 digital reverb unit
- 2 Aphex Aural Exciters
- 1 Yamaha DEQ 7 digital equalization processor
- 2 Yamaha REV 5 digital effects processors
- 1 Valley People 440 Compressor
- 2 Valley People Limiters
- 1 Panasonic R-DAT tape deck
- 2 TASCAM cassette recorders model 122 MK II
- 20 Fostex T 20 Headsets
- 1 Yamaha RX 15 Rhythm Programmer
- 1 Telex Magnabyte Imaging System
- 1 Beseler Overhead Projector

1 Furman 280 point Patch Bay  
4 Tascam PB 32R Patch Bays

### Software

Sequencer Plus MK III  
Patchmaster Plus  
D 50 Sideman  
Roland Mesa  
Bacchus DX 7 Editor  
Mark of the Unicorn Performer  
Mark of the Unicorn Professional Composer  
Digidesign Sound Designer  
Digidesign Softsynth  
Digidesign Q-Sheet  
Finale Music Notation software  
Copy MAC II utility  
Ovaltune  
Jam Factory  
M by Intelligent Music

### **Brookdale Community College Electronic Music Facility - Student Workstations**

#### **A. IBM PC Model 30 System (Beginner)**

IBM Personal System 2 Model 30  
Voyetra OP 4001 Intelligent MIDI Interface  
Yamaha DX 11 FM Synthesizer  
Roland MT 32 Sound Module  
Yamaha KM 602 Keyboard Mixer  
Fostex T 20 Headphones  
Voyetra Sequencer Plus MK III Software

\* Number of Workstations in Operation - 6

#### **B. IBM PC Model 30 System (Intermediate)**

IBM Personal System 2 Model 30  
Voyetra OP 4001 Intelligent MIDI Interface  
Oberheim Matrix 6 Analog Synthesizer  
Emax Digital Sampler  
Roland D 110 Sound Module  
Korg M1 Music Workstation  
Yamaha DX 7 FM Digital Synthesizer  
Fostex Model 450 8 Track Mixing Console  
Fostex Model 80 8 Track Recorder  
Fostex Model 20 Half Track Recorder  
JL Cooper MSB+ MIDI Patch Bay  
Yamaha SPX 90 Digital Effects Processor  
Roland GM 70 Guitar to MIDI Converter  
Roland GK 1 MIDI Guitar Pickup  
TASCAM PB 32 R Patch Bay  
Fostex T 20 Headphones  
Voyetra Sequencer Plus MK III Software

\* Number of Workstations in Operation - 3

#### **C. IBM PC Model 30, Macintosh SE System (Advanced)**

IBM Personal System 2 Model 30  
Voyetra OP 4001 Intelligent MIDI Interface  
Macintosh SE

Opcode Studio Plus Two MIDI Interface  
Kurzweil 250 Digital Sampler  
Roland D 50 LA Synthesizer  
Roland D 550 Linear Synthesizer  
Kurzweil PX 1000  
Roland D 110 Sound Module  
Oberheim Xpander  
Yamaha TX 802 FM Tone Generator  
Yamaha DEQ 7 Digital Equalizer  
Yamaha REV 5 Digital Effects Processor  
Lexicon PCM 70 Digital Effects Processor  
TASCAM 122 MK II Cassette Deck  
TASCAM MS 16 16 Track Tape Recorder  
Panasonic SV-3500 R-Dat Recorder  
Sony 5850 Video Deck with Monitor  
Fostex 4030 and 4035 Synchronizers  
TAC Scorpion Mixing Console  
Roland SBX 80 MIDI to SMPTE Converter  
JL Cooper MSB+ MIDI Patch Bay  
Hewlett Packard Laser Jet Series II Printer  
Voyetra Sequencer Plus MK III Software for IBM  
Kurzweil QLS Software for Macintosh  
Digidesign Sound Designer for Macintosh  
Digidesign Soft Synth for Macintosh  
Mark of the Unicorn Performer for Macintosh

\* Number of Workstations in Operation - 2

#### **D. Macintosh SE System (Music Notation)**

Macintosh SE  
Opcode Studio Plus Two MIDI Interface  
DaynaFile MS-DOS to MAC Disk Interpreter  
Yamaha DX 11 FM Synthesizer  
Fostex T 20 Headphones  
Finale Music Notation Software

\* Number of Workstations in Operation - 4

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### *ABOUT THE AUTHOR*

*Joseph Accurso* studied music at Brooklyn College and Queens College and composition with Robert Starer and Hugo Weisgall. While receiving his Master's Degree at Queens College he taught there under the auspices of a teaching Fellowship. He received commissions from the New York Jazz Collective and was a recipient of an award from the Center for Media Arts, which was used for the production and recording of his film music. In August 1988, Mr. Accurso was the recipient of the Outstanding Faculty Award presented at Brookdale Community College. Mr. Accurso was also awarded three consecutive grants from the New Jersey Department of Higher Education to implement an electronic computer music facility at Brookdale. He is presently serving in the capacity of Project Director for this grant. Mr. Accurso also teaches at the City University of New York.

# Transferring MIDI Data in a Multi-Computer Environment

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## ABSTRACT

The number of musicians using personal computers has grown astronomically, due to the widespread acceptance of the Musical Instrument Digital Interface (MIDI) by the music industry. In addition, MIDI music software is now available for virtually every make of personal computer, catering to each user's particular budget and/or needs. Here, we discuss the various methods one can use to exchange MIDI data from one computer to another, primarily focusing on the IBM PC and Apple Macintosh.

## 1. INTRODUCTION

One of the most recent revisions of the MIDI specification is the inclusion of the Standard MIDI Files (SMF) format. Originally developed by David Oppenheim, this format allows MIDI files to be exchanged on any MIDI software program. The SMF format first surfaced on the Macintosh; however, it has since become a standard format for MIDI file exchange for all makes of personal computers in general. The significance of this development cannot be overstated: In short, SMF provides music software with a compatibility similar to that which the original MIDI standard provided to the electronic instruments themselves. For example, a MIDI user can now take an arrangement that was sequenced on one manufacturer's sequencer software and use the exact file with a different manufacturer's notation software. In the past, users often had to duplicate their efforts for each software package they used. Now they can perform a task once, such as playing a piece of music, and then exploit the strong points of each manufacturer's respective software.

As college educators experimenting with and teaching MIDI systems, we realized that SMF had great

potential for our students. In our classes, we use numerous music software packages for both the IBM and Apple Macintosh computers. An overwhelming desire was to be able to import files from an IBM sequencer program (Sequencer Plus Mark III by Voyetra Technologies) to a Macintosh music notation program (Finale by Coda Music). Various methods that can be used to accomplish this are presented in the following sections.

## 2. TRANSFERRING MIDI DATA IN REAL-TIME

One method for accomplishing this task is to transfer the MIDI data in real-time by simply connecting the MIDI-out of the IBM sequencer to the Macintosh's MIDI-in port.

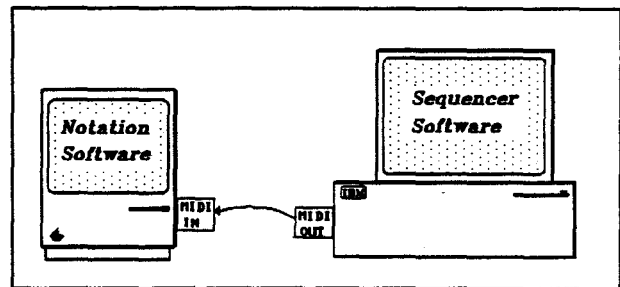


Figure 1 MIDI to MIDI Data Transfer.

This has often been the method of choice since it doesn't require additional hardware or software, however, this method has several drawbacks:

- (1) Setting up the notation program requires an extensive number of keystrokes, especially when transferring multi-track sequences.
- (2) The notation program requires that a rhythmic template track be created because meter changes are not recognized over MIDI.



- (3) Physical logistics requires that the two computers be in proximity of each other.
- (4) Requires that a MIDI interface be installed on both computers.

### 3. TRANSFERRING MIDI DATA USING STANDARD MIDI FILES

There are alternative methods that don't require transferring data in real-time over MIDI. Provided both programs support SMF, files from one program (saved in SMF) can be directly ported to the other (which reads SMF). With this procedure however, an inherent problem exists, which lies outside of the MIDI domain and within the computers' operating systems (OS).

A computer's OS provides the most basic of interfaces between the computer hardware and the user. It is the computer's OS that understands how to run a program, how to display information on the screen, how to receive input from a keyboard, and how to read and write files to and from a storage device (e.g., disk, tape, ROM, RAM). More important, it is the OS that dictates how files are physically organized on the storage device. By managing how the files are stored, the OS provides each program that it runs with a consistent way of finding where a file is located on a disk. The way it does this is somewhat analogous to how a library efficiently manages its books by using an index system.

Being able to find a book in a library does not automatically imply that one will understand the book's content. Only if the book is organized and written in a language common to both the writer and reader will the information be meaningful. The same is especially true of files stored on a disk -- although a program may be able to access a file on the disk, it may not be able to understand the information within the file. SMF solves this problem by providing a common understanding between music programs running on the same OS. It does this by specifying a standardized way of organizing any MIDI data *within a given file*. Unfortunately, the method that the Macintosh OS uses for *organizing* its files is different from the method in MS-DOS. Imagine two librarians who use different methods of storing their books! Because of this difference, SMF stored on an disk from MS-DOS cannot be directly retrieved by a Macintosh and vice versa.

### 3.1 Converting File Formats

In order to use the files created in an MS-DOS format, a user must first convert the files to Macintosh format. There are several methods to accomplish this.

One method is to use communication software as a "common carrier" between the two. This can be done in a number of ways. One way is to use serial communication by way of the serial interface on the IBM and the Macintosh. This is accomplished by directly connecting the serial ports of both computers to each other and using communications software to perform the transfer.

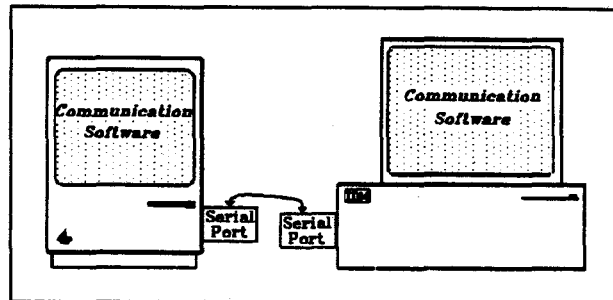


Figure 2 Transferring MIDI Files Using Serial Interfaces.

The advantage of this method is that no additional hardware, other than the cable used to connect the two computers, is needed. Although it does require that communications software be obtained for both computers, the software is relatively inexpensive and public domain versions exist as well. In addition, this method can also transfer the data at a much faster rate than a modem can provide (e.g. 19.2 kilobaud versus 2400 baud). However, when employing this method, it is critical that the proper cable be used to connect the two serial ports together. Although practically every type of computer comes equipped with a serial port, the actual connectors that are used will vary. For example, the Macintosh' serial port uses a DB-9 connector, whereas the Macintosh Plus uses a Mini DIN-8 connector. The connectors used by IBM PCs vary as well, although the most popular is the DB-25 connector, also known as a RS-232 connector. In addition, although the cable itself may be equipped with the proper connectors, the wiring within the cable will vary depending on whether the cable is designed to link one computer directly to another as described above, or if it designed to connect a computer to modem.

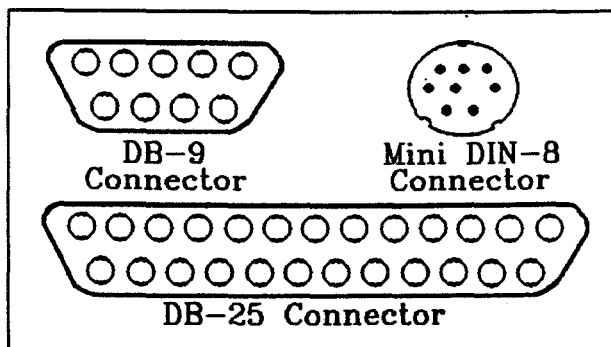


Figure 3 Example of Serial Port Connectors.

Another method is to connect a modem to each computer. The advantage of this method is that data can be sent over a distance by the telephone lines.

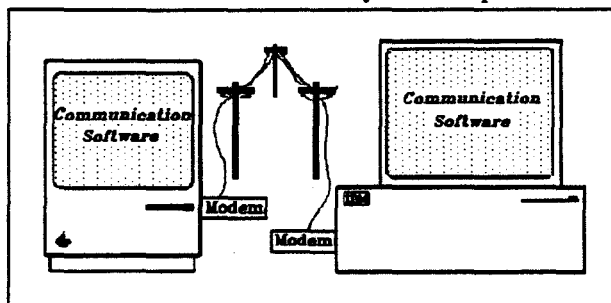


Figure 4 Transferring MIDI Files Using a Modem.

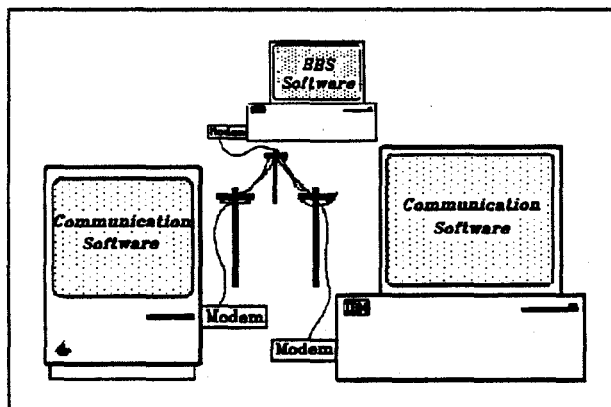


Figure 5 Transferring MIDI Files using a Bulletin Board Service.

In this case, one computer can directly share data with another computer, or it can share indirectly by sending a file to a computer bulletin board for the other to retrieve. The disadvantage of this method is that it requires two modems and two accompanying software packages (a modem and software package for each computer).

Still another method involves the use of Local Area Network (LAN) hardware and software. A LAN can link multiple computers together, allowing each computer to access data on the other computers. LANs present files on different computers as if they all resided on one computer. The disadvantages with LANs are that they typically are difficult to set up on computers using different operating systems and they are not cost-effective unless many files from different computers must be shared.

A final and more direct method is to simply exchange the information from one disk to another. There are devices commercially available that change IBM disk storage organization to a Macintosh format. An external drive that attaches to the Macintosh, such as the DaynaFile interpreter, is such a device.

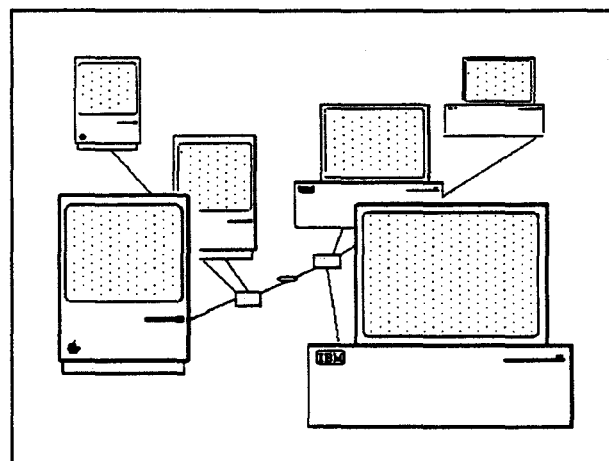


Figure 6 Transferring MIDI Files Using a Local Area Network.

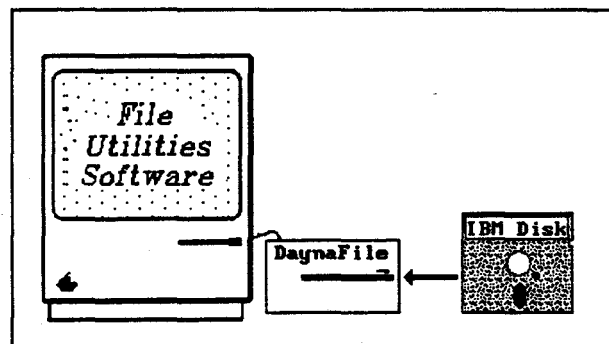


Figure 7 Transferring Midi Files Using a DaynaFile Device.

A simple utilities program, which is part of the Macintosh OS is the Apple File Exchange. This is used in conjunction with the DaynaFile to initiate the entire procedure. A user simply calls up the Apple File Exchange from the main screen of the Macintosh and it walks him through the correct keystroke

combination. Recent product announcements indicate that this capability will be included with some versions of the Macintosh. As a result, this method may prove to be the simplest and most cost-effective to use.

### 3.2 Converting File Extensions

Once the transfer is complete, one final (yet crucial) step must occur. To understand the nature of the problem, it is important to understand some basics of IBM and Macintosh file specifications.

Besides the obvious name the user assigns to a file, IBM files are further identified by means of an optional file extension. File extensions are used to group together similar files. The format used to assign a file extension to a file name is to place a dot after the file name and then assign a three-letter extension. Certain file extensions have become standardized by convention. For instance, .TXT is the standard file extension for text files, and .HLP is the standard extension for help files. Very often the software program will automatically assign a file extension to a file name depending on the format in which it is saved. For instance, the piece Fanfare (J. Accurso) was sequenced entirely on Sequencer Plus. By default, Sequencer Plus automatically assigns a .SNG (song file) extension to it, saving the piece as FANFARE.SNG, a format only Sequencer Plus recognizes. Programs within the IBM domain recognize .MID as the standard file extension for SMF. Therefore, if one uses the provision in Sequencer Plus to save to SMF the file is saved as FANFARE.MID which indicates that it is stored under a different specification -- in this case SMF.

Macintosh nomenclature and file organization are similar. Macintosh programs look for a "file type" in the way of file organization, which is the Macintosh equivalent of a file extension. For example, when the FANFARE.MID file from Sequencer Plus is first translated it defaults to the following specifications:

file type -	BINA
file creator -	mdos

Similar to how the IBM software expects the SMF to have the .MID extension, Macintosh software expects these files to have the following designations:

file type -	Midi
	(spelled exactly like this - uppercase M, lowercase i, etc.)
file creator -	Fina

Incidentally, the file creator is not a critical factor. Other names may be substituted without any adverse effects. These file-name changes can be accomplished with any disk utilities program, such as MAC Tools (which comes with Copy II MAC). Simply load the converted disk, bring up the Macintosh's info-edit window, type in the new name changes over the old ones, and save the changes. One may also create "stackware" using Hypercard to initiate this change. Hypercard now comes standard with the Macintosh.

Once the above procedure is completed, the file is ready to be used by any program on the Macintosh that understands SMF.

### 4. STANDARD MIDI FILES IN PRACTICE

Included at the end of this paper is a piece, Fanfare (J. Accurso) that demonstrates our results. The piece was originally played on a MIDI keyboard, one part at time, and each part was recorded on a separate track using Sequencer Plus MK III. The piece was then saved as an SMF and converted to the Macintosh disk format, using a DaynaFile device. After converting the file extensions, we ran the Finale music notation program, which effortlessly accepted the data and converted the entire score into standard notation in a matter of minutes. At this point, minor editing of the notation (beaming, enharmonic re-spelling, dynamics) had to be done. For instance, the eighth notes had to be beamed manually to correctly reflect their groupings in relation to the continually changing meter. Once our edits were completed, the program yielded a notated score of engraver quality. Please observe the attached results.

### 5. CONCLUSION

MIDI software is entering a new degree of flexibility and sophistication. Musicians cannot only avail themselves of the power of the computer, but they can also take advantage of some very powerful networking and communications features, which are indeed changing the art form by leaps and bounds.

### ACKNOWLEDGMENTS

Many thanks to our colleague Ken McGee for his technical guidance on issues concerning the Macintosh operating system. To Barbara Baron, our esteemed colleague, go special thanks for her suggestions and encouragement.

# FANFARE

Joseph Accurso

maestoso

♩ = 186

(all parts in C)

1

trumpet

1

horns

1

trombone

1

tuba (bass)

1

piccolo

1

flute

1

clar. 1

1

clar. 2

1

lympani

1

sn. dr.  
bs. dr.

## *ABOUT THE AUTHORS*

*Joseph Accurso* studied music at Brooklyn College and Queens College and composition with Robert Starer and Hugo Weisgall. While receiving his Master's Degree at Queens College he taught there under the auspices of a teaching Fellowship. He received commissions from the New York Jazz Collective and was a recipient of an award from the Center for Media Arts, which was used for the production and recording of his film music. In August 1988, Mr. Accurso was the recipient of the Outstanding Faculty Award presented at Brookdale Community College. Mr. Accurso was also awarded three consecutive grants from the New Jersey Department of Higher Education to implement an electronic computer music facility at Brookdale. He is presently serving in the capacity of Project Director for this grant. Mr. Accurso also teaches at the City University of New York.

*Ronald Blechman* is President and Senior Consultant for Sound Processes, Inc. specializing in software design, instruction, and consultation for the business, telecommunications, and music industries. In addition, Mr. Blechman teaches Electronic Music at Brookdale Community College. Mr. Blechman received a Bachelor of Science degree in Computer Science from Rutgers University. In 1982, under employee sponsorship from AT&T Bell Laboratories, he received his Masters degree in Computer Science from the University of Wisconsin, Madison. Mr. Blechman is also a performing musician who has actively been involved in synthesis and electronic music since 1982.



# COMPUTER-GENERATED COMPOSITION FOR DOCTOR NERVE

Nick Didkovsky

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This article describes the integration of computer-generated music composition into one composer/programmer's creative process. The computer program's specifications are also briefly discussed.

Doctor Nerve is a seven piece band based in New York City. The band has gained a reputation for playing hard-edged atonal music of an adventurous and experimental nature. I have been composing for Doctor Nerve for over six years, and have recently introduced computer generated composition to the project. In February of 1989 I began work on a program called DrNerve.hmsl. Coded in Hierarchical Music Specification Language on the Commodore Amiga, DrNerve.hmsl generates musical compositions orchestrated specifically for Doctor Nerve's seven instruments: soprano saxophone, trumpet, bass clarinet, vibraphone, electric guitar, electric bass, and drums. This article describes both the program's specifications and its role in the overall creative process.

## Motivation

My interest in producing DrNerve.hmsl was primarily to give myself a compositional shock. I suspected in advance that the resultant music would exhibit a kind of innocent freshness, unpredictability, and perhaps a curious mixture of clumsiness and precision, as the program would consist of only a limited framework of instructions, devoid almost entirely of world knowledge. Throughout the process of developing the program, I resolved to stay alert to programming errors whose (normally unacceptable) behavior could actually constitute a valid compositional direction. I suspected that the completed program would generate music that my own prejudices could have overlooked, and I was interested in seeing how much of the resultant music would work its way into my own personal aesthetic.

## The Development Environment

DrNerve.hmsl was coded in Hierarchical Music Specification Language (HMSL) on a Commodore Amiga personal computer. HMSL is an object-oriented programming language for music experimentation, developed by Phil Burk, Larry Polansky, and David Rosenboom at the Center for Contemporary Music at Mills College. DrNerve.hmsl is coded entirely in HMSL and the language JForth, of which HMSL is an extension.

Since HMSL is fully conversant with MIDI (a communications protocol which affords a computer the ability to connect to and play a synthesizer), I could audition the program's results immediately, without ever leaving the programming environment. The hardware used for playback included a MIDI interface and the Kawai K1 Synthesizer Module. The K1 is a low cost polyphonic synthesizer, with enough voices to simulate all seven musicians in Doctor Nerve.

The combination of HMSL, JForth, the Amiga, and the Kawai K1 constituted a very fast, interactive development environment. Over the course of a few weeks, the first working version of DrNerve.hmsl was completed. At that point, my attention was directed away from programming and focused on the actual realization of some compositions.

## The Composition Development Process

The complete realization of a composition can be factored into four stages.

### Stage One

DrNerve.hmsl is loaded and compiled into the HMSL environment. Each run of the program takes about thirty seconds of computer time, producing a piece of music from 1 to 3 minutes in length. I typically run the program a number of times, until a piece strikes me favorably.

### Stage Two

If a particular resultant piece contains material worth developing, the entire piece is stored to floppy disk in a file format recognized by most Amiga music software products. This acronym for this file format is SMUS, or Simple MUsic Score. The choice for adopting the SMUS file format was motivated by the need to edit the rough score generated by DrNerve.hmsl, and to print the final score for live musicians to read.

### Stage Three

The SMUS file is loaded into Deluxe Music Construction Set (DMCS), a commercial software product which allows the composer to edit a musical score in conventional musical notation, much in the way a writer would use a word processor to edit and polish a written work. With DMCS, I can rearrange, edit, and develop the ideas originally generated by DrNerve.hmsl. This process of rearrangement can last anywhere from a few minutes to many days. (On one occasion, DrNerve.hmsl generated a piece which I felt required absolutely no rearrangement or editing whatsoever, and is currently in the band's repertoire.)

I follow no rules or constraints as to the amount of rearrangement I may bring to bear upon a score. However, I have never felt the need to introduce additional musical material to a score, and find myself concerned primarily with the simple acts of deleting excessive material, cutting and pasting musical passages, inserting repeats, and occasionally transposing portions of the score.

### Stage Four

Once I feel that a composition is completed, the entire score as well as its individual parts are printed to a dot matrix printer directly from DMCS. Although DMCS only prints in low resolution, I find that xeroxing these parts with an 80-90% reduction results in a clean, crisp, readable score. Finally, I make cassette tapes of the composition for each of Doctor Nerve's musicians. Since DrNerve.hmsl typically generates music which is almost completely insensitive to technical difficulty, these tapes speed the musicians' learning process tremendously.

### Program Overview

DrNerve.hmsl should not be confused with "expert system" software, nor is it a "rule-based" program. To the first distinction, the program functions primarily to generate novel musical material quickly and without prejudice. It does not solve problems posed by the user, nor is it concerned with generating solutions that fit the constraints of a changing environment. To the second distinction, the program does not consult a data base of rules, which might have been used to describe my stylistic preferences or to represent a summary of musical decisions I have made in the past.

DrNerve.hmsl proceeds much more directly, using serial techniques, transformation algorithms, and chance operations. As such, it can generate large quantities of music very quickly, as it works closely to the domain of pure mathematics. Due to its use of chance, it is highly unlikely that any two runs of the program will produce identical results. Running the program repeatedly invokes the image of a band improvising, always trying new ideas.

### Summary

DrNerve.hmsl has contributed a tremendous vocabulary to my compositional work. At times, it has bombarded me with almost too much information too quickly. I find that my principle engagement with the program is one of filtering, or eliminating excessive material from an idea to reveal its essential skeleton.

The compositional shock was delivered in full force. I was repeatedly presented with ideas that I felt should have been obvious to me, but which had never been realized. My attention will now turn toward digestion and assimilation.

### Doctor Nerve Discography

Out To Bomb Fresh Kings (LP, Punos Music, DRN1123)

Armed Observation (LP, Cuneiform, RUNE8)

Did Sprinting Die? (CD, Wayside Music Archive Series, WMAS2)

Three computer generated pieces appear on "Did

**Sprinting Die?". These particular pieces are performed by computer. The next Doctor Nerve CD will include a suite of three computer generated pieces performed by the band. This CD will also be on Cuneiform.**

**All recorded materials available from:  
Wayside Music, PO Box 6517, Wheaton, MD  
20906**

**Portions of the source code for DrNerve.hmsl is available via modem from:  
Dwight School Bulletin Board (212) 879-2625  
1200/2400 baud  
24 hour service**

**For more information on Doctor Nerve, contact the author at the address appearing at the beginning of this article.**

Computer Generated Piece No. 2 for Doctor Nerve (excerpt)  
 Copyright 1989 Didkovsky/Punos Music

Sax

Trumpet

Clarinet

Guitar

Vibes

Hihat  
Toms

Snare  
Kick

Bass

The musical score is arranged in a system of nine staves, each representing a different instrument. The staves are labeled on the left: Sax, Trumpet, Clarinet, Guitar, Vibes, Hihat/Toms, Snare/Kick, and Bass. The music is written in 4/4 time, indicated by the '4' in the time signature on the first staff. The key signature has one sharp (F#), indicated by the sharp sign on the first line of the first staff. The score is divided into three measures by vertical bar lines. The first measure contains music for all instruments. The second measure contains music for all instruments. The third measure contains music for all instruments. The score is numbered 1, 5, and 5 at the bottom, corresponding to the measures. The instruments are: Sax (Soprano), Trumpet (B♭), Clarinet (B♭), Guitar (Electric), Vibes (Vibraphone), Hihat/Toms (Drum), Snare/Kick (Drum), and Bass (Electric).



## THE COMPUTER AS AN ART TOOL AND ART FORM: ISSUES AND CONSIDERATIONS

by Nancy J. Freeman

*Abstract: As artists we find ourselves in an important and pivotal era in the development of the computer as an art tool, an art form, and as an art movement. In some ways, this is the end of an era, while in others, it is part of the continuum. In any case, computers and the artists who use them are multiplying, and the inevitable effect on the art world and the art movement will be profound. I write from the perspective of a painter, but most of these remarks also apply to the other arts.*

Art has always been about information, yet the Information Age has been relatively slow in coming to the art world. This is an important time in the art movement. The advent of computers as an art tool and art medium will have, is having, a profound effect on the world of art, and the resolution of the resulting issues is of great importance. As an art tool, computers are already in the third era; as an art movement, we are nearing the end of the first era. The coming period should be interesting as the art world and the computer (r)evolution converge/clash.

### THE COMPUTER AS AN ART TOOL

#### The First Era: Few Artists. Many Limitations

The first era in the development of the computer as an art tool was the pioneer era. The equipment was rare and expensive, limited in capability, and available only through major institutions. Only a few lucky and determined artists had access to these early graphic computers. These early pioneers often had to develop the tools and programs themselves. They had to be technically proficient as well as artistically inclined.

The major support of and impetus for early computer graphics development was from the military, research, and industrial sectors. The space program, military training simulators, engineering, industrial design, science and medical research all had special graphic needs. The obvious benefits of computers to these industries justified the enormous expense of research and development, and the long training time of those who were to use the equipment.

Although even the earliest machines were capable of producing images, the medium was one of limitations. Still, the early artists took advantage of this medium, even with its limitation, to produce a diverse and sometimes compelling array of art.

#### The Second Era: More Artists. Fewer Limitations

The second era was an era of expansion, and arrived with the appearance of the graphic workstation. The capabilities of computer systems were improving dramatically, and powerful programs were beginning to become available. Applications for the television, advertising, publishing and other industries spurred development, and justified the still considerable expense of capable graphic systems. In addition to research facilities and major universities, systems appeared in a few corporations and design firms. These systems, though still expensive, were not so limited, and not so difficult to use.

Although the applications for these expensive graphic systems had to repay the investment, some of the people who produced the commercial work were artists who were also interested in non-commercial applications, and used their access to the equipment to produce creative art as well. Occasionally, corporations would also

allow independent artists access to their equipment. Artists no longer necessarily had to be programmers, developers of the tools. There were many more artists producing creative works than during the first era, but the numbers were still rather small compared to other kinds of artists.

#### The Third Era: Many Artists, Few Limitations

The current, or third era, is one of diversification and access. Graphic computers are plentiful and sophisticated tools of great flexibility and range. Relative to the recent past, current equipment and programs are refined, powerful, and inexpensive. There is a great range of options available at every level of application. There are few limitations left, and these few are fast falling away.

The range and flexibility of creative options is especially impressive at the personal computer level -the level which the independent artist can afford. In many cases, personal systems can rival (or even surpass) the capabilities of major systems of just a few years ago.

This third era was ushered in by the appearance of personal computers that were not only finally capable of producing graphics acceptable to artists, but were also easy to use, and affordable even at the level of the individual artist. The MacIntosh was really the first of these. Although limited to black and white, it had a resolution fine enough so that individual pixels were no longer noticeable, and an impressive array of graphic options to manipulate images. The introduction of the Amiga computer, and then the Mac II and others brought color and an even greater array of options. These computers have interfaces that feel more like painting or drawing, and not very much like computing.

Artists now do not have to be able to program, do not even have to be "computer literate". They do not have to be affiliated with corporations or institutions or firms. Artists now can go down and buy a capable system just because they feel they need one in their work. Many more computer artists are coming from the art disciplines rather than the computer disciplines; they are artists first, computer people second. And there are many, many more

artists using computers now than ever before

As is typical of the computer development as a whole, the evolution of this tool has been very fast and intensive. Many of the pioneers and developers are still working in the field, as are most of the artists from the second era. In other words, all three generations of computer artists are concurrently active. The tools and systems that are currently being developed continue to expand the capabilities and applications of creative systems. These "high-end" systems show us the future of the personal systems.

#### THE COMPUTER AS AN ART FORM AND ART MOVEMENT

By this classification, I refer to the kind of artwork produced, and the critical acceptance of it by artists and by the established art world. In this respect we are, I believe, still in the first era, but just barely.

As an art movement, this is a short but critical era. Independent artists are beginning to enter the field in ever larger numbers, the tools are maturing, and the era of technical limitations is ending. The aesthetic explorations are just beginning in earnest.

This is the era when one can still tell that a work was produced with a computer, before the "simulation" is indistinguishable. The earlier works were transitional or primitive, produced despite the limitation of the infant medium. The resolution of the systems and output options that most independent artists now use are capable of sophisticated images, but are still noticeable as being produced by a computer. Now, the last vestiges of limitations are falling away. As far as the technology is concerned, this first era is already passing, has passed. At the high end, the resolution, color range, and even the output devices are of broadcast, magazine, or photographic quality. For the art world, however, the first era is not quite yet over.

This is also the first era in the acceptance of the computer as a valid art medium, and the transitional period into the information age. This is the era that the important issues are being raised and debated.

### Resistance, Unfamiliarity, and Misunderstanding

Artists and the art world have, by and large, been curiously restrained in embracing or even accepting this new technology as a valid medium for producing fine art. One would hear remarks like, "How can you produce art with a machine?" And, "There is no mature computer art yet." And, "The computer does all the work. Who needs artists?" There is still an issue of legitimacy for both computer art and computer artists.

The lack of acceptance by the art world is in part deserved: with some stunning exceptions, much of the early computer art was garish, amateur or sophomoric, "gee whiz, new toy"ish, or of technological interest more than aesthetic interest.

Most of the resistance, however, stems from a mixture of a lack of current understanding of the nature and abilities of the medium, conflicting expectations, and some implications for and fundamental conflicts with the status quo.

One of the most frequent remarks I hear from gallery owners, museum curators, and other artists is, "I didn't know you could do that with computers." Actually, this is understandable. Computer graphic capabilities are advancing so fast that even if one works in the field, it is difficult to keep up. Furthermore, computer artists are just beginning to reach a "critical mass", and are just beginning to push the limits and capabilities of the medium. Most people haven't seen very much contemporary computer work.

Many artists, art world people, and even some computer artists share one of the most fundamental misunderstandings of the nature of the computer medium; that is, a computer artist uses a machine to produce artwork, that it is a mechanical medium. This is only partly true. They use something far more powerful - an information processing system. The equipment is only one part of the system, the most visible part. The computer actually does manipulate the magnetic medium, but it is the software that controls the computer. The artist in turn directs the software. It is the software, of course, that makes this such a powerful medium.

Some computer artists say they "paint with light". It may seem like it

to them, but the actual medium being manipulated is one of magnetic pattern. The image on the monitor is in fact a translation of the "original", only one of many output options. There are layers of translation between the artist's direction and the magnetic original, and then more layers of translation to produce the final image in a form that humans can comprehend. This usually happens so fast that the artist is only aware of the change of the light image on the screen. Since their aesthetic decisions are on this level, and what they see is light, they think that light is their medium.

### Acceptance by Painters and Other Artists

Curiously, artists have, by and large, been slow to accept the computer r/evolution. Many established artists have in fact been actively hostile towards this powerful medium/tool.

How can a medium inspire hostility? One would think that any medium for positive creation and expression would be enthusiastically embraced, especially such a powerful one. But this one challenges many of the basic tenets of art as it has traditionally been practiced. Although most of the challenges are not without some precedent in the art world, they have never come in such an all-encompassing, comprehensive, and inescapable way.

One fundamental aspect of traditional art that computers most effectively challenge, and that traditional artists seem to have the most difficulty with, is the issue of craft. Throughout the history of art, the skill of the artist in manipulating his medium has been of great importance. Now we are faced with a medium that the artist cannot directly manipulate at all, that must be manipulated for him by electronic means. The computer has taken the craft of art away from the artist.

This results in the frequently encountered attitude that "the computer does all the work". There is the fear that "anyone can be an artist". We have all seen ad copy for graphic computer products that imply this (or come right out and say it). And it is true that non-artists can often do a considerably better job with a computer than without.

These attitudes give little credit to the artist. If the craft is gone from the production of artwork, what

remains for the artist to do? With a de-emphasis on technical proficiency, the emphasis moves to aesthetic choices. What remains is the aesthetic decision making process. An image is only as good as the concept behind it, and the level of understanding of the artist. No matter how capable the computer or the computer program, someone still has to pilot it, tell it what to do. The artist still needs an understanding of color and color theory, of composition, of structure. The artist still needs a concept, and an understanding of the medium.

Another stumbling block for painters also has to do with the de-material nature of the computer medium. They think they won't like it because of a lack of texture, a lack of tactile quality, and because they think they will feel "removed" from the process.

Finally, many artists are worried that working with a computer will be too difficult, too technical. They think they will have to learn all about computers, and that they are not "mechanically minded".

It is interesting to note that many of these issues and objections also applied to photography when it was first introduced. It is also important to note that these attitudes are generally more prevalent among older artists. Young people have little fear of the technology. They do not have as much vested interest in the status quo, and they also do not have the same preconceived notions of what is or is not art. More and more educational institutions are now installing computer labs, if they have not already, and the students are signing up in droves.

#### Acceptance by the Art World

The computer, by its very nature, brings up a number of issues that will have/are having a profound effect upon the art world. Many of the issues are not necessarily new with computers. Many issues already have precedents in the art movement. What is of note is that so many issues are involved with this ONE medium.

One of the issues is, just what is computer art? For example, last year at the SCAN conference, we attended presentations by sculptors, painters, printmakers, photographers, animators, video artists, composers, musicians, and educators. Dancers and performance

artists also use computers. These are/were all separate disciplines, with different issues and sensibilities. Yet, they now all use exactly the same medium, magnetic pattern. Many artists using traditional media were already blurring the distinctions between the various arts. The computer facilitates this, makes it possible in a new and profound way.

Another issue, especially in the plastic arts, is just where the "art" resides. Does it reside in the output, in the storage medium, in the original magnetic pattern? Since the original medium has no substance, is the art the image divorced from any material manifestation of it? A single image can easily be translated into several different sizes, formats, media. Since a computer image is actually created in a de-material medium, and any visible manifestation of it is a translation into another medium, any computer produced artifact is after the fact.

A very important issue to the art world is the artifact issue. With a few mostly contemporary exceptions, the history of art is a history of the production and existence of an art object, an artifact. The established artworld industry deals in art objects. This is what artists produce, what galleries sell, what collectors buy, what museums display, and what critics and historians write about. Without art objects to sell, most artists would not be able to afford to continue to be artists, and the entire structure of the art world industry would collapse.

The things that traditionally have made art a collectible commodity is its exclusiveness, and the skill of its execution. The use of computers is calling both of these issues into question. The de-material nature of the medium, coupled with the ease of repeatability of hardcopy, threatens the notion of exclusivity and rarity; while the fact that it is not the direct skill of the artist that manifests itself as hardcopy questions the notions of craft.

There are certain populist aspects to computer images. It is easy to pass work around on disk, even telecommunicate them through the phone lines. Anyone with a printer can theoretically print out any image they can put on a screen. An image can be as cheaply and exactly replicated on disk as a bootlegged program, or produced by

printer or photography in any volume. Unlike a photograph, there can easily be an infinite number of "negatives", out of the control of the original creator. This is not only a copywrite issue, but also questions the artworld notions of exclusivity. Curiously, at the same time this kind of dissemination is not populist. The recipient must have access to computer equipment, often a certain kind.

#### Critical Acceptance

Finally, there is the issue of critical acceptance. There seems to be a conflict in expectations as regards what computer art "should be".

One camp says that computer art must deal with the fact that it is being produced with a computer; otherwise it's not relevant or important. The images should be new, not the same old images done with a new medium. For example, last year at the SCAN conference, Ruth Leavitt said that computers "should be used in new ways", and the "work should be unique to computers". Salmia Halaby wrote in the Proceedings, "For ...painters to use the computer in place of traditional media there has to be something new that cannot be investigated in paint."

The other camp maintains that the use of the computer should be transparent, and complains that most computer art has been too "computer-ish". Pamela Taylor said in her contribution to the Proceedings, "Much computer art has more to say about computers than about art." One computer artist I know, upon hearing which computer I used, said, "You need better equipment, more resolution and color." "Why?", said I. He replied, "Why, for a more perfect simulation!"

This desire or expectation for a perfect simulation of paint (or photography or any other medium) both drives the further development of the medium and interferes with the acceptance of the medium in its own right.

#### CONCLUSION

Many of these issues will sort themselves out over the next few years, and many of these issues will be the continuing topics of lively debate in the arts communities. Increasingly, one sees the signs of acceptance: computer art categories in art competitions and image registries; graphic computer labs not only in major universities but in junior colleges and high schools; the occasional gallery showing computer artists; museums organizing more shows dealing with computer work. These are the natural and inevitable results of the maturing technology and the increasing numbers of artists using computers.

This era is a short but critical one -the transitional era between material based art and information based art. Although both of these important movements will coincide for many more years, there is no doubt which is in the ascendancy. By the time the art world realizes the importance of this era, it will be over.



# 3D SURFACE DIGITIZING

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## ABSTRACT

This paper provides a tutorial on the techniques of 3D surface digitizing. This is a process in which ranging devices are used to measure the surface contours of a three dimensional object, and capture the surface data base automatically by scanning the object from a distance. Some applications for the artist, designer, architect, sculptor and art teacher are suggested.

**KEYWORDS:** laser digitizing, 3D scanning, optical reconstruction, structured lighting, range finding, robot vision,

## I. INTRODUCTION.

### A. Historical background.

Some recent advances in the techniques of remote sensing have allowed remarkable improvements in remote measurement. It is now possible to measure the surface contours of a three dimensional object (assuming the surface is reasonably well behaved) and, by using image analysis techniques, capture the shape data in a remotely located computer.

The science of remote sensing and image analysis became important in the 1960's and was developed to a powerful tool by the NASA Jet Propulsion Laboratory and others. Now this tool provides essential insights into the universe and the modern world. United States satellite sensors examine infra-red emanations and know the Soviet wheat crop is in trouble weeks before the Ukrainian farmer on the ground is aware of anything amiss. Lost ships at sea with appropriate gear can locate their position on the surface accurately to within a few hundred feet. In 1984, US KH-11 satellite photographs were able to identify the Iranian hostages in the exercise yard on the grounds of the Iranian embassy.

### B. Natural remote sensing.

Ranging capabilities have existed in nature much longer than with man. We know the bat has used sonar ranging in a highly

sophisticated real-time distance measurement using sound wavefronts as the active component. Dolphins possess much more than this sonar ranging capability. The dolphin brain contains more neurons than the human brain and there is a strong possibility they are more intelligent than humans. They possess several communications systems, one of which is a series of fast clicks which they use as sonar to locate underwater obstructions. If a dolphin's sonar probe shows an obstruction ahead, he warns the others by emitting sound which reconstructs the acoustic wavefront of the rock shape in three dimensions in the water. The school "sees" the sound wavefront and knows the shape of the offending obstruction. Just as we now sign with species of ape and chimpanzee, someday it may be possible to converse via computer with these elegant creatures using active remote sensing techniques.

### C. Computer Art.

The computer possesses the capacity to control electronic scanning devices such as the laser, to locate and identify distant objects through a robot vision camera, and record the surface profile of the object in an internal database.

This becomes a powerful tool for art-making when combined with the computers ability to previsualize conceptual forms and designs and to modify these shapes after creation of the prototype model. This problem has plagued the designer, sculptor, architect and independent artist. The commercial art system of thumb nail sketches, comps etc. consumes time and materials. The architect requires months to prepare conceptual plans to illustrate his ideas to a client. The installation sculptor cannot show the piece as it will appear in a site installation, even after energy has been invested in a small scale real-life model of the piece.

This awkward evolution of concept to finished art is typically illustrated by the problem of the automobile designer. Months are required to create original drawings of the prototype. These are then placed in the hands of a highly paid

skilled model maker, who over many weeks creates the first physical model by hand. The process of revision then begins. The model is reviewed by all departments of the organization from top management on down. A revised concept is agreed upon and the new model must be designed, drawings made and a prototype created by the model maker. This process continues, creating physical scale model after model, each one slightly larger, smaller or a slightly different shape than the previous one. It is estimated that the auto industry creates about 200,000 car models per year in this manner.

## II. INTERCHANGING REALITY AND IMAGE.

### A. The Real to Virtual Transform.

Software methods have existed for years which allow the creation of a virtual model directly from an electronic conceptual design. Called Solid Modelling software, these tools allow design on the screen of 3D electronic objects. Techniques will be discussed here which allow the artist, once a physical model exists, to capture the surface data base of the object, move it to computer memory, and use commercial software to modify the design by scaling, shrinking, rotating and performing all the other spatial transformations and graphic manipulations commonly used by solid modelers for manipulating 3-Dimensional virtual object databases.

### B. The Virtual to Real Transform.

Sufficient computing power now resides in the '386 generation of microcomputer to manipulate large data structures which represent sophisticated 3D objects. Once the database exists in memory, either by range scanning an existing model or by creating it with design software, it may be modified, and the output file then may be routed to traditional CAD software such as Autocad, where the object data is translated into standard drafting mechanical drawings, or the data may be output to conversion software to modify the data file into a Numeric Control (NC) file of commands suitable to operate a 3-axis milling machine. The machine then begins cutting a new model from the modified database. Turn around time is reduced from months to minutes.

### C. 3D Reconstruction.

A still more elegant solution for the virtual/real transform is offered by a company called 3D Systems. Their expensive patented process is able to take the object data base in memory and feed it to an infra-red laser which paints the surface of a vat of infra-red sensitive polymer fluid. Wherever the laser scans

the fluid it instantly solidifies. The laser beam is guided by a computer controlled mirror and paints layer after layer of the object on the fluid surface. This slowly solidifies it from the liquid. An oven cure makes the shape permanent. Some objects made in this fashion appeared in the 1989 SIGGRAPH art show.

## III. THE RANGE SCANNING PROCESS.

### A. range finder types.

#### 1. Triangulation rangefinders.

##### a. Simple spot triangulation.

Figure 1 shows the arrangement. These were used on early robots at Stanford Research Institute in 1969. Modern cameras such as the canon AF 35mm use infrared as the light source and compute the range to the subject while setting the lens focus automatically.

A spot of light is reflected from the object surface and imaged by the detector, often a vidicon or CCD camera. The separation of light source and observer is known (b) and the distance to the object surface is computed by trigonometry. The larger b is the more accurate the measurement. No digital image need be involved and image analysis is not required. This technique is very slow since the spot must be tracked over the object surface in order to image the shape completely, and the computation redone for each new position. A large file of data is created.

b. Solid state detectors often use PIN diode arrays instead of CCD's since they are much faster than CCD devices by at least an order of magnitude.

#### 2. Range from Structured Lighting.

This is one of the more facile techniques, and the one which the author used. It will be illustrated in detail below. The illumination on the object is expanded from a spot to a line, grid or other structured light pattern. A computer controlled sensor interprets the pattern and computes the range to all points on the light pattern.

##### a. Light stripe pattern ranging. (fig. 2)

Here the scene is lit by a sheet of light, often from a laser with a cylindrical lens. The light is scanned across the scene producing a vertical stripe at each position. A rotatable mirror often is employed to move the beam. The camera views from a fixed measured angle with the light sheet. Accuracy increases with the separation of sensor and light source, however portions of the object remain

invisible to the sensor. The author placed the object on a computer controlled turntable operated from a robot vision controller, allowing the object to be rotated through carefully measured angular displacements. Thus it was not necessary to scan the beam. A helium neon laser was used emitting at 6328 Å.

The surface should be well behaved and lacking holes or self-shadowing protrusions. These obscure the pattern and cause discontinuities in the digitized lines.

#### b. Patterned illumination.

In this mode the surface is illuminated with some known regular pattern such as parallel stripes or a square grid, and features of this pattern are recognized by intelligence programmed into the computer controlled sensor. e.g. kinks in the vertical stripes may indicate the presence of a surface edge. The kinks are detected and joined together using edge following algorithms and then these object edges are joined to represent a 3 dimensional object. The machine now "knows" the object as a 3D surface instead of a pattern of grey dots. Figure three shows typical results from [16].

#### c. Color pattern.

One problem with patterns and multiple stripe methods is distinguishing one stripe from another on the surface. It is possible to color code the individual stripes in order to differentiate them with a frequency sensitive sensor.

#### d. Moiré projections. (fig. 4)

Moiré fringe interference is created wherever two regular patterns which are of different frequencies overlap each other, or cross at an angle. They will form patterns of spatial frequency reinforcement and cancellation. The effect may be used to do remote range scanning. A scene is illuminated through an equispaced optical grating. The identical grating is used in the camera to view the scene from an oblique angle. The phase of the camera grid must be shifted from that of the light source. Contour lines are generated as moiré interference patterns. These may be detected and used to compute the contoured surface shape.

Substitution of the second grid by the TV scan line pattern of the video viewing camera may be made. [Idesawa] The phase or pitch of the viewing pattern may be changed to regulate the thickness and position of the contours.

#### 3. Range from time of flight.

Time of flight rangefinders are among the most sensitive known. One was used to measure the distance from the earth to the moon with an accuracy less than one foot. They represent a new technology over triangulation types. No image analysis is involved. The measurements are made coaxially. No assumptions need be made about the surface behavior. This is the mode evolved by nature for the bat and dolphin.

#### a. Ultrasonic rangefinders.

Polaroid developed these devices for their range finder cameras, and they now sell the device as a kit, including a test board and range readout display. [Jarvis] describes the device. A 1 millisecond chirp of 56 pulses at four frequencies between 60 and 50 kHz are emitted. (multi frequencies are used to minimize cancellation). The wavefront bounces back from the object to a transducer detector, is amplified and the time between send and receipt measured. Distances to 35 ft are measured to within one inch. (most camera lenses do not focus much beyond 40-50 feet). The spatial sensitivity is low and flat surfaces on the target can deflect the signal energy away from the receiver. This device is very useful as an obstacle detector.

#### b. Laser range finders.

These devices are of two types. One measures wavefront phase shift of an intensity modulated coaxially returning beam. The other measures the time of flight of a coaxial beam reflected from the target. Since light travels at 1 foot/ns the circuitry must resolve 50 picoseconds for a range accuracy of 1/4 inch. These devices are expensive.

#### B. Other image analysis ranging techniques.

There are many visual cues which the human eye uses for depth cuing and it is possible to use most of these for range sensing computers. There exist ranging devices using many technologies and more are listed here without explanation for the sake of completeness:

1. range from occlusion cues.
2. range from texture gradient.
3. range from focusing.
4. range from stereo displacement.
5. range from camera motion.
6. range from Streak Camera range finders.

#### C. Image Pre-processing:

Prior to analysis of an image by computer, it is often necessary to pre-process the captured image to correct for

certain distortions and errors introduced by the process of sampling. Images are degraded by non-linearities in the cameras, lenses, and electronic circuitry. It is desirable to prepare the image and correct for these non-linearities in order to save excessive processing during the actual analysis phase.

### 1. Noise reduction.

In general there are two types of noise introduced during sampling. One is periodic in nature and the second is random.

#### a. Periodic Noise.

This noise typically comes from other electrical circuitry such as the 110 VAC power grid. This noise is sometimes visible upon magnification of the image. Its presence may be verified by doing a Fourier Transform of the 2D image. If the transform contains sharp high peaks, they represent periodic noise. If the noise source is unknown, periodic noise may be reduced by removing the noise components from the Fourier transform, and then applying the inverse transform to the result, thus obtaining a noise free image.

It may also be easier to do a 1D transform of the incoming analog video signal (assuming the noise is carried in). A noise source may be more visible in this linear signal with cleaner peaks than when dispersed around the image.

#### b. Random Noise.

Thermal noise is typical of random type noise. It is not spatially periodic. Where it corresponds to the brightest and darkest pixel it is called "salt and pepper" noise. A spatial 3x3 matrix may be sampled for typical values surrounding the spike. Then replace the spike with a more reasonable value such as one interpolated from the neighborhood.

Another technique is to apply a smoothing operation. Noise may be reduced by averaging  $k$  images over the time domain where there is no object motion in the image. If the pixel brightness at  $i,j$  of the  $k$ th image ( $k=1,2,\dots,n$ ) is given by  $b_k(i,j)$ , the time average of  $k$  images is

$$\text{avg}(i,j) = (1/n) \sum_{k=1}^n b_k(i,j)$$

This reduces noise without loss of detail. Other solutions such as low-pass filtering are not recommended due to attenuation of the hi's.

### 2. Geometric corrections.

All imaging systems produce distortion of the sampled image. A system's distortion may be estimated by imaging a tightly constructed grid and studying the image distortion.

Any image sampled with a photographic lens will contain all six lens aberrations to some degree. Modern lens design is a constant compromise among these interconnected physical phenomena. An example of barrel distortion is shown in fig. . This distortion is also often caused by the camera tube. Point positions may be corrected by interpolation, knowing the correct positions of points around it.

Another method is based on correcting the horizontal and vertical distortions separately. Barrel distortion is quadratic in nature. New corrected  $x$  and  $y$  positions are calculated where the correcting function  $c(x,y)$  is based on the quadratic correction:

$$\begin{aligned} x &= c(x',y') \\ y &= c(x',y') \end{aligned}$$

### 3. Gray level correction.

Input devices may be non-linear across the image field. This may be studied by illuminating a gray target with evenly distributed brightness. Vidicons are prone to this problem and such non-uniformity is called "shading". As CCD cameras become less expensive another more random non-uniformity will dominate which is determined by the sensitivity of each photoelement.

One correction method requires making up a matrix of coefficients to correct each pixel back to even background. Another technique involves saving the irregularly shaded image and subtracting it from the captured image.

This problem can get complex since the shading pattern may be a function of image brightness or other system parameters such as the iris setting. Separate correction functions may be needed for specific areas of the image.

### 4. Nodal Separation.

If a lens is not a thin lens, the optical center of the lens separates into (usually two) nodal points. For many photographic lenses the distance  $N$  between the optical centers is much smaller than the lens thickness. Moreover the effects of this separation on the image are proportional to  $(N/z)$  where  $z$  is the range to the target. This term approaches zero for points far from the camera. [Mansbach]

## 5. Raster Misalignment.

### a. Non-perpendicular.

If the pixel raster is not perpendicular to the outside coordinate system (see below), significant errors can occur in measured range data. This alignment should be checked.

### b. Rotation.

If the pixel raster is tilted relative to the object horizon, the object will appear to be rotated thru angle theta. This sometimes occurs in vidicons if the camera tube is incorrectly aligned during installation. If xperf and yperf are pixel coordinates in perfect alignment and (x,y) are the misaligned coordinates,

$$x = x_{\text{perf}} * \cos(\theta) - y_{\text{perf}} * \sin(\theta)$$

and

$$y = y_{\text{perf}} * \sin(\theta) + x_{\text{perf}} * \cos(\theta)$$

for small angles the first order correction is

$$x = x_{\text{perf}} - \theta * y_{\text{perf}} \quad (\theta \text{ in radians})$$

$$y = y_{\text{perf}} + \theta * x_{\text{perf}} \quad (\theta \text{ in radians})$$

### c. Raster translation.

There exists the possibility of the raster center not coinciding with the lens axis. If s and t are the respective horizontal and vertical pixel spacings (e.g. mm/pixel), and the pixel located on the optical centerline is offset from the center by (k,l) then

$$x = x_{\text{perf}} + k * s$$
$$y = y_{\text{perf}} + l * t$$

## 6. Misaligned light source and camera axis.

Even small misalignments between the camera axis and light plane give rise to significant errors. If beta is the angle of interest, and the primed system of coordinates are measured in the light plane world system, letting I be the x' coordinate of the front nodal point and J be the angular misalignment between x' and x in radians, (i.e. error in beta measured about y'), the true values are

$$x'_{\text{perf}} = x' + J * z' + I$$

$$z'_{\text{perf}} = z' - J * x'$$

## 7. pixel quantization.

Since points in the image plane may only lie on one pixel or the next, they are integer values only. [Mansbach] shows for objects exceeding several pixels in height and width, that quantization increases the scatter of the data but does not introduce appreciable systematic errors into the results.

### D. Method.

A structured light digitizing apparatus was operated by the author using the hardware shown in figure 2. It is in use and will be described in detail in this section.

#### 1. hardware setup.

A Helium-Neon laser operating at 6328 Ångstroms was used with a cylindrical lens to project a sheet of light onto the stage area of a rotating table operating from a robotized controller. An IBM AT (8MHz) is capable of passing instructions to the controller, turning the sampled object a precise increment at the appropriate times. A teach pendant may also be used if the operator so desires. A robot vision camera and frame buffer with 512 x 480 x 8 resolution is capable of recording 256 grey levels in the image. The camera watches the object surface as it is delineated by the projected light stripe from the laser. The camera image is displayed on a high resolution black and white display monitor.

#### 2. Procedure.

Precise alignment of the camera and laser system must be done prior to each data run. The need for accurate angle measurement between laser light plane and optical camera axis is discussed in the preprocessing section. When the operator has aligned the system the object to be digitized is placed on the rotating stage and the software to digitize and do the image analysis is run. The image of the object in first position is captured and analyzed. The image is first scanned to detect the x and y coordinates of each pixel in the laser line. The screen pixel coordinates are transferred to the world coordinate system and the distance to the object surface for each point on the line is triangulated and saved as (X,Y,Z) triples. (computation is discussed below). The object is now rotated to the second position and the entire process repeated.

Sometimes the scanned line contains an excess number of triples so that the surface polygon mesh would be overdetermined. The program offers options to group the coordinates and average the values before saving a smaller dataset.

Sometimes the surface contains concavities and sometimes the surface self-



shields itself as it is rotated. These conditions cause discontinuities in the laser line. The program offers the opportunity for the operator to manually override the discontinuities by tracing over the discontinuity and "drawing" the missing section with the mouse.

Software has been written to convert the datafile of coordinates into an Autocad data exchange file. The software can create a 3D polygon mesh model of the object surface. The object may be shaded and rendered using appropriate software.

### 3. Image Analysis.

#### a. Theory.

Figure 5 shows the geometry from which the conversion equations may be derived to convert the coordinates from image coordinates to world coordinates. The focal plane of the lens, denoted by  $f$ , is the distance between the lens optical center and the point behind the lens where the image is formed. It is necessary to calibrate the setup to determine the correspondence between world coordinates and the screen image coordinates in the horizontal direction. Once this relationship is established, a linear relationship exists between the horizontal pixel spacing on the image screen and the displacement of any point on the image from the vertical. This calibration is set by measuring angle  $\alpha$  with a calibration grid chart set up in object space. Figure 6 shows [6]:

$$D_i = b_i \cdot \tan(\theta_i)$$

This gives the distance between an arbitrary light stripe and the reference plane in terms of the column number (counting from image center). The constants are input prior to a measurement, and  $z$  coordinates are proportional to the column number.

#### b. Thresholding operation

The intensity of the reflected stripe is affected by ambient lighting and must be accounted for. A minimum value may be input to the program to represent ambient levels to be ignored. Alternatively a bandpass filter at the lasing frequency passed only the stripe information to the camera.

#### c. Edge detection algorithm.

A thresholding operation detected the center of the stripe which was sometimes several pixels in width. A  $2 \times 2$  neighborhood around the pixel was examined and the partial derivative computed (i.e. the gradient function). This partial indicates the beginning of the stripe and must continue beyond one pixel to be

distinguished from noise. The decline in gradient values indicates the end of the stripe. Values from the beginning and end condition are averaged.

### 4. Data treatment.

#### a. Size of data file.

As many as 200 data points may be gathered during the measurement of each vertical image stripe. Since the database would quickly become un-manageable, points may be grouped and averaged to whatever degree of accuracy required to adequately define the polygon mesh comprising the modelled surface. It should be noted it is important not to overdetermine the surface, causing inordinately long computation times and huge datafiles.

After the surface points have been taken, the data file is not in suitable form to be used to create the polygon mesh. It is necessary to do the graphics computation in integer form and so each value in the spatial coordinate file must be interpolated back to the nearest intersection vertex in three space so that the surface mesh will not appear ragged and irregular in shape. If such a surface is viewed, it is very difficult for the eye to compensate for hidden lines and make sense of the entire object. Commercial software was used to smooth the data file from Golden Software, Golden, Colorado. The processed dataset is then post processed through software which shapes it into an Autocad data exchange file.

### 5. Image display and modification.

At this point the image may be displayed using Autocad. Autoshade or other shading rendering software may be used to view and rotate the surface so the viewer may see it in the round. The artist may then begin to modify the design by shrinking, stretching or pulling points off the surface of the model to other positions in space. Commercial software exists to create a Numeric Control File of commands to instruct a milling machine to begin cutting the defined shape from material. A new generation of 3-axis micro milling machines is just emerging on the market. These may be controlled by a microcomputer and sit on a desk top. A new generation of art making tools is truly at our fingertips.

### V. ACKNOWLEDGEMENTS.

The author wishes to thank graduate student Saeid Motovalli, who wrote and debugged software and who contributed many ideas for the evolution of this concept to a working system.

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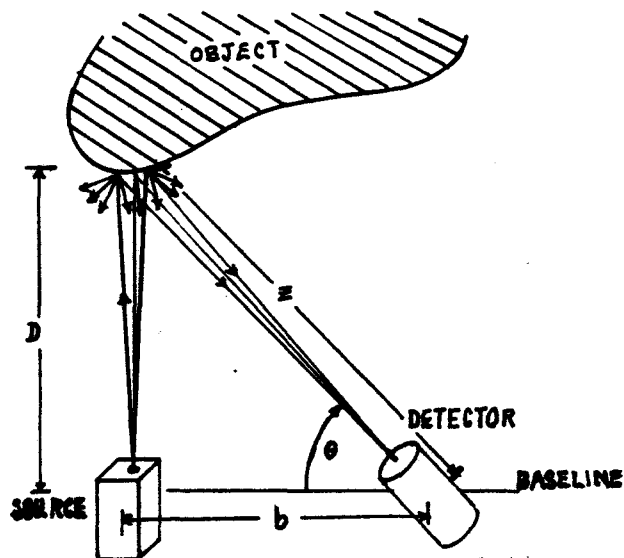


FIG. 1 - Range Sensing by Triangulation.

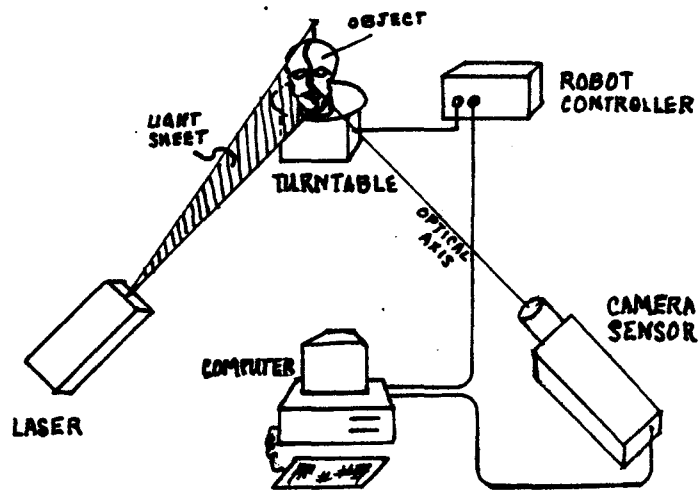


FIG. 2 - Light Stripe Pattern Ranging

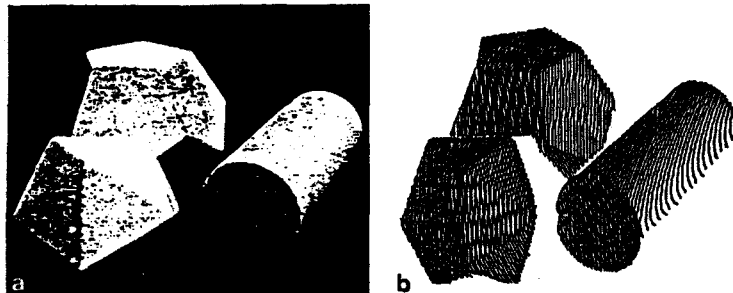


FIG. 3 - Typical Structured Light Scan Results  
by Y. Shirai in "3D Computer Vision"[16]

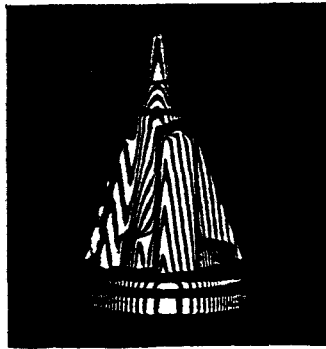
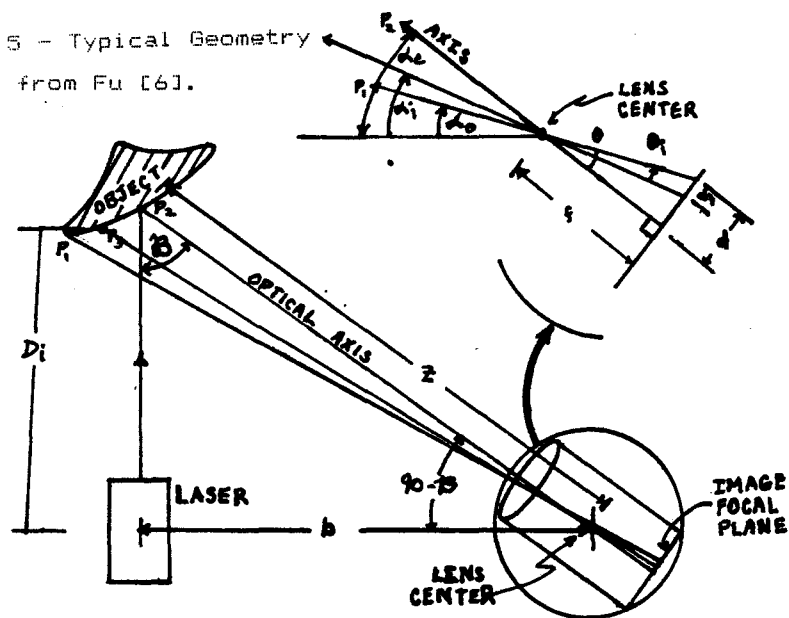


FIG. 4-Moiré Projection by Shirai [16].

FIG. 5 - Typical Geometry  
from Fu [6].



## ARTISTS, PROGRAMMING AND THE USER INTERFACE

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### Abstract

Experiences in both using and writing software have lead to many questions about the User Interface between the artist and the computer. This paper will try to touch on some definitions and to examine a few examples. A discussion of the split-brain theory and of what is meant by entropy in art are included. Finally a brief discription of the author's experience in teaching the programming of user interfaces to art students concludes the paper.

### Conceptually speaking

The conceptual model of an interactive computer graphics system includes three basic parts: 1. the computer, including application software and device drivers, 2. various input and output devices and 3. the user according to Foley and Van Dam in Fundamentals of Interactive Computer Graphics.<sup>1</sup> The link between the first two parts and the third is commonly referred to as the User Interface. It is generally considered that the User Interface resides somewhat magically within the software of the application program being used. This is a simplistic and incomplete view.

The User Interface is a system which includes many aspects of any given project. An understanding of the operation of extra-systemic devices (like printers and plotters, a mouse or a bit-pad) may be crucial to the project's success. The movement of data to and from files and between application programs may be left to the wills of a particular operating system and thus those aspects of the operating system should be thought of as part of the User Interface.

Newman and Sproull in Principles of Interactive Computer Graphics, outline a programming approach to the design of the User Interface. They break the UI into four basic components: 1. the conceptual model followed by the user, 2. the system of commands which are available to the user,

3. a feedback system through which the user learns the effectiveness of the commands as they are applied to the conceptual model and 4. an information display of some sort showing the progress of manipulated data.<sup>2</sup>

Before 1974, when Intel and Motorola first introduced their microcomputer chips<sup>3</sup>, UIs were the domain of computer programmers working on main frames and minicomputer systems. Most applications for computer graphics were aimed at engineering graphics systems. The introduction of the Apple, Commodore, Tandy and other small computers brought a wider audience to computer imaging technology. In 1984, Apple Computer introduced the Macintosh and the first effective Graphical User Interface.<sup>4</sup>

### Gooveys and Non-gooveys

The GUI, or Graphical User Interface, as the name implies, is an interface which makes use of the graphic display mode as opposed to the text display mode. Thus most of the Newman/Sproull definition, i.e., the command system, the feedback system and the information display is achieved through interaction with bit-mapped graphics.

Historically, most command systems have been text-based displays organized in command line or menu driven methodology. User input was usually through keyboard entry of single character, function key or verbose character strings. External devices like light pens, joy-sticks, tablets and the mouse have come into use to allow more immediate feedback to the user. Still, the typical graphic workstation, before GUIs, necessitated a text display for information and interaction as well as a graphics display for feedback.



In the 1970's, Xerox Corporation developed the Xerox Star Workstation which utilized one of the first Graphical User Interfaces. This led to the Macintosh Desktop, written for Apple Computer. A myriad of other GUIs followed including Microsoft Windows, Presentation Manager and even Open Look from Sun Microsystems.<sup>5</sup> With the advent of the GUI, the text and graphics screens became essentially identical. This allowed interactive manipulation of screen elements in the command system while simultaneously viewing the results.

#### The WIMP Interface

The real strength and potential of the GUI lies in its making operating system functions easy by translating them into physical actions rather than language responses. The WIMP interface, (Windows, Icons, Mouse Paradigm) lets you point and click where once you had to hunt and peck. Dragging the icon of an document from one folder to another is less confusing to most people than is typing, "COPY C:\MYPICS\HOUSE.PIC A:\BACKUPS". The major difference between these two approaches is that the first is primarily visual while the second requires cognitive thinking. Using the WIMP interface, you recognize an object by its form, identify a new location for the object and symbolically pick it up and place there.

#### WYSINNWYG

What You See Is Not Necessarily What You Get. What you don't get from the use of the WIMP interface is an understanding of how the computer stores information so that you can make use of it in other ways. You don't know anything about the makeup of the data: is it a binary file or an encrypted ASCII file? Are files stored in blocks on the disk or scattered willy-nilly? Is the MacWrite document you just produced compatible with the Word Perfect file stored on your PC?

In fact, embodied in nature of the WIMP interface is the concept of invisibility. Much of the actual operation of the computer is hidden from the user. Why? By bringing the operation of the computer and its software out of the realm of the traditional language-based evaluation/decision/selection process and placing it into an analog of a vision-based recognition/tactile-action system it seems we have abandoned the notion that understanding a process can enrich the final product.

#### Real men don't use icons

In "The Know Business is Show Business: Graphic Design and Computer Design", Aaron Marcus trisects the computer into three components, like the three faces of eve. He calls them the Outer-face, the Inter-Face and the Inner-face:

The Outer-Face is the image of information that computers produce: charts, maps, texts, and photographs. The second face is the Inter-Face between human and computer, or the means by which the user communicates with the computer. . . . The third face is the Inner-Face, or those elements that make the intricacies of the computer understandable to the people who build and maintain it.<sup>6</sup>

The attitude expressed in this definition of the design aspects of the computer is a common one: that somehow the "intricacies" of the computer need not concern the user. At the same time, it should be the primary concern of the artist or designer to formulate a visual language for all three of these "faces"; to ". . . determine and refine the nature of that visual symbol communication."<sup>7</sup>

One wonders if the relegation of the artist to this specific role might not be too simplistic. In Marcus's view there are three classes of people involved in any given computer operation: Users, Builders and Designers. The Users don't need to know or understand the process they are using. They only need to understand how to set that process in motion. The Builders, which would include software as well as hardware engineers, need only concern themselves with the proper functioning of the system. The product, which is the end result of the interaction of the user with the machine is merely a remote side effect of the engineer's work. The Designer, therefore, is the hero of the day, having been assigned the task of inventing a bridge between these two diverse parts of the assembly line. As we will see, there is a danger in too much of this kind of division of labor.

#### Right-side, Left-side, all around the brain

There is a great deal of literature about the theory of the double brain. Artists and art-educators may avail themselves of the excellent summary of these theories in Betty Edwards' book, Drawing on the Right Side of the Brain.<sup>8</sup> In a nut-shell, (no pun intended) the brain consists of a left hemisphere and a right hemisphere

connected by the corpus callosum. There is a cross-over of neural networks such that the left half of the brain controls the right side of the body and that the right half of the brain controls the left side of the body. Impulses from both the eyes and the hands are crossed in this manner.

Through studies of brain damaged individuals the theory has evolved that the left hemisphere is the center for language functions. The left hemisphere tends to be "intellectual" while the right tends to be "intuitive". Edwards further characterizes the two halves with these attributes: the left is verbal, analytical, symbolic, abstract, temporal, rational, digital, logical and linear; the right is nonverbal, synthetic, concrete, analogical, nontemporal, nonrational, spatial, intuitive and holistic.<sup>9</sup> She also points out that:

Based on the evidence of the split-brain studies, the view came gradually that *both* hemispheres use high-level cognitive modes which, though different, involve thinking, reasoning, and complex mental functioning.<sup>10</sup>

We never use only one side of our brains, but certain types of functioning may take precedent during portions of the mental processing we do when involved in a task. A flash of "insight" may come from the right brain to be broken down one step at a time into concepts by the left. Information may be gathered by digesting a series of symbols through the use of left brain activity then imagined in the right's mind's eye.

Although western culture has become more and more visually attuned due to the inventions of photography, film, television and now the computer, our educational system is still dominated by the printed word which has held sway since the age of Gutenberg in the sixteenth century. Researchers and educators, Murr and Williams in a recent article about education in our visual culture have this to say about split-brain learning:

Our emphasis on the linguistic transmission of knowledge through speech and text during at least the last 500 years has meant that certain areas in the left hemisphere of the brain linked to these features of language processing have been well exercised, while the realm of spatial reasoning, symbolic processing and pictorial interpretation, which seem to be predominantly tied to the right hemisphere of the brain, has remained largely ignored.<sup>11</sup>

The potential use of new "visual tools" like television and the computer suggests to Murr and Williams that the educational establishment needs to shift its emphasis away from "... serial lectures, serial text, serial data and data collection as well as our obsession with reading, writing and articulating at an intellectual standard derived from a sense of scholarship invented before the middle ages."<sup>12</sup>

#### Throwing away the baby with the bath water

Now that we have the Graphical User Interface to help us incorporate imagery into the Outer-Face and the Inter-Face we would seem to be on the way toward achieving whole-brain computing. But somehow much of the GUI software is like the joke about eating Chinese food: you're still hungry. I suggest the use of icons in place of language symbols is inadequate for a number of reasons. First, the symbolic content of many of the icons used in today's software is too specific and necessitates interpretation. Second, the difficulty for the user to reprogram at the function-level of the interface creates entropy. Third, the separatism represented in the cohabitation (not the collaboration) of the engineer and the artist leads to complacency and could result in another rain of terror like the Gutenbergian linguistic one alluded to by Murr and Williams.

I believe that the Macintosh Desktop is probably the best GUI to be found on a personal computer to date. For this reason, I feel I can pick on it. Like many other artists, the Macintosh was not the first computer I ever used or used to make art. Because I had already had to exercise parts of my left brain in order to navigate several other operating systems possessing language oriented interfaces, I actually found the Macintosh hard to use. I was constantly having to try to figure out what the icons meant.

### Garbage out

The process of removing a file from a disk is accomplished in the Macintosh Desktop by selecting an icon which represents the file, dragging it out of its folder, across the Desktop and into the garbage can. Obviously, this visual/tactile action analogy was designed to simulate the actions of a business executive sitting at his (or her?) desk, pulling a document out of a file folder and throwing it into the "circular file", the waste basket. In many parts of the world, this symbolic representation would be totally incomprehensible. It could even be misleading. In Trinidad the garbage can icon might be mistaken for the national musical instrument, the steel drum. As I attempted to point out above, when the use of a visual symbol obscures the real process underlying the action it directs there is a loss to the user.

In Visual Thinking<sup>13</sup>, Rudolf Arnheim makes a case for the idea that thinking is primarily a visual process which has been traditionally misunderstood and not acknowledged. Visual perception, including all the biological apparatus and mental activity which goes into it forms the model upon which all cognitive processes are built. Thus when we say that we "see" an idea (we visualize it or imagine it) we are giving expression to Arnheim's theory that "... concepts are perceptual images and that thought operations are the handling of these images."<sup>14</sup> He distinguishes three kinds of images which should concern us here: pictures, symbols and signs.

An image may be a *sign* if it stands for something without being made up of the visual characteristics of that something.<sup>15</sup> The shape of a stop sign, for example, makes no reference to the visual aspects of the concept of stopping. Instead it is based on the consensus notion that a red octagon

will trigger an instant response. It is through repetition of the image that we come to associate it with its meaning. Many of the icons used today may be called signs. They depend for their usefulness upon the recognition of their meaning by the user and thus may fail.

An image may be a *symbol* if it portrays something which is at a higher level of abstraction than itself.<sup>16</sup> The icon for entering the function which produces rectangles in the paint software, TIPS, is a square (at least it looks like a square to me). Since a square is a kind of rectangle it may be used as a symbol for all rectangles. This seems to work, however, it requires some interpretation on the part of the user, since it could also mean "all squares" or "all equal polygons".

An image is a *picture* when it portrays something at a lower level of abstraction than itself.<sup>17</sup> A picture gives specific details about what it portrays although the portrayal may be incomplete. The Macintosh garbage can is a picture being used as a symbol. It happens to be an incomplete portrayal of the process it represents. This not only necessitates interpretation on the part of the user but allows for many interpretations.

It is clear that we need to create a visual language to facilitate the visual/tactile/graphical user interface of the future, but it is not clear where this language will come from. Visual languages already exist in our culture. They are formed in much the same way verbal languages are formed: by popular acceptance of a root language which is changed and modified through usage over a period of years. Sign language, gestures and body language are examples of evolved languages. However, visual languages which depend upon technological media, such as the language of cinema and television, sometimes called pictorial continuity, are slow to change because of faulty user interfaces.

### Ah, entropy!

In his book, Expanded Cinema<sup>18</sup>, Gene Youngblood wrote about entropy in the arts, particularly in commercial entertainment art (read that movies and television). In thermodynamics the term, entropy, describes the amount of energy which cannot be transformed and hence used to produce work. By substituting the word, information, for the word, energy, the analogy thus formed illustrates a system which is a closed loop, that is, there is no feedback of information within the system to produce change. Here is how it works:

Commercial entertainment may be considered a closed system since entropy dominates the feedback process. To satisfy the profit motive the commercial entertainer must give the audience what it expects, which is conditional on what it has been getting, which is conditional on what it previously received, ad infinitum. . . . Since the viewer remains passive and is acted upon by experience rather than participating in it with volition, there's no feedback.<sup>19</sup>

The visual language of the cinema had its root form in the early experimental filmmakers of the silent film era, like D.W. Griffin and Sergei Eisenstein. Gradually a form developed which remains relatively unchanged today. In the late sixties and early seventies when Youngblood was writing, many film and video artists emerged who attempted to create new forms of visual language for their medium. Much of it died on the vine. Some of it influenced a small group of future media artists. Computer artists are now facing some of the same questions that were asked two decades ago, mainly, how much control do we have over our chosen medium?

#### Why artists should learn to program

Another personality from the sixties, painter Andy Warhol, created the notion of the artist as User. Warhol felt that an artist should be able to create art by picking up the phone and ordering it. Indeed, he enjoyed the efforts of many helpers and his studio came to be known as "the factory". Warhol and his contemporaries were pushing the boundaries of the conventional view of what art was and how artists worked. This approach to the making of art is now accepted and even expected. Many computer artists function much in same way as Andy Warhol did when they buy a computer system and software. The (mythical) collaboration between the artist and the engineers who actually produced that artist's tools is given as a rationale against learning to program.

In the traditional sense of the studio artist, a personal style of working is developed. This includes how an artist feels about their working environment, the selection of their tools, the placement of those tools and working surfaces, the selection of materials, the lighting, sounds, smells, food and drink, and other elements of the environment. A lot of the choices the artist makes are aesthetic ones.



When an artist uses a computer, the user interface becomes that artist's style of working. Many of the choices have been made. Most software is an entropically closed system. As far as I can determine, there is no artificially intelligent software for artists available commercially. Certainly there is no artificially intuitive software. The only way to break through entropy is to generate some kind of feedback system where the User (at the Inter-Face) can communicate with the Builder (at the Inner-Face) so as to affect change. Most manufacturers are so protective of their products that this is simply impossible.

Choice number two in the war against entropy is to learn to program. I can think of no argument that can be given for remaining unskilled when attaining the skill in question is not beyond one's grasp. Entropy in an information system is caused by ignorance.

#### Teaching the programming of the user interface

At the university art school where I teach (Northern Illinois University) we teach a beginning course in computer graphics programming and two advanced courses which involve programming. Last year, I began to adapt one of the advanced courses to include the use of peripherals such as plotters. As I began to organize the material I began to see that the course was really about User Interface.

I worked with about 14 students who had previously taken a course in BASIC programming on Apple II computers. My first task was to try to unteach the BASIC and teach a programming language that was structured and which used libraries of routines. We still had to work on Apple IIs, so the logical choice was Apple Pascal running under the UCSD P-System. In addition to the standard Apple library we used a unit for controlling the mouse, called MOUSE, written by Dr. William Mego.

#### The journey of a single step

After learning Pascal, including the Turtle Graphics unit and MOUSE, the class was assigned the problem of writing a paint program. This was begun by giving a core program which included a few procedures that worked interactively with the mouse to draw lines on the screen. The students had to develop a user interface for their programs and to change the core program into a personalized paint program. Most of the final programs included procedures to display on screen menus which lead to submenus of special functions. These functions included drawing freehand with the mouse in line or dot mode, drawing perpendicular or grid-related lines, rubber-band cursors, built-in shapes such as regular polygons, squares, circles, triangles, etc., changing colors and so forth.

After the initial experience of writing a paint program the students agreed that much of the commercial software they knew about had been demystified to a certain extent. They began to look at it differently. A second project was given to modify their paint programs to save data to disk in a specific format. This format was simply an array of structured variables called records, containing the values of coordinate points and colors of images made using their paint programs. A second program was then written to retrieve this same data and to use it to produce musical tones rather than visual images.

#### Finale

I haven't touched on some of the newer approaches to the design of the user interface such as Hypercard and Hypertalk. I'm reserving judgement on these until I teach a class using them. My criteria for evaluation is simple: the interface must not hide real operations of the computer from the user and the interface must be user modifiable.

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## Desktop Photorealism

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### Abstract

Photorealistic rendering for designers and artists who use small computers has become a reality with Pixar's RenderMan™ Interface and PhotoRealistic RenderMan™ renderer. Trends, imaging domains and the RenderMan story are discussed relative to the desktop.

### Introduction

In only twenty years computer imaging has evolved from mainframe driven line printers to individual graphic workstations capable of producing photorealistic rendering. It is remarkable to look back to see how far we've come in the development of new tools for visual creation. In retrospect, one may notice that a clear pattern has emerged. In effect, every significant breakthrough either in imaging hardware or software is being down-sized to the desktop metaphor. Desktop workstations with tremendous computational power and imaging capability are measured in MIPS (Millions of Instructions Per Second) and footprint size.

This is great news for the creative users of technological tools, especially those of us who use small computers as a form of individual expression. And now the latest! We can add realistic three dimensional image synthesis or what is commonly known as photorealistic rendering to the array of fine imaging tools already available to small computer design and art users.

The article that follows is about the latest step along the synthetic-image-making-tool path, overall trends are discussed, a clarification of imaging domains is presented, a new standard in photorealism, Pixar's RenderMan, is discussed and some common questions regarding it are answered.

### Trends

There are trends that suggest the personal electronic studio will soon become reality and that desktop rendering will be one of its important components.

There are trends in hardware. The electronic studio of the future is going to consist of affordable off-the-shelf platforms with supercomputer processing power (eg. Intel's i860), adequate mass storage (eg. Optical laser

disk), quality high resolution color displays (eg. HDTV) and superior output capabilities (eg. Digital film recorders). Without doubt all these components will be devices physically small enough to fit on the desktop. It is not unreasonable to assume that these workstations will be fully integrated and "plugged into" a variety of information and service networks.

There are trends toward color systems. Color is a natural and logical extension of current Black and White (B&W) desktop systems. Although color capabilities are an order of magnitude greater than B&W, as soon as price/performance barriers are breached (say, 2-3 times the cost of B&W with same ease of use) color will become pervasive.

There are trends toward standardization.

According to the Davis Report,

"Standardization is gaining momentum because major players ... are now convinced that standardization is in their best interest and (they) are making it their policy."<sup>1</sup>

Adobe's Encapsulated PostScript (ESPF), Aldus' Tagged Image Format File (TIFF), Autodesk's (.dxf) files, Truevision's (.tga) files and Pixar's RenderMan (.rib) files are examples of significant emerging standards that will play a role in the realization of the personal electronic studio.

### Imaging Domains

There have been efforts to clarify imaging by dissecting it into two domains, namely geometry and imaging<sup>2</sup>. Both worlds are currently separated by significant hardware and software differences.

Image computing or image-based picturing begins with an image comprised of pixels arranged in a grid or array format. Most of the time these images are obtained by some form of sampling. For example, grabbed video images, digitized satellite photographs (remote sensing), computer tomographic (CT) and magnetic resonance (MR) scans, mathematical and scientific data images (scientific visualization), algorithmically generated imagery, etc. By definition this imaging domain is discrete and an image is typically represented by integer numbers.

Geometric modeling or geometry-based pictures begin with the three dimensional description of objects or scenes in terms of geometric primitives such as, polygons, wedges, blocks, cylinders, spheres, tori, etc. Data can be described a number of ways, such as, measurements of real objects or abstract descriptions of real objects in terms of geometric primitives. Advanced modelers allow complex objects to be formed by Constructive Solid Geometry (CSG) techniques, vis-a-vis creating holes by differencing cylinders with blocks. To make a digital picture of an object or scene requires that the object or scene be rendered, that is to say, rasterized or scan converted, into pixels.

Future graphic workstations will work simultaneously in both domains. We can expect to see paint systems integrated with image processing systems integrated into presentation and publication graphics systems. Moreover, we expect to see modeling systems producing three dimensional object and scene descriptions to produce photorealistic rendering which might be integrated into imaging systems or animation systems.

### RenderMan

In May 1988, Pixar introduced a 3-D scene description interface entitled, The RenderMan™ Interface<sup>3</sup>, to bring photorealistic image synthesis to a wide range of graphics systems. Photorealistic image synthesis is the ability to produce digital images of photographic quality. RenderMan is important because it divides geometric imaging into the domains of modeling and rendering.

The RenderMan story is pertinent to this discussion because it responds the impetus of the aforementioned trends and uses the geometric modeling paradigm to produce photorealistic pictures. The RenderMan™ Interface and the PhotoRealistic RenderMan™ renderer are a benchmark in quality imaging. The RenderMan™ Interface establishes a standard for rendering which has heretofore not existed. The PhotoRealistic RenderMan™ renderer gives a desktop user the means to produce quality imagery. In fact, PhotoRealistic RenderMan™ is the very same software that was used by John Lasseter and Pixar's Animation Group to produce *Tin Toy* which won the 1988 Academy Award for Best Animated Short and, Lucasfilm's Industrial Light and Magic to produce major motion picture effects, such as the "Pseudopod" sequence for *The Abyss*.

The RenderMan Companion, A Programmer's Guide to Realistic Computer Graphics by Pixar's Steve Upstill was recently published by Addison-Wesley Publishing Company.<sup>4</sup> With the permission of the author we can liberally quote from this fine book to Q & A a number of commonly asked questions about RenderMan.

Q: What is RenderMan?

A: RenderMan is primarily a complete scene description methodology, a powerful means of describing the appearance of objects. However, the visual interest of much of the world comes not from shape, the geometric configuration of objects, but from shading. The second

purpose of RenderMan is to bring "surface variation" to synthetic imagery.

Q: What is the Shading Language?

A: Within PhotoRealistic RenderMan appearance is governed by a special programming language called the shading language. In a C-like format, procedures are written that are associated with individual surfaces and called during rendering so that shading can vary with the position of surface, angle of view, time etc.

Q: How is the shading language different from texture mapping?

A: The shading language goes beyond texture mapping. Texture mapping is the application of an image to a surface in the manner of applying decals. The shading language uses not only an image, but any function of position on the surface of an object to modulate a surface's appearance.

Q: Why does RenderMan separate modeling from rendering domains?

A: The development of a modeling system no longer requires concurrent development of a renderer. A modeling system using the RenderMan Interface can have immediate access to the full power of all the features of the PhotoRealistic RenderMan renderer, including the shading language. The notion of using a standard rendering interface will allow a user to employ any number of modelers with a single renderer.

In summary. The RenderMan Interface seeks to provide access to high quality synthetic imaging to ordinary mortals and visual artists. It is a method for describing the content of an image to a computer program to reach realistic levels of complexity and quality. The RenderMan Interface by design aims to be simple and complete for the purpose of creating realism.

### Current realities or, How do you get RenderMan?

On September 15, 1989 Pixar began shipping PhotoRealistic RenderMan™ Version 3.0 to its Original Equipment Manufacturer's (OEM). Basically, version 3.0 complies with the published specification. (See Reference Number 3.) At the same time, independent developer's could purchase from Pixar, Developer's RenderMan. Developer's RenderMan consists of the RenderMan Interface™, PhotoRealistic RenderMan™ renderer Version 3.0, as well as, documentation and software. Developer's RenderMan comes in both MS-DOS™ and UNIX™ flavors and does not come with a "modeler." Developer's RenderMan requires someone knowledgeable in graphics programming to create imagery.

However, non-programming designers and artists take note. Two major desktop modeling or Computer Aided Design (CAD) vendors are in the process of "front



ending" RenderMan. These companies are, Autodesk, Inc. of Sausalito, CA (Autodesk RenderMan™ will be available First Quarter, '90) and CADKEY, Inc. of Manchester, CT (CADKEY RENDER™ will be available Fourth Quarter, '89). Both companies produce popular desktop Computer Aided Design packages and through their respective interfaces, users will be able to produce geometric representations of objects and scenes that may then be rendered. Other popular modeling companies are planning to front end RenderMan, but at the time of this writing it is too early to be specific.

## Conclusion

Desktop rendering is a reality. Both programmers and CAD users have access to a sophisticated renderer capable of producing realistic computer graphics. Desktop rendering is one step closer to the ideal personal electronic studio that every small computer in the arts image-maker dreams about.

## Disclaimer

After twenty years of professing engineering graphics, computer graphics and design at the post secondary level this author left the academic world to join private enterprise. Pixar is a very third-wave company and I have a very third-wave responsibility, namely, RenderMan Evangelist. Working at Pixar is a dream come true. (What I always wanted to do when I grew up.) I mention this to explain why this article may seem to be biased towards Pixar and RenderMan.

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## **Micro-Tonal Tuning via MIDI - Chapter II With Implementation on the Ensoniq EPS**

by Richard H. Lord - UPWARD CONCEPTS  
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Advantages of real-time micro-tonal pitch control are explored. A variation of the MIDI standard is discussed to support micro-tuning. Implementation on the Ensoniq EPS is shown and a micro-tonal keyboard design is discussed.

A skilled violinist, when playing chamber music, is able to make small ( micro-tonal ) adjustments in pitch to produce perfect harmony. With keyboard instruments, this is much more difficult. The physical principles of musical harmony do not allow a fixed 12 note octave to be consonant in all keys. Throughout the Renaissance and Baroque periods, many tuning systems were tried that would extend the pure non-beating harmonies to more than a few keys. The almost universal "equal-tempered" scale of today was known for many years as a clearly audible compromise that achieved equal amounts of dissonance in all keys. It was late in the 18th century before musicians and composers were able to accept this compromise which allowed existing keyboard instruments to modulate to distant keys.

An alternative that has been considered for several centuries is the addition of more notes within each octave. Keyboards have been built with anywhere from 13 to 121 keys in each octave and a corresponding number of strings or organ pipes. The complexity and expense of this approach have limited its popularity, but the fascination with pure intervals has persevered throughout the ages.

Today we have a unique opportunity to explore alternate keyboards and tuning systems. Thanks to the influence of synthesizer pioneers such as Wendy Carlos, the manufacturers of many modern digital

keyboards have included some facilities to provide alternate temperaments. While economics prevent the original manufacturers from providing all the tools that a dedicated micro-tonalist would like, at least some programmable capability is now present in several keyboards and modules. The Ensoniq EPS includes a feature that permits as many as eight tuning tables to be assigned to an instrument.

While it is now becoming possible to program alternative fixed temperaments in various MIDI keyboards and modules, there does not seem to be an easy way to alter micro-tonal pitch dynamically. Attempts to realize compositions that feature just-intonation or other dynamic tuning systems require more than these simple pitch tables.

In a paper presented at SCAN '88, I proposed a variation of the MIDI standard that would permit dynamic re-tuning of pitch. At the conference, I demonstrated software for the Ensoniq Mirage keyboard that provided dynamic pitch control via MIDI. The poly after-touch code, normally used to represent key-pressure, was proposed as a dynamic pitch control. This code is a note-specific 7-bit value that can be used for any after-touch effect. There is nothing in the standard that would prohibit its use for micro-tonal control.

The note-on event sounds a note at equal tempered pitch, and the after-touch code is then used to specify the pitch deviation from equal temperament in cents. If this pitch correction code immediately follows the note-on code, it will be processed in time to cause the note to be sounded at the proper pitch. The after-touch code can have a value ranging from 0 to 127. This can be interpreted as a signed number with a value from -63 to +63.

Defined in one cent increments, this range is sufficient to span a semi-tone. Thus the 6-byte long MIDI message can define any pitch in a ten octave range to within one cent of accuracy.

For example, a Pythagorean E, which is 8 cents sharp of equal-temperament, would be sent as:

```
90 34 7F ; Note-on for E
90 34 00 ; Correct E to +8 cents
.....
80 34 7F ; Note-off for E
```

This implementation is attractive for a number of reasons. Foremost, is the fact that it can be incorporated into the existing MIDI standard. An equally important consideration is that, if adopted by manufacturers or third-party developers, it then would be a universal, device-independent solution. It utilizes the full 128 note ( 10+ octave ) range of MIDI, whereas micro-tonal pitch tables within an instrument would be limited to 128 micro-tones.

This extended range also allows someone to create a generalized micro-tonal MIDI keyboard controller. The several hundred keys of such a keyboard could send the correct pitch data without the 128 note limitation imposed by the present MIDI specification. Each key would simply send the note-on command for the nearest equal-tempered pitch, followed by a pitch correction code.

The proposed micro-tonal standard also can be used with existing MIDI sequencers and sequence software. The software does not have to assign polyphony to different MIDI channels. This allows full use of the poly-instrument capability of 16 MIDI channels. The micro-tonal information can be added to a standard equal-tempered sequence by inserting poly-after-touch commands after the notes that are to be micro-tonal. It also permits specific forms of dynamic vibrato to be added to individual notes.

The disadvantage of this standard is that it is not a feature already incorporated in any existing product by the manufacturer. It will need to be recognized as useful, before any manufacturers will consider adding it to their modules and keyboards. Fortunately, several MIDI instruments are built with disk based operating system software. This design

allows third-party developers to create alternative operating systems that add many useful features, including micro-tonal pitch capability. These enhanced operating systems are simply loaded into the existing product from disk.

At last year's SCAN, I demonstrated an operating system disk that added this capability to the Ensoniq MIRAGE. This system was used to realize a micro-tonal piece titled *"-and, as I was saying ..."* written by composer, Ezra Sims. This composition contains one-sixth tone, one-eighth tone, and one-twelfth tone pitch inflections sharp and flat of equal temperament. He played his composition from the keyboard into Mark of the Unicorn's Professional Performer in equal-temperament and we then put in the pitch inflections by inserting after-touch codes.

A variation on this "standard" that is worth considering, is to interpret the poly-aftertouch code as 0-127 cents sharp. With this system, a micro-tonal flat is sent by sending the note a semi-tone lower and then sharpening it 100-N cents. While this version is not as convenient to use for exotic vibrato, it has the advantage that it can be directly implemented on the EPS and several other keyboards without software modification.

All that is needed in the EPS, is to set the pitch modulation source to PRESSURE and to set the modulation value to +13. Since this version of real-time pitch control is available to EPS owners without additional expense, I hope that they will experiment with it.

I am presently working on a generalized keyboard that will send note information using the two variations of this standard. I presently have disks of both versions available to MIRAGE owners who are interested in further experimenting.

The MIDI transmission of real-time micro-tonal data opens up another whole new world of exciting possibilities. I look forward to seeing the concept evolve into a useful standard for everyone to use.

## GOING BATS

William A. Mego

The School of the Art Institute of Chicago

Batgraphics is a library of Pascal functions and procedures that is intended to be part of a first encounter to computer graphics programming. Modeled on a bat that skywrites with colored smoke, Batgraphics represents a "top down" approach, in which the class immediately begins to program three dimensional images, while learning the elements of a computer language. Then students explore the elements of the library, using the now familiar functions as examples of a structured approach to graphics and kinetics.

Students of painting and sculpture are routinely taught a modest amount of anatomy. Most art students never master this discipline, and few would argue that they should. It is enough that they gain some insight into the workings of the human mechanism, and an intuitive understanding of the basis of human movement. To many, a professionally trained artist without such knowledge is considered limited.

Of all the contrary forms of life on earth, art students are probably the least willing to accept limitations and restrictions or, for that matter, guidance and good advice. That is why it is perplexing that students of computer art customarily accept the constraints imposed by commercially available software, convinced that true artists simply cannot program computers. It is as if they believe that artists and technologists, while capable of interbreeding, constitute two entirely different forms of life, which are incompatible within a single individual. That attitude is certainly reinforced by the average bits and bytes "bottom-up" computer course, which is typically taught as a rite-of-passage ceremony for those to whom the pie chart represents the ultimate accomplishment in computer graphics.

It has occurred to some teachers, including myself, that an alternative would be a more digestible "top-down" approach, oriented toward graphics and kinetics rather than accounting and data management. Ideally, in such an approach, the student would immediately be able to program images and would, within a reasonable amount of time, be able to construct drawing and image manipulation programs utilizing all the features of the available hardware. In time, curiosity, enterprise, disconformity, and perversity would cause creative students to inquire into the

workings of the system, and begin to follow the path some or all of the way back down to logic levels and interface adaptors.

My efforts along these lines have led to a library of routines for graphics and kinetics that I call Batgraphics. For the past two years, I have used them, somewhat experimentally, in the classes I teach at the School of the Art Institute of Chicago. In Batgraphics, an imaginary bat skywrites with colored, or patterned, smoke. Drawing movements can be absolute or relative, in a manner similar to the MOVE and TURN commands of the very popular Turtlegraphics. However, in Batgraphics, they always occur in three dimensional space, and the scene is always viewed in full perspective. For no reason other than my personal prejudices, the procedures, functions, and data structures that constitute Batgraphics are written in Pascal, and used as a library in a version of the UCSD p-system programming environment. Since an affordable version of the UCSD operating system is available for virtually every computer ever made, the system is very portable. It is also easy to learn; students who have never used any computer can create and modify a simple 3-D drawing program by the end of the first day.

The idea of a skywriting bat, although admittedly whimsical, creates strong visual images that help our beginning students, a large number of whom possess no knowledge of algebra or geometry, visualize three dimensional space. The bat can FLYTO any x,y,z coordinate. Its progress can be followed either by a trail of colored smoke or by an cursor, which becomes smaller as the bat recedes from the viewer. The system supports several peripheral devices, including a mouse, even though I believe it to be a truly wretched implement for artistic purposes. However, a popular first program is to have the bat chase the mouse by using the x and y positions of the mouse either for the x and y coordinates of the bat (in which case one draws on the screen surface) or for the bat z and y coordinates (in which case one draws on the left wall, etc).

Relative vector movements are illustrated by having the bat create a variety of aerial polygons (termed "stunt bat" by one fellow). Thus, the bat can FLY for some distance in the direction of its flight path, which is defined by a vertical and a horizontal angle from its current position, then change paths and FLY again. To express the path in absolute terms one has the bat LOOKTO a certain

computer as an imaging device, an approach that has allowed extensive freedom to control the picture meaning through various digital processes. These processes are very quickly becoming much more closely allied with traditional photographic approaches to image making and will indeed become intimately bound together in the near future. This is easily a topic of great importance and complexity, but one that I will not try to fully encompass in this paper. Rather, I will discuss some current directions that have occurred which are aesthetic intentions empowered by the use of current electronic imaging systems.

My first involvement with serious photography was influenced enormously by the work of news photography published in the original Life magazine which were at once "real" yet surreal in execution. Photographs in the magazine in the 1950's seemed to be able to magnify, transcend and yet never leave behind the fact of the real. They were magic, they transformed the mundane into the monumental but seldom polished it so much that the event was lost. Later, as I became aware of serious photographers such as Bresson, Frank and Klein, I understood that the camera and reality were linked in a wonderfully delicate embrace that danced between the fact and new fiction of the photograph.

Although in later years my work tended to push the alterable aspect of the photograph, my interest in not losing the link to the real remained closely tied to a working aesthetic. Ironically this interest was a source of profound dissatisfaction with current trends in photography, much of which seemed similar in approach, usually frontally oriented and very self consciously controlled. The turn of photography from the sense of intimacy with the real into what amounted to illustration in photographic media did not appeal to my own interests in the potential of the medium.

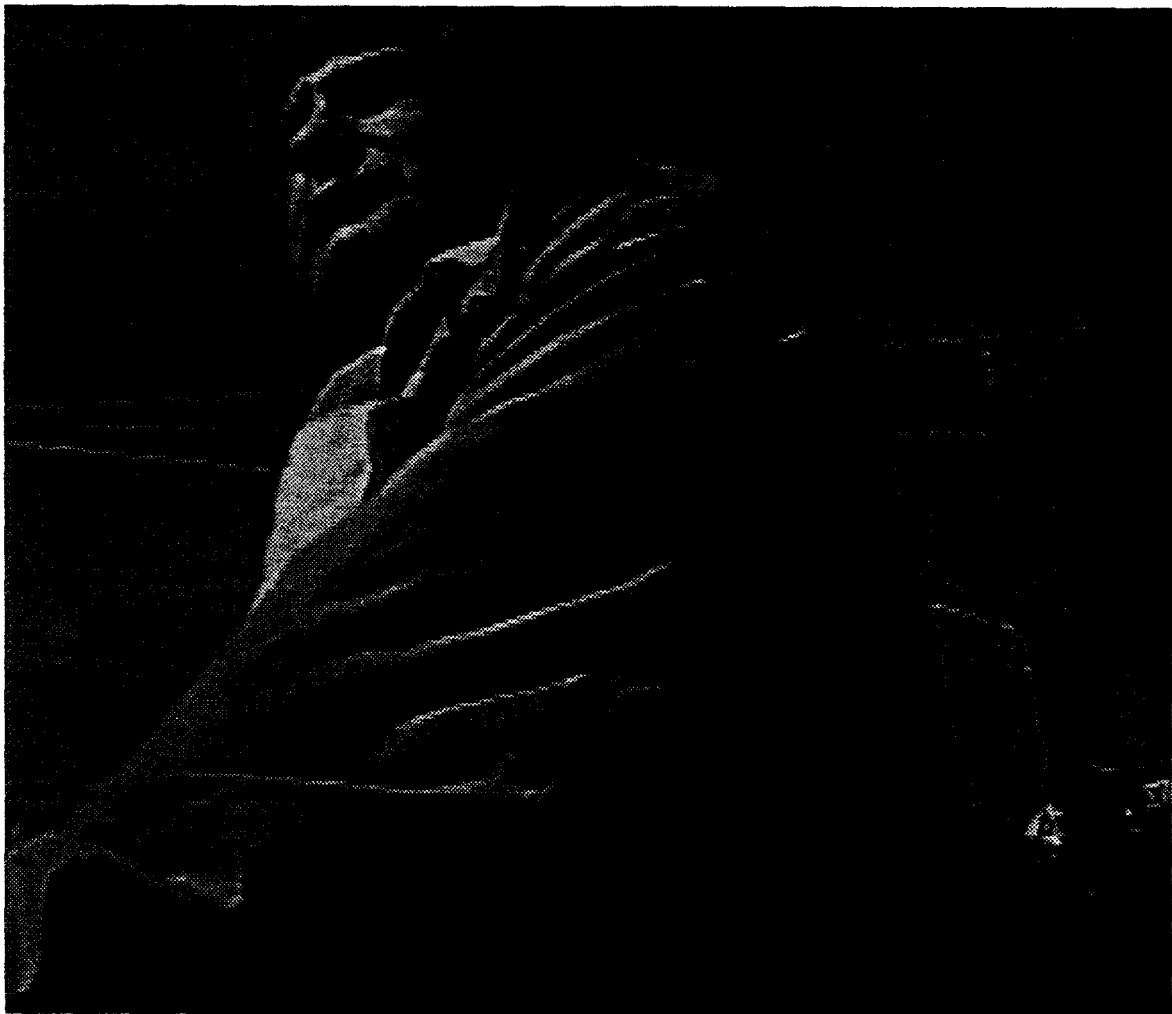
Video imaging has been a primary means of bringing the photographic image into the digital realm, and it is this means that for the past ten years I have been using as a "photographer" in the digital realm. Most of the effort has been oriented to work that conceptually lies between photography and printmaking. It has been exhilarating working in a medium so charged with potential expressive power, and has itself led to many personal discoveries. Interestingly enough, one of these branches of exploration has led me back to some seminal interests that I feel are close to the essence of the photographic medium.

Among the limitations of digital imaging today is the problem of producing hardcopy or prints from an image on the monitor screen. The image resolution, and color can now be rather easily created or altered from very abstract and crude to very realistic or even photographic. However until rather recently there have been very few alternatives available to arrive at a finished print even approaches the quality that appears on the monitor. This is rapidly changing as new printing technologies begin to emerge using a variety of approaches such as high resolution ink jet, thermal wax transfer, electrostatic toner and dye sublimation processes. The sublimation process is typical of a new class of digital tools that will begin to bring the merger of traditional photography and digital imaging together. Such devices consists of several subunits integrated into the one chassis. First, there is a video frame buffer allowing instantaneous capture (1/30th of a second) of a full 525 line color video frame. Second is an input/output section that allows input of composite video, S-Video or RGB, and output as RGB or composite video, a remarkable integration of processes. Finally there is the printer section that takes the data stored in the frame buffer memory and prints it to a glossy print or transparency film.

I began to work with one of these devices and was most impressed with both its output capabilities and flexibility in accepting a variety of analog signals. I utilized a Super VHS video camcorder as an image capturing camera, intending to make still images from the taped events recorded with the camera. Rather than proceed through an event with the camera waiting for some circumstance to trigger the shutter release, I simply kept the camera on continuously recording on the two hour long tape, yet as keenly aware of the moments as if I were equipped with the still camera.

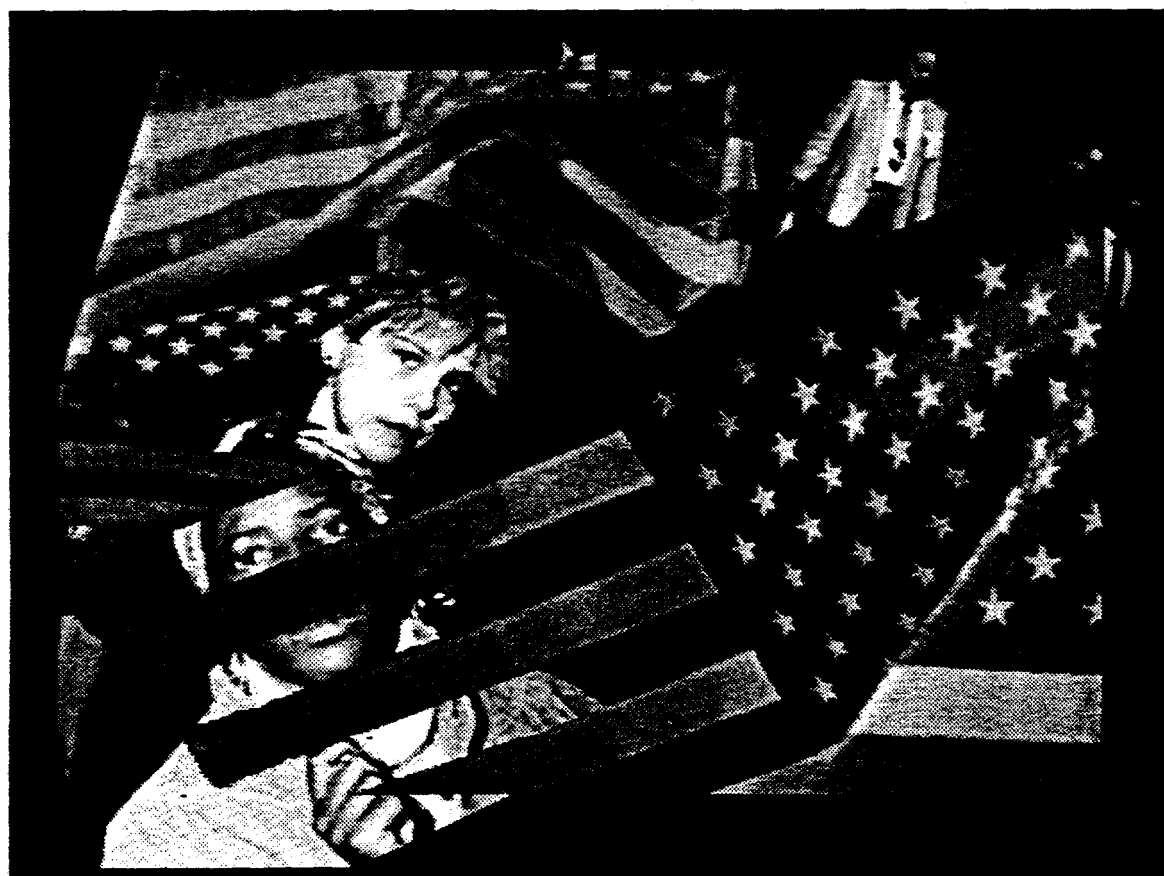
Later when I was in the studio searching for frames to print a rather powerful realization occurred, I was able to review/relive/reshoot the reality of the events. The realization of this ability to replay was extraordinary to one more used to the conventions of still photography. It reconstructed the filmic reality for re-exploration, and offered the option to examine these events in 1/60 of a second slices under total control. Indeed I feel this potential will alter the concept of still photography as a art of the moment, forcing us to redefine the nature of that medium. It is easily possible to imagine that the tool of the videographer and photographer will be identical, delineated only on the basis of motivation and specific need. Such a merging of processes reflects the ongoing integration of creative activities that have been made possible by digital processes.

Most exciting to me has been the rediscovery of that link between the real and the expressed which has provided the medium of photography much of its power and vitality. I suspect that this approach will become increasingly routine given the pace of evolution in imaging tools and ideational models for using them.









# **An Introductory Course in Computer Graphics**

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There is a need for artist and art educators to participate in the development of new computational art forms, and to consider how these might influence more established forms of visual expression. Before these issues can be addressed effectively, some basic principles need to be understood. This article describes a course designed to introduce issues related to computers in the visual arts.

The growing profile of the computer in modern society compels the artist to consider it as a vehicle or object of expression. Historically, computer science has not been a component of a typical art background, so many artist and art educators are confounded by computer graphics technology. If an art program is to be truly broad based and relevant to contemporary society, it should introduce students to basic principles of computer graphics. An introduction to computer graphics should include studio experiences in order to effectively develop an understanding and appreciation for the nature of computer imaging. Experience of this type is valid whether an art program features an emphasis in computer graphics or not. For programs contemplating a computer graphics emphasis, development of an introductory course, or courses, is a logical first step.

The Advanced Computing Center for the Arts and Design (ACCAD), at the Ohio State University, has developed such a course entitled "Introduction to the Computer in the Visual Arts" (ART EDUC 252). This course addresses computer graphics in relation to established art forms, and as a new artistic domain. Course content is broad and general in order that it be as

transferable as possible. Hands-on tutorials are used in procedural learning, and lectures help develop procedural learning into conceptual knowledge. The students' understanding of techniques and concepts are developed through projects and tested through examinations. Students are encouraged to consider how computer technology might stimulate the development of new art forms as well as influence the development of more traditional ones, and to share their insights in class discussions. In addition, students are encouraged to consider what role computer graphics technology might have in their own development as an artist. Even if a student comes to the conclusion that computer graphics has no relevancy to him/her as an artist, that conclusion is based upon an educated understanding of relevant issues.

"Introduction to the Computer in the Visual Arts" begins by introducing the student to the procedures associated with working in a menu driven, computer graphics environment using a two-dimensional input device. Students photo-digitize a subject and save the digital image onto a floppy disk. The objective of this exercise is to develop the procedural knowledge associated with initiating, executing, and documenting an image generation process. Since learning a particular type of image generation process is not a primary objective of this exercise, photo-digitizing is used because it is quick and does not require a lot of previously learned procedural knowledge. In addition, photo-digitizing resembles a familiar visual form (photography), which allows students to concentrate on the lesson objectives.

Next, students load a photo-digitized picture into paint software and transform the photographic quality of the image into one that is more

"painterly". Students produce a second version of the "painterly" image through manipulation of the software palette only. Procedural knowledge continues to be developed and is broadened. Students learn to classify computer graphic operations as image generation (eg. photo-digitizing) or image processing (eg. palette manipulation). Students are introduced to the digital representation of an image as an array of discreet bits of information, and how this format lends itself to types of transformations. Finally, students come to appreciate the "multi-media/meta-media" nature of a computer graphics environment.

The second section of the course addresses computer graphics technology as an influence on established art forms. For example, the capability to covertly manipulate discreet elements in a digitized photograph may compromise the creditability normally associated with that visual form. Students create an editorial statement by compositing elements from two or more digitized images into a single, integrated composition. An understanding of technical issues is exercised through the deliberate manipulation of display memory, image resolutions, and software palettes.

Up to this point, computer graphics has been addressed in the context of more conventional artistic forms and processes. The next section of the course addresses one of the more significant qualities unique to computing, ie. the manipulation of synthetic models. The first stage of the lesson directly addresses the computer screen as a two dimensionally modeled space. This is done by having the student create a pattern based on grids of various densities (the grids are tools created by the paint software used for instruction). The student specifies the density of each grid by distance (in pixels) along the horizontal and vertical axis of the screen space. Next, the student grabs part of the pattern as a brush, and activates a mode of the paint software which maps the brush onto a two dimensional surface which "exist" in a 3 dimensional "world space". The student now has a third axis of placement and grid resolution to contend with. This second stage helps acclimate the student to manipulating a three dimensionally modeled space through a two dimensional interface. Instruction is facilitated by using the same paint software used for the previous lessons.

The final stage of this section introduces students to the basic characteristics of three dimensionally modeled forms (eg. vertices and faces) and some 3 dimensional transformations (ie. placement, rotation and scaling). Students create simple

objects by instancing and transforming primitive forms, such as cubes, cones, cylinders, etc. The students then composes these objects into a still life and render an image.

The last section of the course serves as a review of technical knowledge introduced in earlier lessons; the final project involves incorporating elements created by photo-digitizing, computer painting and 3D modeling, into a single image. Students are permitted access to more sophisticated software which offer wider ranges of artistic possibilities. However, the student must teach him/herself any new tools she/he wishes to use. Students will find that they learn new tools more efficiently if, first, they apply their acquired understanding of some general principles, and second, refer to documentation. Referencing software documentation is an important skill for the computer artist that is cultivated through out the course.

ART EDUC 252 is taught in the Hopkins Microcomputer Laboratory (HOML) in 352 Hopkins Hall at the Ohio State University. The HOML is equipped with sixteen Commodore/Amiga 2000 microcomputers, each with 3 mega-bytes of memory. Each microcomputer is networked to a SUN 386i/250 file-server; the SUN is equipped with a 327 mega-byte hard disk. The HOML is also equipped with a video camera for video input, and a 3/4" video recorder for documenting animation. In addition to the hardware described above, the HOML features an extensive library of sophisticated, commercial software. Software used for instruction in ART EDUC 252 includes DELUXE PAINT II, DIGI-VIEW, PIXMATE, SCULPT-ANIMATE 4D, DIGI-PAINT, and PHOTON PAINT. One of the reasons that the HOML is designed around off-the-shelf hardware and commercial or public domain software is so that it may be easily replicated and serve as a model for other institutions interested in establishing their own computer graphics instructional environment.

The accessibility of computer graphics technology has implications beyond the production of art objects. Computer-aided visualization of symbolic data is currently a major initiative in the computational sciences (1), and may soon be one in areas of education (2). The sophistication of user-friendly systems will stimulate the application of computer graphics to a growing range of main-stream activities. Artist and art educators need to be aware of how the wide spread application of computer graphics might transform the popular visual culture.

For this reason alone, some introduction to computer graphics is a requisite part of any comprehensive, visual arts education. In the future, even the decision by artists NOT to apply or address computer graphics technology, in some form, will need to be a deliberate one, based on an understanding of relevant issues. The course described in this article is designed to give the visual art student a basic understanding and appreciation for some of the artistic implications of computer graphics.

**Table 1: Syllabus for ART EDUC 252.**

**ART EDUC 252** *Introduction to the Computer in the Visual Arts.*

**Required text:** - Computer Graphics for Designers and Artist, Kerlow and Rosebush, Van Nostrand Reinhold Company, New York, N. Y., 1986.

- ART EDUC 252 Handbook.

Each session last two hours, with 2 sessions per week. In addition, students are expected to arrange four hours of lab time outside of class each week.

### Section 1.

- session 1* - overview of course.  
- introduction to paint software.
- session 2* - introduction to photo-digitizing.  
- loading and saving images to floppy disk.  
- duplicating disk.  
- project #1 assigned.
- session 3* - basic computer science concepts.  
- display memory.
- session 4* - display memory continued.  
- introduction to image processing.

### Section 2.

- session 5* - basic image processing operations.  
- project #1 due & project #2 assigned.
- session 6* - file systems and directories.

### *session 7*

- review for mid-term examination.

### *session 8*

- mid-term examination.
- class discussion and exhibition of projects #1 & #2.
- project #2 due & project #3 assigned.

### Section 3.

- session 9* - introduction to 2D screen space and coordinate system.
- session 10* - 2D screen space vs. 3D world space.  
- introduction to 3D graphics.
- session 11* - 3D scene parameters.  
- 2D data (images) vs. 3D data (objects).  
- project #3 due & project #4 assigned.
- session 12* - basic transformations: rotation, placement, scaling.  
- object generation: transforming and instancing geometric primitives.
- session 13* - low level display algorithms.  
- lighting models.  
- surface attributes: color.
- session 14* - project #4 due & project #5 assigned.

### Section 4.

- session 15* - high level display algorithms.  
- surface attributes continued.  
- object generation: solids of revolution.
- session 16* - object generation: extrusion, lofting.
- session 17* - demonstration of higher level paint techniques.
- session 18* - video presentation of computer animation.  
- class discussion and exhibition of projects #3 & #4.
- session 19* - documenting projects.

**session 20**      - review for final examination.  
                     - class discussion and exhibition  
                     of projects #5.

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**final period**      - final examination.  
                     - exhibition of final slide sets.

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1. McCormick, B. H. et al. (ed), Visualization in Scientific Computing, *Computer Graphics Computing* 21, 6 (November 1987), ACM SIGGRAPH: New York.
2. Brown, Judith R.; Cunningham, Steve; McGarth, Mike; "Visualization in Science and Engineering Education". Submission to *Computer* magazine for consideration for the August, 1989 Issue on Visualization in Scientific Computing.

# THE AESTHETICS OF ART AND THE COMPUTER 25 YEARS OF ACHIEVEMENT

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## ABSTRACT

Artistic involvement with computer graphics poses many questions. While the art and technology of mixing computers and imagery have clearly come of age, die-hard traditionalists continue to question the merits of any art produced through the intervention of a machine, just as at the height of the Industrial Revolution, the British art critic John Ruskin declared that "anything made by a machine is inherently ugly". Indeed, the conservative old-guard rejects the legitimacy of computer graphics in much the same way that their great-grandparents questioned the legitimacy of photography as an art form a hundred-fifty or so years ago. Yet computer graphics do fit into the continuum of art history. The milestones of computer imagery can be identified from their beginnings in the mid-1960s to the pivotal contributions of today that will lead to the next decade and beyond.

## A NEW ART WORLD

Computer graphics is blindingly new. No one ever produced computer art before 1960, nor could have before this century. This very fact affects in profound ways how people who make computer graphics can function. Few can be certain of how to approach this new tool, and rarer still is the viewer who knows what to look for in this burgeoning medium. As history has demonstrated time and again, format and aesthetics are almost always adjusted from older, established artistic fields, and rarely invented afresh.

With the emergence of every new field, early participants bring the values and philosophical foundations of the world in which they originated; only later adjusting standards of judgment about what is good, how to work, and a sense of the problems that need to be solved anew.

For instance, the first photographers, working in the newest arena for artistic expression 150 years ago, tried to duplicate what painters were producing at that time,



Louis Daguerre The Artist's Studio 1837

mainly still lifes, documentary records, and portraits. One of Louis Daguerre's earliest works (1837) was a still-life set-up in a corner of an artist's studio, and so titled by him. Such a subject, he reasoned, would replicate what a painter could do---find beauty in simple themes. For the next 50 years, photographers continued to emulate painters, by focussing their skills upon portraiture, then the most lucrative assignments offered to artists. The standards for evaluating both still life and portrait photography continued to be those applied to the same themes handled by painters.

On the other hand, cinematography, born in the 20th century, saw its closest parallels to be with theater. Early full-length films told stories in straight-forward fashion like stage presentations or else they imitated burlesque comedy with slapstick style the most common. Cinematography was considered successful when audience response seemed comparable to that of staged presentations. Yet, a scant 10 years later in 1924, filmmakers discovered the possibilities of space-time manipulation in such works as Sergei Eisenstein's *POTEMKIN*, and very shortly thereafter became aware of the advantage of extreme close-ups impossible to achieve in theater, as well as panoramic views. Films are judged today on the criteria unique to the medium and often far removed from standards applied to the stage, and rightfully so.



The ever more popular art form of video, nurtured from roots in television, was much affected by a symbiotic relationship with film. The first televised offerings imitated the "eyes and ears" approach then used in filmed news and sports clips, combined with radio news gathering. Our increasing addiction to television has forced some development of the medium toward concentrating on its electronic traits. As a fresh art expression it seems clear that the aesthetic philosophy of video has yet to be fully articulated.

The raw new art form of computer graphics, like any unknown, untried medium, has with time, predictably, derived its approach from its predecessors in art history, though having first pursued closer ties to science. The birth of the earliest digital computers in the 1940s suggested an aesthetic for graphics that was more appropriate to the technology that produced it than to fine art. As a result, computer art departed only slowly from its scientific roots, finding some affinities by the 1960s with optical art that was "trendy" at that time. If we examine those earliest computer artworks, we find that linear patterns certainly predominate. These computer-generated graphics demonstrate connections both with drawing and with printmaking; not surprisingly, since with printers, images like prints are produced by inks applied directly onto paper. The obvious difference between all three media lies in the absence in computer graphics of any direct trace of the artist's hand in the execution of the piece. The steadiness of the computer line cannot match the hand-drawn line that reflects every shade of feeling intended by its creator. Clearly, then, the aesthetic of computer graphics will have to stem directly from the unique characteristics of the computer medium alone. Yet if the scope of graphics continues to expand, whatever inherent individualization exists in the medium will become increasingly difficult to pinpoint. The very prolificity of the art tends to blur the fine differences that do exist. The key criterion may remain with the technological base of the medium seen as an extension of the human body and mind, while also amplifying intellectual and visual experience.

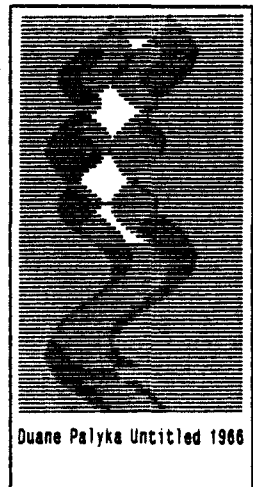
#### HISTORICAL PERSPECTIVE A GALLERY OF ART

Art by machines has a venerable history. In our time, Andy Warhol was said to have remarked (1963), "The reason I'm painting this way is that I want to be a machine, and I feel that whatever I do, and do machine-like, is what I want to do." He must have been thinking of computers. We do know that he briefly dallied with a Macintosh, delighted with the endless repeats that the machine could generate.

Computer graphics in the early 1960s consisted of diagrammatic forms, produced with a digital electronic computer and a drawing instrument connected to it. Some of the first images might be taken to represent "action" works, not far removed from the "action paintings" that dominated the decade. A 1963 work produced by Andrew Colin at the University of London on an Atlas computer involved five standardized shapes: the circle, the ellipse, the triangle, the square, and the rectangle; randomly selected, randomly sized, and randomly oriented with overlapping shapes, distinguished texturally in the printout. "While the bulk of pictures produced in this way," Colin observed, "were of little aesthetic value, many were successful visual experiences, offering textural variety with unity in related, though diversified, shapes, cohesively arranged." 1

1 Colin, Andrew "Computer Pictures" Cybernetic Serendipity, Studio International, London, 1968. p. 95.

Somewhat later (1966), a more sophisticated program was written by Duane Palyka in Algol on Carnegie-Mellon University's Bendix G-21 computer with a standard uppercase character set. Beginning with simple shapes, programmed to relate to each other on a 6 X 6 grid. The relationships based upon reflexive properties and negative variations of the original shapes he designed, exhibiting "a subtle radiating diamond structure radiating beyond the viewers' immediate encounter with the print. All the mathematical manipulations and calculations of each print are programmed to occur in the first part of my program. Only when the computer has finished this phase of the operation does it print out the completed form of the print. Thus in my more complicated pieces, the machine manipulates the design structure for one-half to three-fourths of an hour before finally printing it out. The value changes in the printing process are created by printing alphabetic characters upon each other, and range from the initial white of the paper to a total black character created by printing a "T" upon an "E" upon an "N" upon a "Z". The increased time-length occurs in works where each design is considered to be composed of 10,000 variable point positions...The output contained the inputted code of the program followed by a sequence of computer prints, each differing from the one before it. This variety



Duane Palyka Untitled 1966

results because a random generation was used throughout." 2 Expressing rhythm and flow, these works can be considered optical art, embodying the other characteristics typical of the style coincidental in time with the historical movement; while utilizing the computer's strongest features, namely, random and controlled repetition of programmed patterns.

2 Palyka, Duane "Computer Prints" Op. Cit. p. 92.

With the introduction of scanned images, a new era in computer art was born. The reclining nude mural by Kenneth Knowlton is particularly memorable. A photograph that many characterized as conventional was transformed through computer quantizing into 8 levels of brightness. "A given density was reproduced in the processed picture by the number of primitive black points occupying a 10 x 10 square...When the computer found a quantized picture region of a particular level, the appropriated subpicture was called up and printed by a microfilm plotter at the proper location. The resultant microfilm was then enlarged photographically to produce the final mural...The effect is very much like that of viewing a newsprint photo very close up at first, then stepping back." 3

3 Harmon, D.L. and Knowlton, K.C. "Computer Generated Pictures" Op. Cit. p. 87.

The entry of a human figure at this point in time brought to computer art a new dimension, quite different from the aesthetic of the earlier optical art pieces. More than the mere addition of live subject matter, the nude reveals its technologically derived origins. The 5 x 12' mural attracted considerable examination from varying distances, not unlike the viewing of neo-Impressionist works. Close scrutiny explores the 11,616 tiny patterns that entirely disappear as the observer moves away from the computerized piece.

Pattern continued to dominate computer graphics for some time, while subject content became expanded. Landscape textures and forms were introduced by Colette and Charles Jeffrey Bangart. A linear quality dominates in their random observations of leaves and grass. Since the growth of grass is also random, and random is an innate computer facility, computer grass is natural grass. Colette Bangart who conceives and produces most of the works derived from her partnership with Charles, describes the procedures quite clearly.

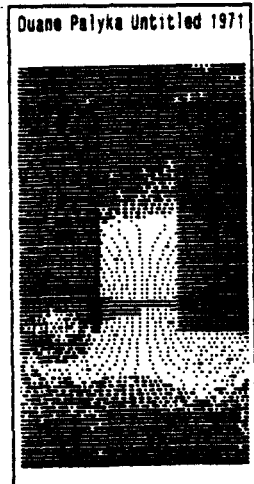
"I always seem to be in the process of learning about line and land forms. I learn from what I see and what I draw. What my hand-eye draws is different from what the computer draws. A computer helps by

offering new visual ideas. These ideas in turn enrich new hand work which generates additional ideas which extends my thinking about computer generated lines. The learning circle closes on itself. The computer and Jeff force me to verbalization and conception of what the making of a graphic drawing really is about. And I in turn force Jeff to think about the programming of serious aesthetic problems. Together we try to define what makes up a drawing we would like to see. Without conscious understanding of what a drawing is we could not use the computer as a drawing medium. A line carves out form on a white sheet of paper, a line carves out implied visual space. A line is an abstract element which I have seen and explored. A line is grass or the edge of a leaf, a shape, a symbol. The line does not exist, it can be drawn." 4

4 Bangart, Colette S. and Charles J. "Computer Grass Is Natural Grass" ARTIST AND COMPUTER, Leavitt, Ruth, Harmony Books, New York, 1976. p. 20.

These last works are not only examples of computer technology but also a humanistic exploration into nature. Mathematical formalism and pure geometry, in combination with the human hand, offer us new insights into a somewhat eternal preoccupation with the world around us, made palpable through computer technology. Duane Palyka's untitled 1971 works seem also to push natural interpretation quite differently but still further in what suggests to the viewer the onrush of waters as observed through more static elements, perhaps evocations of trees.

Darcy Gerbag, on the other hand has established a vocabulary of non-objective flat colored shapes that are texturally embellished and quite characteristically identifiable as her oeuvre even among masses of other computer art. All exhibit a powerful thrust in patterns that offer considerable diversion and individuality within a non-figurative idiom. Surprisingly perhaps, these computer pieces, usually presented as serigraphs, are strong fine art statements that none-the-less evoke the somewhat mechanical computerized procedures required in their production. Perhaps their success as art statements can be directly attributed to these factors



Much of the viewing public associates fantastic, futuristic worlds with computer output and David Em, in partnership with Jim Blinn for his programming expertise, never fails to delight us with his creations. Devoid of any human reference, these brilliantly colored graphics plummet through space, projecting incredible complexities of structural systems, more likely to surface in the 21st century than in our own. The textural diversity in all of his imagery titillates the eye, while the viewer travels through surreal space, savoring another time and other worlds. The special effects that include texture mapping depend upon other options unique to the computer; thereby accounting for the success of these works.

One of the unique advantages of computer graphic options is iteration, accomplished by writing a programming loop, which in some cases, repeats imagery while making some standard change each time.

William Kolomyjec's BIRDS is a fine example. The outlined form of a single bird begins a programmed odyssey that turns the bird slightly with each repetition. This continually revised orientation provides a pleasing swirling movement, but the linear pattern formed by the bird grid itself offers constant diversion. Some of Kolymjec's work evokes our fascination with illusion, exemplified by the paintings and drawings of M.C. Escher. However, beyond the German artist, Kolymjec capitalizes most successfully in the wondrous potential of the computer for serial repetition and transformation.

Perhaps more than any other contemporary artist, Duane Palyka demonstrates the virtuosity inherent in an ultimate merger of science and artistic skills. Such striking work as Picasso 2 demonstrates highly complex computer programmed manipulations and transformations that often yield disconcerting, surreal results.

In several of his images, Palyka begins with a 3-dimensional female form originated by Ed Catmull for o r m



Duane Palyka Picasso 2 1978

a live model. Evolved from a series of geometric shapes, modified by computer, the figures can be shown from any angle and illuminated from any direction. Beginning with four of these figures, he "texture mapped" the forms, retaining a serendipitous "bug" in the program that caused a random sparkle of texture. Palyka concurrently displayed front and back facets of the figures, not far different from Picasso's early Cubist stretched and twisted nudes, as he experimented with form and texture. For the average observer, this piece epitomizes the fusion of mankind's absorption with the female form as expressed in the framework of technology.

Since the dawn of the computer age just after World War II, Bell Laboratories has been a leader in computer applications and experiment. Recent work by Bell Laboratory's artist Turner Whitted and scientist David Weimer has continued this tradition of experiment. The painted grid pattern that recedes in most of their work, vaguely reminiscent of the late Northern Renaissance fascination with receding patterns in floor tiling, also echoes the pushing out of frontier horizons (in art) while the clarity of their images and reflections are among the finest of computer-created imagery being produced today, anywhere. Simulating photographic precision, produced by the most complex computer calculations and operations, their artworks reflect the unparalleled popularity of verisimilitude in today's society. Our plastic simulations of the real thing seem often to be preferred to natural creations...from our "marbleized" kitchens to the indoor-outdoor turf of our ballparks. Art look-alikes, a computer painting that masquerades as a photograph, adheres to this tradition. The critical point, however, is often overlooked in our sheer delight with the technological virtuosity. Not everything photographed with a camera can be classified as art, nor can everything that simulates a photograph, produced on a

monitor screen, even utilizing fractal geometry, be considered a work of art. It would seem that some of the most successful computer graphics allude to the human form, expressing its natural origins in the spirit of the technology that produced it. Eve, the Mother Of All Living appears to have attracted critical acclaim because it addresses universal sexual drives phrased as computers say it best. "With its series of concentric boxes, superimposed over the



Stella Russell Eve 1986

figure of a voluptuous nude...is a resonant work, the boxes seeming both like wombs enclosing the figure and forces radiating outwards toward us." 5

5 Lipson, Karin New York Newsday Art Critic, November 6, 1987. p.29.

"The most haunting piece by far is "Eve", a softly rendered female torso on which a series of ever-smaller rectangular shapes have been positioned; the smallest could almost be an embryonic form, floating in "the mother of all living". 6

6 Braff, Phyllis New York Times Art Critic, February 23, 1987.

In the final analysis, perhaps computer graphic art that incorporates reference to humanity at the same time that it explores the unique potential of the computer as a graphic tool within the framework of the art historical process may exemplify graphics at its best. Recent works of Peter Voci at New York Institute of Technology take all these factors into account, while inventively also making reference to video. Focussing on the most cryptic, and vitriolically received block-buster of 1907, now universally regarded as a masterpiece, Voci parallels the many repeats of Picasso's Les Femmes d'Alger (O. J. R. M.) with his own configuration, composed of many computer print-outs painstakingly assembled. Voci may also be addressing the fractioned "clips" popular in today's media presentations, referring to the pervasive control by the media of many aspects of modern life. However, as is typical of The Appropriating 80s, a term coined by H.H. Arnason, author of today's most popular college text on The History of Modern Art, Voci has plucked his image out of art historical context, endowing it with new impact. It is as if he "had determined to retaliate against the media for having coopted art, along with every other product of civilization, by coopting the media's own obsession with imagery and their filmic processes of overlaying, juxtaposing, or sequencing all matter of disassociated visual data." 8



8 Arnason, H.H. The History of Modern Art Harry Abrams, New York, 1986. p.636.

## SUMMARY

The computer represents the ultimate creative tool, capable of creating images of captivating power and beauty. From its beginnings in the 1960s, used, mainly, as a handmaiden to science, computer graphics evolved as an art form with technique and content reflective of this era. The focus has changed from optical art to a broad spectrum of styles and themes faithful to the mainstream of fine arts. Closely tied to the cultural life of today, perhaps, the finest computer graphic art of all is yet to come.

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# **Philosophical Aspects of Computer Art**

Isabelle Sabau, M.A.

Computer assisted imaging needs to be defined and explained. This paper proposes an attempt at developing some key items for distinguishing and understanding the meaning of the concept "art via the computer". Any aesthetic theory which proposes to explain this new art form needs to consider the interactive processes and social impacts as necessary components.

Man has been concerned with the quality of his aesthetic experience from the beginning of civilization. He is constantly struggling to improve his tools of creation that enable him to achieve greater freedom of expression. This search is evident even from a semantic point of view. The meaning of the word "art" derives from Latin, and the meaning of the word "technique" from Greek, and yet they both denote the same activity. These words have been used interchangeably since antiquity. Even today the term "art" signifies both the fine arts and the technical creative skill. Following the development and usage of materials through the history of mankind, it becomes apparent that these advances have allowed man to produce a multiplicity of objects which were not only functional, but became outlets of creativity. Art allows

man the opportunity to express himself through a variety of media. The overwhelming abundance of technological advances in the field of computers and electronic media has reduced the gap between art and technology to the point of almost bridging the pre-existing chasm, resulting in a new and unique art being born, which requires its own interpretation.

As a manifestation of the present social environment, the art created by the small computer reflects the advanced technological era of our times. Within this context previous aesthetic theories fail to provide the necessary guidelines for a proper understanding of this art, and thus requiring fresh interpretations.

For the purposes of this paper, the term "art" will be understood as referring to a holistic approach of interpreting and providing insights into human experience and environment. Some may object to this concept for it is very general and broad. Consequently, this definition diminishes the exclusivity and uniqueness of art products (a view quite prevalent for centuries), yet the modern art world and especially the computer medium appears to gladly embrace and support such a view.

The intertwining of art and modern society is most evident in the arts via the computer which have made the value of art as a social product eminent. Within his cultural framework, the artist needs to incorporate the overall context and attitudes of the modern lifestyle. Thus the new art is not an isolated instance of creation, rather it becomes closely interwoven with the social context from

which it was born enabling art to span a variety of fields and to furnish educational creations and environments in which the viewer himself can participate.

The small computer has evolutionized our attitude toward art and aesthetics. Instantaneous processes enable computer artists to achieve faster results and interaction with the media. The interaction between the artist and the computer is very personal and in many instances it allows for new solutions to artistic problems. One no longer deals with a single instance of a work, rather, one may have a monitor and at the same time reproductions of the image through slides or video cassette. One of the most important and at the same time challenging aspects of the computer era is the possibility to combine a variety of media which produces multi-media endeavors that manifest themselves audio-visually at the same time. This is a unique feature, for it allows the artist to manipulate animated or real time. In other words, one does not have to create an illusion of time or space, one actually works with 4-dimensions which opens up the avenue of creativity and allows the artist to create aesthetic experiences on many levels of significance. At the same time the computer is a meta-tool which allows the artist to make his or her tools and map out their own creative process so he can further investigate the meaning and function of art. Through algorithmic art the artist produces a program which, when run, gives rise to changing images on the screen.

After considering this brief description of the possibilities available, their implications need to be considered. First, the aesthetic process has been divided into three stages: the idea, the production, (which includes not only craftsmanship, but also the technical involvement of the machine), and the ultimate product, which is a statement taking a variety of forms, such as image, sound or other combinations. The major question arises: what makes a product of this process an actual work of art? The available

aesthetic theories discuss the cognitive aspects of a work (N. Goodman) or the intentional attitudes of the artist (W. Tolhurst, P.N. Humble). The term "aesthetic", however, does not have a clear definition; it is used to denote some unique experience or value that a work of art may produce in the viewer, yet this is extremely vague. There is no one value for art, since each media propagates its own experience. In other words, a work of music will have different values than a visual work. At the same time the audio-visual combination will not necessarily unite their respective values, rather it may generate new ones. One may solve these problems by limiting the use of the word "aesthetic" to the process by which a work evolves, namely, from the conception of the idea to the finished product. In this case one is not concerned with the essence of art, which is ephemeral at best, rather one should be discussing the progression and development of a work.

New questions arise when considering the electronic media, such as: what constitutes the actual art, the program, the images, do those images remain art if one transfers them to a video tape and reproduces them over and over again? New formulations for these problems are necessary, for the computer era has humanized art to the level of the everyday man, and yet it has given man a new challenge: what exactly is art produced by the computer, how does it manifest itself and what exactly is the new relation of computer graphics and computer art to the area of art aesthetics?

It would definitely be a mistake to separate the finished product, say the video, or the printout from the process by which it was developed. This is not to say that the program, for example, is the art work, rather, it is a conglomeration of program, manipulation, and product that together constitute the work. None of these parts can be separated, much like one can not separate the oil from the canvass, or the brushes from their manipulation. In order to understand the

relationship between computer-aided art and aesthetics, one would have to incorporate the interaction of machine and man which undergoes an aesthetic process and may manifest itself as a printout or video. But this manifestation would only be one instance of the work. In the case of programs that create time art, or art that is in constant movement, the program's significance becomes obvious.

It is my opinion that a successful aesthetics explaining art via the computer will have to involve the social significance of the work, in other words, its impact on the societal and cultural world. Since this media involves active interaction - not only of artist and computer, but in some cases also of viewer and the equipment - the success of such interaction should play a major role in deciding the value of the work. Instead of focusing on the physical aspect of the work, one needs to shift emphasis to the production and interaction of technology and man. Naturally, this is not to say that the machine will create works unaided, rather, one can accept into the realm of fine arts the program that allows the machine to randomly produce displays or works which can be considered art. Even such works will necessitate the input of man, and therefore, creativity still remains in the realm of humanity (this seems to be a major objection to computer-aided art!).

Another important point to remember is that the computer has enabled art to come down from its pedestal and become available to everyone. To judge the values of computer-aided works, one can still employ the aesthetic concepts of technique, composition and statement, but alongside these ideas one needs to add the four dimensionality and interactivity which are unique features of the electronic media. In other words, the possibility of combining media as well as the input (intention) of the artist are necessary criteria for a successful understanding of this new art form. And above all, one should not forget that electronic media produces art that has its

roots in the cultural and social environment.

In conclusion, I would like to add that this new and exciting field is opening many doors into the expansion of the imagination (it is only the imagination of the artist that sets limits for the works) and the freeing of the creativity of mankind. Bridging the science, technology and art gap provides a deeper understanding of the creative processes by simulating similar mental acts and allowing for the four dimensional artwork to be created.

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# BIBLE COMIX and Other Stories

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On the following several pages are included drawings and computer graphic images that show the gradual integration of electronic tools into a series of militantly hand-made projects.

I began to draw a comic strip of my own creation, **SPIZNET COMIX**, in the summer of 1985. Within several months I collected some of the pages into two limited edition comic books of twelve and sixteen pages respectively.

The learning process involved in publishing is long and painful. After I had published the first issue completely from black and white Photostats, I realized that in nearly half of the pages, the subtle gray tones I had added with brush and ink had been lost, much of it in fact going to black, making the pages less appealing (see Picture 1).

For the second issue I resolved to correct this error. I used Chartpak zip-tone sheets, and cut out areas that needed to show up as different levels of gray. There is precision involved in cutting and laying-in the zip-tone. You also need to know the maximum possible reduction size you will need so you can calculate lines-per-inch of your screens (a camera can resolve only so-densely packed dots without (again) going to black). Certainly this process limits the future versatility of the page of work.

The choice between Velox (a half-toned stat process which would interpret gray values on the page as a series of larger or smaller tiny round dots at the finally output size) or the Photostat using ziptone was purely financial, fifteen versus five dollars per page. And indeed, the second issue printed properly using the Chartpak technique (see Picture 2).

Unfortunately, I felt my material in that second issue was less enduring. Perhaps I was running out of plot ideas, and felt over-extended as a cartoonist testing out a new range of artistic styles under publishing pressure. I definitely needed to learn how to balance the chaos and order of black and white page layout.

Eventually, I attempted to digitize the Spiznet pages for the sake of ease of editing. The only means I had of doing this at that time was to use a low-resolution camera and MAGIC software for the Macintosh, bringing the images into SuperPaint for a 72 dots-per-inch once over. I found this method inadequate if I brought in a whole page at once, since my pictures were fairly intricate and I wanted to keep my handwritten text intact. This technique only worked for very large, simple images (see Pictures 3a & 3b).

The solution came in the form of what amounts to computer drudgery. Digitize each of six panels at full page size, rework and add patterns with SuperPaint (see Pictures 4a & 4b). Saving each panel (or sixth of a page) I could then place them one at a time into the PageMaker program, reduce each to 25% of its original size, position, and eventually come up with a full 300 dots-per-inch page with all six panels. I only did three pages using this method before turning to other artistic pursuits away from the computer.

Between 1985 and 1987 I worked constantly with different media: pencil, pen & ink, brush & ink, charcoal, pastel, brush and acrylic. Much of my work at this time took place in various clubs and coffeehouses in the Philadelphia area, where I sold artwork and created large-scale charcoal and pastel murals over the course of an evening. The performance allowed the audience an evolving "view" through a fantasy "window" that I could manipulate fairly quickly for maximum theatrical effect.

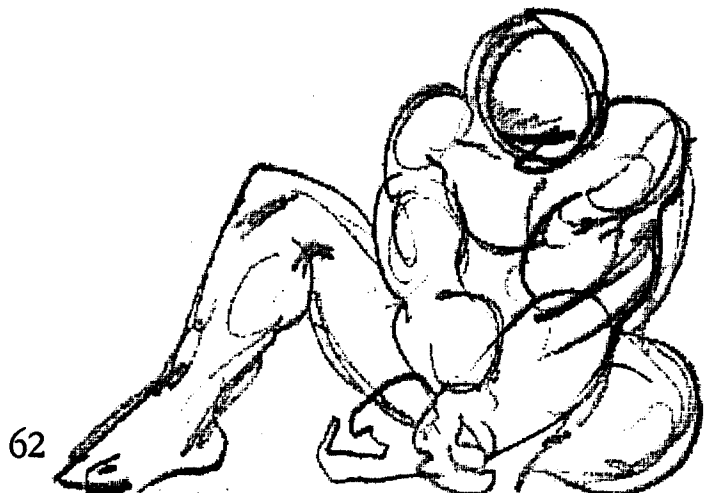
To keep perspective while interacting in this "non-academic" environment, I began to read with determination through the Judeo/Christian/Moslem scriptures. I incorporated passages from the Bible into a series of screens done on the Amiga while becoming familiar with the **Deluxe Paint II** paint program, which I was using for a commercial job (see Picture 5).

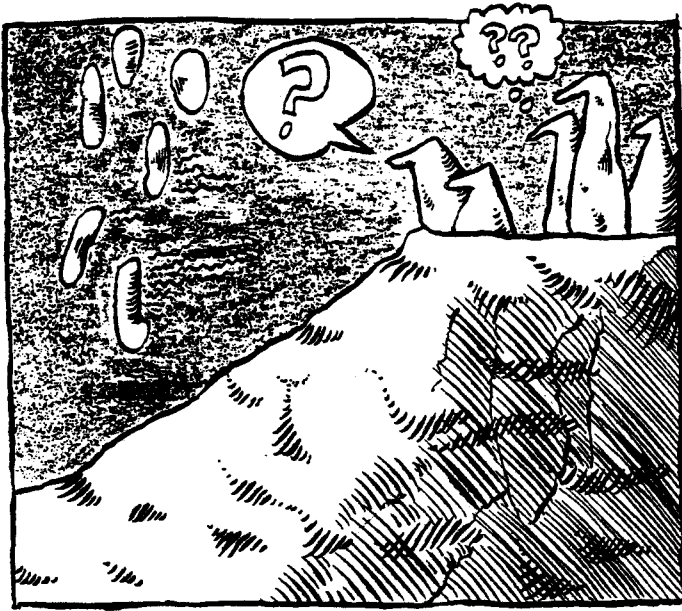
A little later on, in the summer of 1987 it seemed time to embark on an extended graphic project, but no big plot ideas had crystallized from the Spiznet world-system. By this time I had read through the Bible completely by reading one chapter a day from each of seven bookmarks positions.

I began the work from a random point, which happened to be **I Samuel**, Chapter 28, which involves David fleeing the wrath of King Saul into the hinterlands of the Philistines. My interest in the project increased with time, and I have so far created 40 pages of continuous material. A certain cure for writer's block!

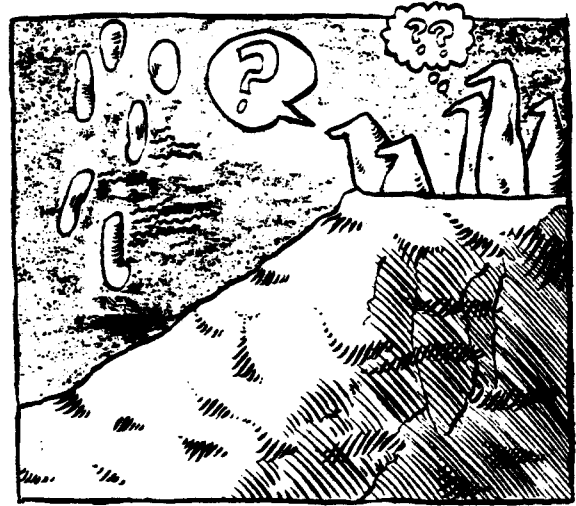
In July of 1988, I began to send **BIBLE COMIX**, a six-page mini-comic, to a small mailing list. I finally felt ready to test out the boundaries of the published work once again. And this has led me back to computers, specifically the Macintosh II with a scanner, as a means of producing type and incorporating it with pre-existing, traditionally created graphic images. I am also working with effects that can be achieved from scanned images (see Picture 6).

It still feels to me like the two-dimensional creation process thrives best in non-electronic media. But at this point we are finally able to "produce" on computer. It is a vehicle that can get the goods to the market.





**Picture 1a:** Original reduced 75%

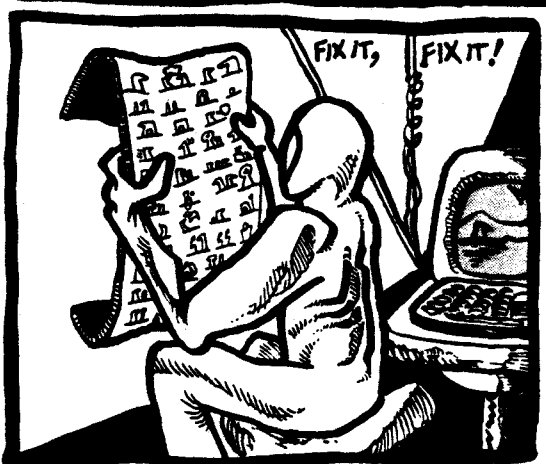
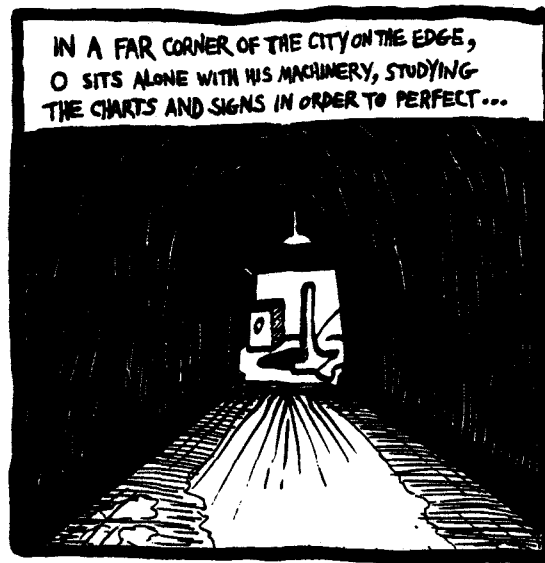


**Picture 1b:** Photostat of original w/ black areas

**Picture 1c:** Digitization of photostat on Mac

**Picture 1d:** SuperPaint modified version





Picture 2: Page from SPIZNET COMIX, issue 2

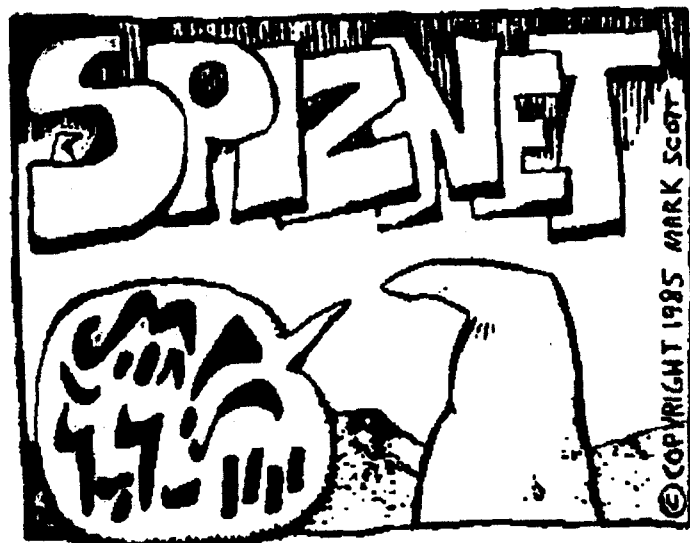


Picture 3a: Original drawing

Picture 3b: Digitized, reworked image



Picture 4a: Photostat of panel from  
SPIZNET COMIX, issue 1



Picture 4b: Digitized, reworked image

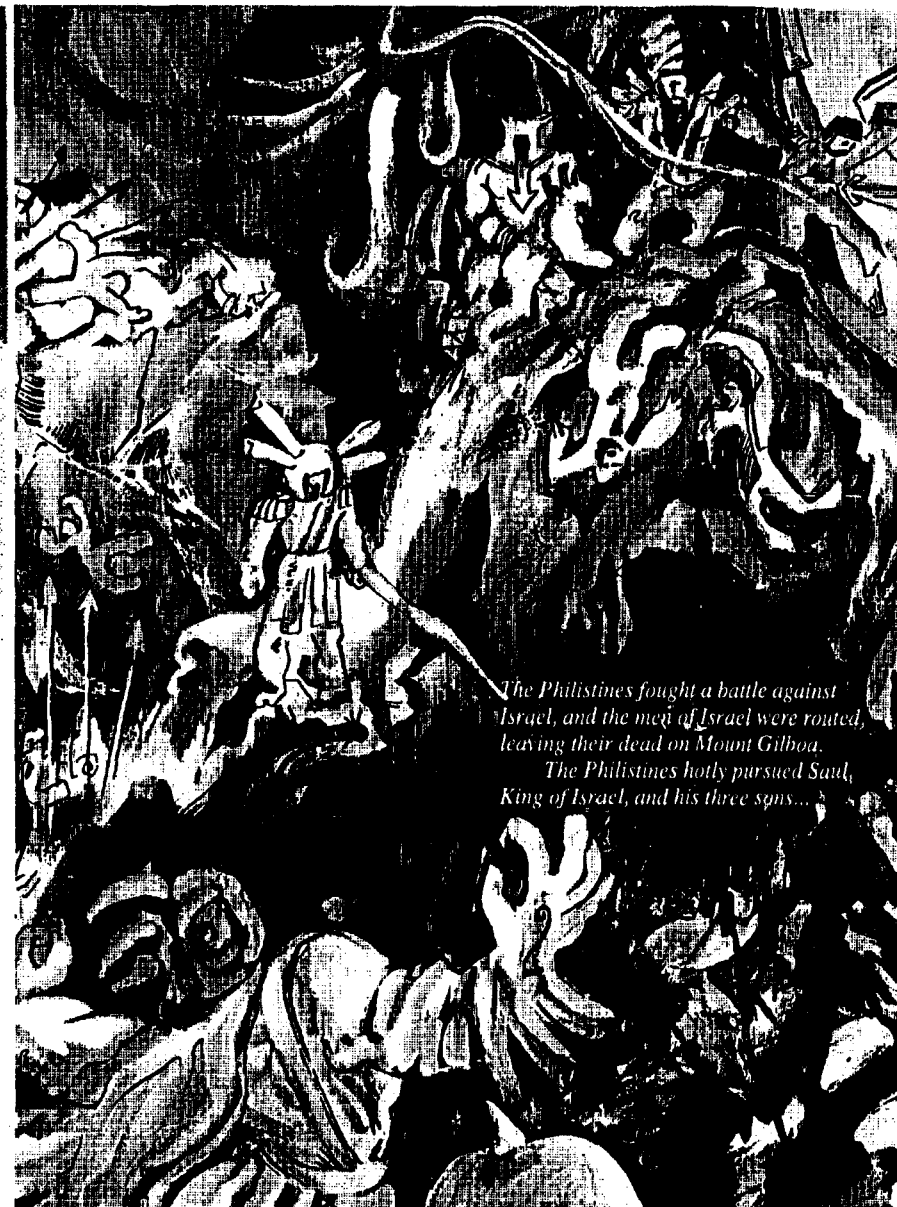




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**Picture 5:** AMIGA Deluxe Paint Image, 1987

**Picture 6:** MAC PageMaker, scanned image  
w/ text, 1989





# Art and the computer

*David Sorensen is a Quebec artist and associate professor of Fine Arts at Bishop's University, Lennoxville.*

*Please note that the second part of the article will be published in the june issue.*

## Automation and the arts

In an age of rapidly-increasing automation the artist finds himself faced with possibilities of considerable appeal: some say if Leonardo lived today he would surely be exploring with a computer. To others the artistic process seems to be irreconcilably opposed to high tech. Can we expect a future scenario in which the two will blend, or perhaps the appearance of two disparate schools, one unique expression coming from within the world of the computer, while another remains totally aloof and detached from it?

To some artists the rather difficult harmonics of these two realms have already been tapped and indeed put forcibly to work for well over a decade. With a broader segment of adventurers, a thrust that could constitute a popular movement is underway; a multitude of computer artists, media people or do-it-yourselfers, often with little formal art background, are producing work that, though inappropriate for the gallery/museum circuit, is vast in its implication as a new and radical form of communication. Conversely and within the art field, some rare pioneers have inadvertently laid what could be the foundations of an Academy in Computer Arts.

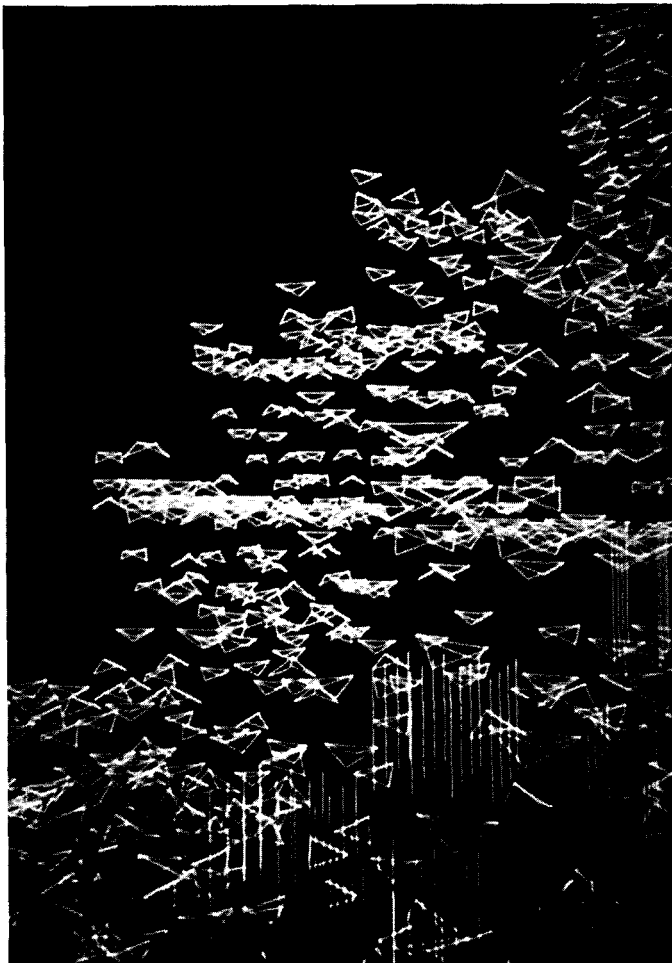
In the education field art comprehension is being taught in innovative ways on the computer and programs of great variety are being developed to teach hundreds of thousands of students from the elementary levels up (1). The contemporary music industry has

been indelibly altered since Robert Moog introduced his first synthesizer in the early sixties, and much in the way the printing press contributed to the demise of the oral tradition the computer is predicted to subtly and gradually alter our lives, our art forms, and our very thinking patterns.

## Symposium

At a recent conference in Philadelphia, the 1988 "Scan" Symposium (the Eighth Symposium on Small Computers in the Arts), during three days of workshops on music, education, and art, a board of sculptors moderated by Jon Fordyce, the Ohio artist and educator, explored existing and potential computer-assist sculptures in our milieu.

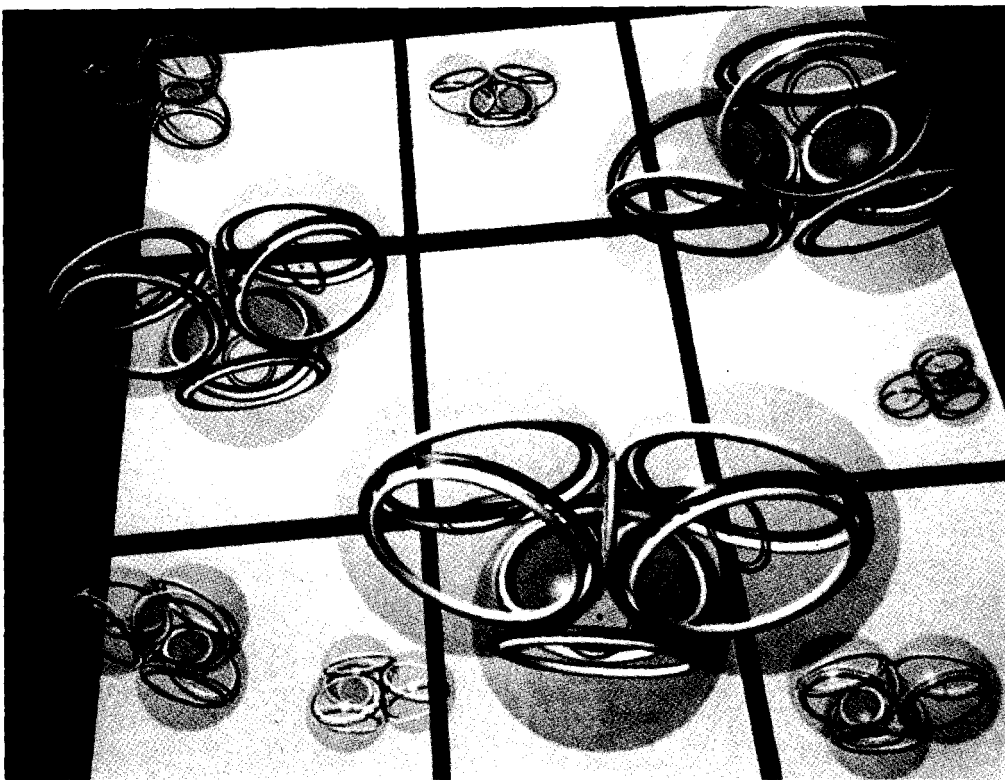
Rob Fisher, *Skyharp-Osaka*, 1986. Computer graphic.



An impressive board of panelists included Tim Brock and Licio Isolani, 3-D design educators from Pratt Institute, Rob Fisher, co-author of "The Design Continuum" from the College of Engineering at Penn State University, David Morris, sculptor and teacher of computer graphics and interior design from the School of Visual Arts, N.Y.C., Steven Pevnick, of the University of Wisconsin and recipient of the 1988 award at the Chicago Navy Pier Art Fair for his innovative computerized fountain, Ron Coleman, computer expert and long time fountain specialist from Bowling Green State U, Ohio, as well as international sculptor Kenneth Snelson, best known for his tensegrity pieces and now exploring atom structures on an Iris computer, and myself, a neophyte in the field, developing a sculptural color panel that gauges variation in electrical consumption in a small city. These panelists shared and exchanged views on the pros and cons of technology and its effects on art forms in their current production. In addition, Manfred Mohr, a pioneer in the field, was consulted in his New York studio.

## Technical information:

A concern of many was that of approach: how does the artist integrate the new technology into his or her creative flow? Once the needs have been defined, to explore or add to his present repertoire he seeks appropriate software programs (graphic design software, for example, provides rendering or



Kenneth Snelson, *Invasion of Cyclopropane*, 1988. Computer image

multi-angled visualization of a sculpture), and then the hardware (the actual computer 2) to run the chosen program. Isolani and Brock described the operational process: various types of polygons (multi-sided planes) are projected onto a cartesian planar coordinate system (x,y,z) on the screen. A point is a very small four-sided polygon, a line a long narrow polygon, a plane a single polygon, a volume numerous polygons connected to suggest a solid. Drawing combinations in wireframe (a see through 3-D, connect-the-dots method) enables composing of basic 3-D geometric forms such as cubes, spheres, cylinders, and cones, or more complex combinations. Free hand sketching on the screen with the aid of a hand held "mouse" or graphic tablet and digitizer allow for further transformations. Images can be stored and recalled or, if print-out equipment is available, recorded on paper or canvas.

#### Animation

Beyond three-dimensional representation animation provides a fourth dimension, that of movement or rotation in time. "... through interpolation, points can transform into lines, lines into planes. A single plane, while rotating, can transform into a curved plane; a curved plane can transform into a

double curved plane and so on. A simple interpolation from a plane to a double curved plane, for instance, consists of two workspaces containing the same number of polygons. The computer then averages the in-betweens, articulating the transformation over time. ... time becomes another axis for compositioning."<sup>3</sup>

#### New Approach

In addition to these abilities, enabling us to produce drawings and even tonal renderings for ourselves or for a client, we were informed of the computer software writers new approach to us, the artists. Fordyce's introduction and his article in the "Proceedings" pointed out that "until recently, highly capable 3-D solid modelling computer graphics had been the exclusive dominion of a few computer programmer/sculptors who reside within corporate or academic walls". But now... "one trend has been to package ever-greater computing power into ever-smaller physical computer chips. The megabyte plus computer memory requirements of 3-D solid modelling can now fit into competitively priced table top computers (for under \$1000.00 any of us can have truly amazing 3-D computer graphic system in our studio) ... and ... "despite the fact that these new products have been developed primarily for commercially oriented designers who will use them to produce inexpensive animated computer graphics television advertisements, the sculptors of the world also profit."

These notes of optimism led directly to exposition and discussion with the individual artists. How has the computer served as an assist in each case, and conversely what limitations has it presented?

#### Kenneth Snelson: structured explorations

Kenneth Snelson is an artist who moves effortlessly forward in his creations. In his early "tensegrity"<sup>(4)</sup> sculptures an elegance and sparseness define his connection with the underlying forms of nature and even demonstrate a somewhat remote association with science. These works reveal a directness, a crystalline structural integrity that evidence

5a lightness of spirit and a poetic orchestration of elements. What Buckminster Fuller made tangible through building and architecture Snelson expressed in the realm of sculpture. Indeed the two men worked together at Black Mountain College in North Carolina and Snelson's "tensegrity" propositions keyed many of Fuller's inventions.

Snelson's training with Fuller, Joseph Albers and Willem de Kooning at Black Mountain led him to The Institute of Design in Chicago and further to the Atelier Fernand Léger in Paris. From these Bauhaus/constructivist-based schools he assimilated both a feeling for the graphic elegance in elementary structures and for the extensive lightweight spanning potential of modular planning. Numerous exhibition and commissions executed from the late 50's through the 70's in the States, Europe, and Asia have established him now as a major figure in his field.

Snelson's fascination with the module which underlies his "tensegrity" works can be rediscovered in his ongoing research on atomic structure. His first questions remain constant in his vision: "What kind of inner organization determines space-structure arrangements? What really makes things stay together and manifest in tension-compression relationships?" A modular hollow tube, a compressive element held inertly in space by a tensed cable can contribute, in conjunction with other modules and cables, to a configuration that hovers and floats weightlessly in space. Images and structures, both from nature, (the skeletons of flared and floating dandelions), and man-made, (kites, itinerant tee-pees, and bicycles) ally themselves with Snelson's sensibility.

The atom to him is the ultimate module, the working ingredient of the known universe. And so what could be more



natural than to investigate its inner dynamics? The spaces, the crystalline orderly pattern, the internal forces determining its angularity or curvature, its working mechanics, and most importantly its actual appearance; these issues fascinate Snelson. In the past few years, setting "tensegrity" propositions aside, he has courageously moved into computer technology and with the aid of a Silicone graphics Iris 3130 mode with Wavefront technologies software(5), a computer created to do 3-D graphics and animation, he is schematically exploring and documenting a unique principle that has fascinated him for decades... atomic structure.

Though Snelson concurs generally with most computer artists that, given a long and arduous introductory period, this technology can be very useful and efficient in the areas of graphic representation and rendering, he still hesitates to rely on it for more complex problem solving. Perhaps as the technology evolves and becomes more time-efficient a future computer may be able, for example, to portray a random sized tubular member on the cartesian grid of the screen, locating it via a polygon and number system with a series of commands, appropriating a comprehensible angle and the required force and stress in the overall structure; but thus far it is still far easier and faster to build a maquette. Surface texture-wrapping, color and tone application, illumination, animation, and backdrop mapping with perspective grids are available and estimable now.

The computer, once the problem and program is defined, can achieve results comparable, even superior, to an air brush artist, in a reasonable fraction of the time, but structural projection is still not the property of the computer artist. Snelson reports that a 74 cable, 16 tube arrangement took him four days to 'draw' on a computer whereas a model was built, in a more direct, and 3-dimensionally more fulfilling way, in one day.

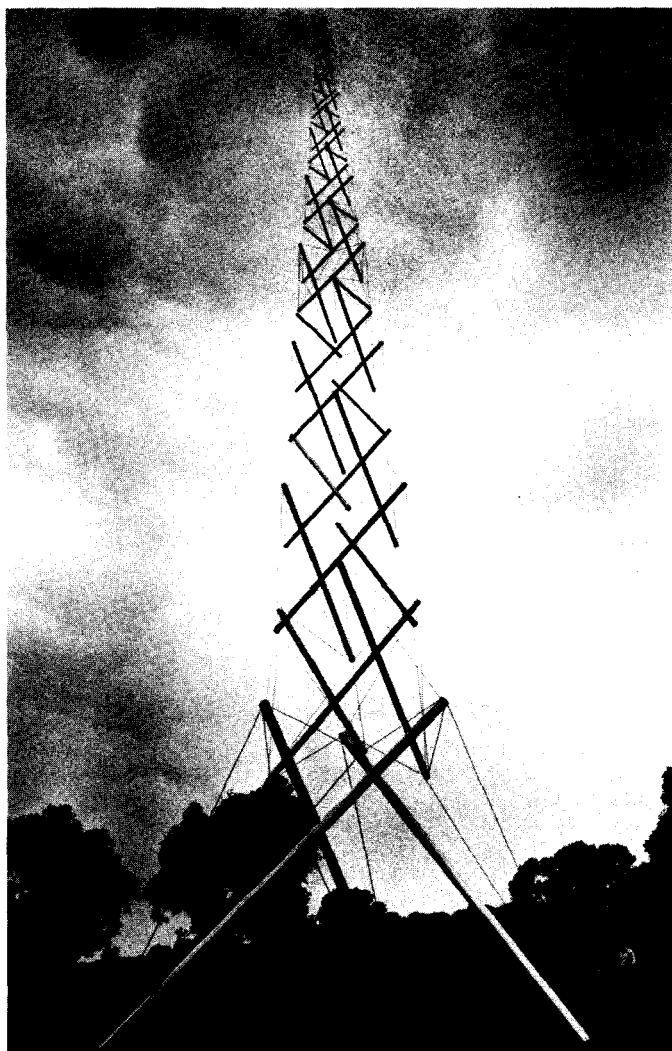
Snelson, with typical modesty describes himself as a kind of modeller, using a method close to that of a clay sculptor. His concern with form is on the level of internal dynamics represented by modules, so he emphasizes structure rather than mass, but he still arranges his elements much in the way a modeller would sculpt a form, piece by piece, lines replacing daubs of clay.

When questioned on the relationship between science and art he talks of a certain dissimilarity of goals, but also of bridges between the two fields. For example to Snelson the atom is really a subject of public domain; neither the artist nor the scientist can lay claim to it with exclusivity. The scientist, with laws and proofs, has little interest in what his topic actually looks like, what its natural manifestation as form is, whereas this is a point of entry for the artist. Perhaps each discipline can feed the other even though their defined requirements are seemingly contrary.

Snelson says he uses science and science books much in the way a tableau painter might use a library and historians to research a topic. If such an artist were to paint a canvas on the civil war, for example, he or she would need to know which captains, what kind of horses, what colors, what kind of foliage was involved. Similarly Snelson investigates the information that science can supply him with and he can occasionally use this material as a point of departure in his art.

In the instance of the atom, Snelson saw a dream come true in the late 70's when the price of computers dropped significantly and he could finally make real the visualization that had played in his imagination for years. The graphic computer image rather than a sculptural

Kenneth Snelson,  
*Needle Towers*, 1968. Aluminum and stainless steel. 60 ft. High.  
Collection of the Hirshorn Museum and Sculpture Garden,  
Washington, D.C.



one defined a final lightness and transparency appropriate to the atom.

Snelson entered a no-man's-land between science and art in pursuing his curiosity but pays tribute to his computer as an aid that "when doing its job properly... is a genuine-spirited, willing slave, entirely at ease with requests that require it to stay awake all night in order to render a multi-megabyte picture in time for breakfast. Even so, my dream of a fully animated tour through my invented submicrocosm will require more months, even years, than I ever imagined..."<sup>6</sup>

The results of his initial research are on view in a touring exhibition called "The Nature of Structure", which opened at the New York Academy of Sciences in Jan. 88 and runs until Apr. 89, then goes to the California Museum of Science and Industry (June-Aug. 89), and finally the National Academy of Sciences in Washington (Apr.-June 90).

By gliding and bridging from one discipline to another in search of the common principle Snelson reveals not only the humanism of an artist but also the wonderful curiosity of a true scientist.

#### **Rob Fisher: Atrium Design**

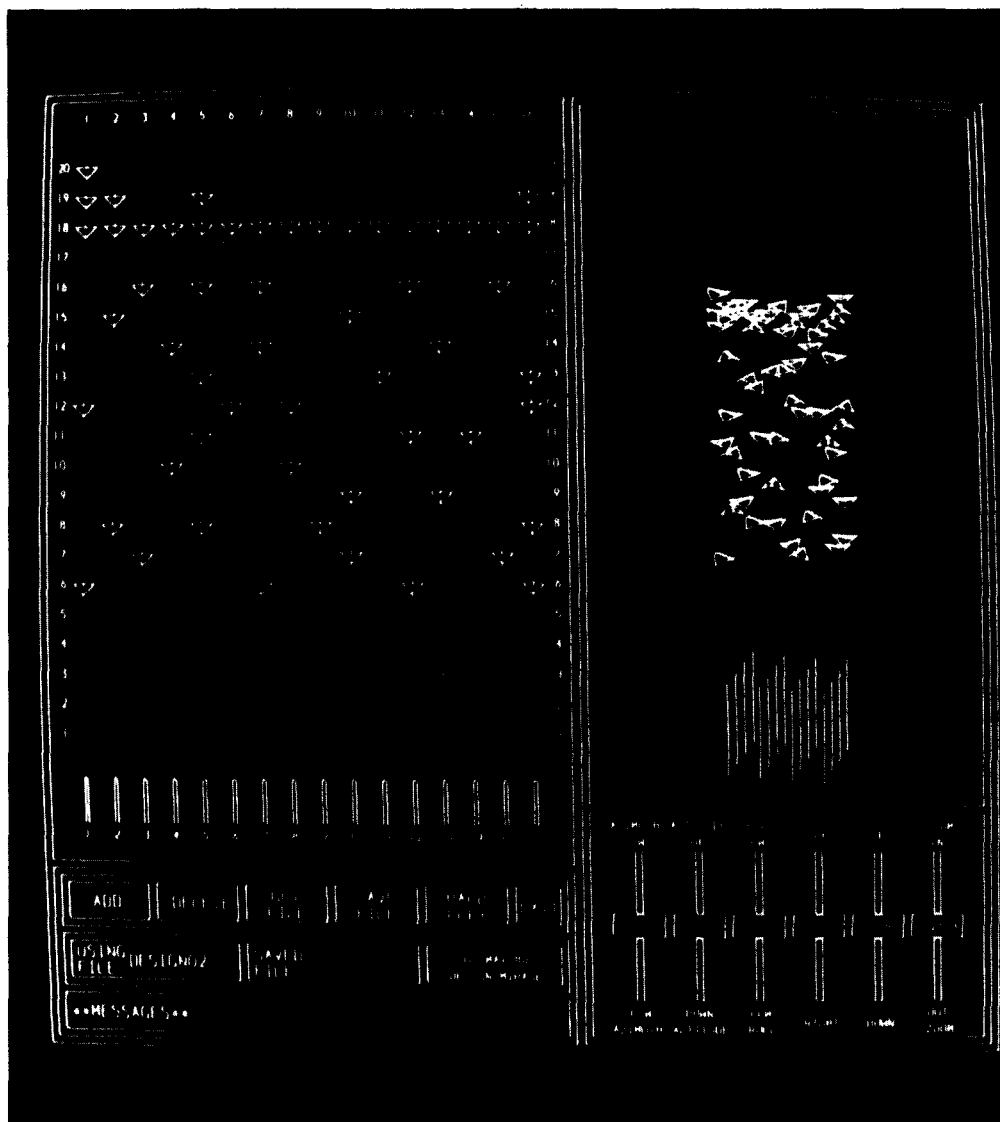
Rob Fisher, the co-author of the Design Continuum, a comprehensive survey of design principles published in the sixties, has become fully immersed in the computer age. In a number of large scale commissions, complex mobile configurations that are often suspended in the space of multi-levelled atriums, he has found the need to pre-calculate and pre-visualize a wide range of components for two reasons: first to present clear images to his client, who often speaks a different language than he, and secondly to better understand the space he is dealing with as it is often on a different continent than his studio.

In a Osaka commission for Hilton International he had to pre-visualize the interior space of a three-floored, vast open atrium that would be filled by hundreds of delicate floating aluminium shapes suspended on fine lines and anchored in place by stainless tubes at their lowest extremities. Fisher uses up to five computers ranging from Commodore Amiga 500 (serving Deluxe Paint, a powerful graphics program from Amiga), DEC Micro Vax GFX (processing 3D data from architects plans as well as Fisher's preliminary sketches of the work), 3 Evans and Sutherland Computer Graphics workstations (to achieve exact dimensions and locations of each component of the sculpture) and Stereo 3-D (assisted by color-glasses to distinguish background environmental data from the interior workings of the sculpture). In wireframe too many lines simply become a jumble and, as he has often not seen the actual space, composing bunches of lines with aluminium elements at different heights, then locating them in the overall configuration, requires clear 'walk around' viewing and high resolution 'real-space' visualization.

With an assistant, Ray Masters, who writes unique and ingenious programs to resolve the given problems, Fisher has managed to successfully overcome practically all the limitations a non-computer situation would present.

He even feels his sensitivity to real space has increased in a Zen-like way since using computers and Stereo. The surroundings now compliment and emphasize the emptiness of the space. Through the forward-receding resolution that Stereo revealed to him the newly defined in-between space is now much more visible in everyday situations. He concludes that the process has led to new perceptions, changing assumption to knowledge.

The experiential dynamic of the realm of form in real space is very hard, if at all possible, to duplicate. The complexity of eye and hand intuitively at work are Fisher's goal on the computer. By programming in such a way that the creative process in uninterrupted in any way, he comes close to duplicating the studio situation. This means pre-working much of the program so that stored images are solved and available like inner thought patterns. One such animation program has two active areas,



Rob Fisher - Simultaneous Viewing on computer program "Control" used for composing "Skyharp - Osaka", 1986.

one for defining individual clear frames, a second for storing and editing view sequences.

'Control', a program that Masters wrote, is able to locate his aluminium elements at different heights on a vertical scale, grouping a number together in one window, and simultaneously view them in rotation in a 3D, 'real space' situation in a second window.

Fisher advises artists to use and maintain all existing abilities and techniques and *then* to refer to computers, not to depend on video color as it is too intense, but to use it only for rough estimating (computer offers 17 million colors), and to employ computers not to duplicate the existing, for drawing updates, etc., but instead to use it at the conceptual level where it can enhance his ability to make decisions in new ways.

- 1 Pamela Sharp, *ZoeTropes*. Art Department, San Jose State University, California.
- 2 Suzanne Langer, A work of art as a public form of feeling.
- 3 Computers running graphic design software are Apple, Atari, Comodore, IBM, Tandy, Texas Instrument and NCR.
- 4 3D Design and the Cartesian Coordinate System in the Computer Licio Isolani and Tim Brock.
- 5 Tensegrity = tension and integrity
- 6 Produced in Santa Barbara
- 7 Catalogue: Kenneth Snelson "The Nature of Structure". The results of his initial research are on view in a touring exhibition called *The Nature of Structure* which opened

at the New York Academy of Sciences in Jan. 89 and runs until Apr. 89, then goes to the California Museum of Science and Industry (June-Aug. 89), and finally the National Academy of Sciences in Washington (Apr.-June 90).

Coming: David Morris, Steven Pevnick, Jon Fordyce, Manfred Mohr. Compiled by Yolande B. Auger on Atari 1040 ST

La traduction française de ce texte paraîtra dans le prochain numéro de juin.

# Art

## AND THE COMPUTER (continued)

*The first part of this article was published in ESPACE, Volume 5, # 3, Spring 89.*

Water, like light to a painter, is a primal gift. To David Morris, the sculptor/teacher, it is rooted in his beginnings. When he was very young his parents, both artists, in search nourishment, left the New York art scene, the turmoil of Pollock and Rothko, and settled in the mythic realm of the Pacific Northwest. Mark Tobey was Morris' godfather and memories of the world of calligraphy and flowing rivers linger affectionately with him to this day. Morris' parents are still painting and sculpting today and he is still an artist fascinated with water events: the relationship of liquid to solid mass, and more universally, the underlying principles of growth; to Morris these are inherent and discernible in the flow of the river.

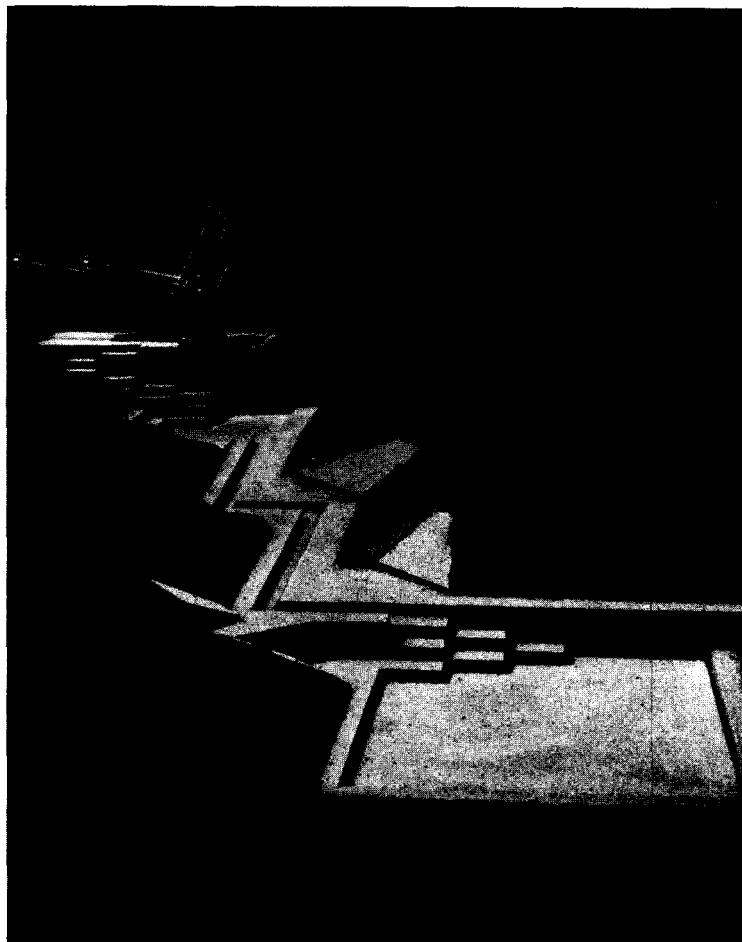
In his Brooklyn studio, Morris has recently used the curvature that reoccurs in many of his maquettes of aqueducts, underground waterways, cascading walk-under plateaus, to program structures on his 386 P.C. Del Computer. By starting with an intuitively-derived, meandering line and by building crystal-like polygons around the curving line, he is generating forms that can be translated into free standing scul-

tures. The polygons can be neatly welded into faceted units of growth, collected around the vertical original line.

To David Morris the computer can reveal unknowns, a latitude of possibilities, and as with the nurturing of a child, by coaxing it in a direction, not knowing where it will actually end up, some pleasant surprises can result. He also feels the need to compile; having worked freely for years in an area of familiarity he wants now to write down some of the rules, and to extend them. Although he can achieve as much, as quickly, with cardboard and a glue-gun with intuitive structuring, he enjoys the surprises of the computer. He nonetheless maintains a sense of apprehension; and he questions the depth of its questing.

"A good drawing can make your day, or your month for that matter. The computer image doesn't provide that satisfaction." To be on the cutting edge of the art world via technology doesn't interest him... the machine is like fancy cutlery, enjoyable, luxurious, but not essential to the fulfilment of one's daily diet.

As a child damming irrigation ditches, observing the marvelous objects that water often washed up, Morris unconsciously set his course. As an undergraduate at Reid and graduate at M.I.T., he worked his way through myriads of complex form situations and arrived at final and simple resolutions. Now he uses the computer key board over week-long periods to see what will wash up on the screen. To Morris, a mathematical form is as natural as a piece of driftwood or a walk in the forest, and the computer is the tool to get at an infinity of mathematical forms.



David Morris, *Umbrella Fountain*, 1970. Portland State University Proposal (Oregon).

The river, as it flowed from somewhere to nowhere, always had the quality of a liquid that magically transformed the world of solid mass; it also had an inner crystalline structure that somehow was the growth principle itself. Perhaps technology is now playing a role in his adult life by helping to order his perceptions into concepts and structures that are palpable expressions of those early dreams.



Steven Pevnick, the *Rainfall Project*, 1984  
Helix Image, 5 ft tall.

#### Steven Pevnick: Water and Myth

An artist and professor at the U. of M., Milwaukee, has made one of the most significant, art-related breakthroughs in the technology of our times. When Steven Pevnick became curious about computers in 1974 and approached a group of computer musicians, they agreed to include him in their ongoing research; they let him use their computer systems, providing he create some visual complement to their own musical interests. With its rhythms, syncopations, repetitions and complex patterning, music offered a real challenge to a visual artist, and Pevnick, on that rainy afternoon, did some soul searching. He returned with a unique proposition: to create an acoustic, percussive definition of space using water droplets.

In the pursuant months, he produced a computerized waterfall that actually shapes and comes close to painting, a space with falling water configurations. Pevnick's excitement about the fountain is not solely over the technical breakthrough that the computer has provided and which has brought him considerable acclaim in hi-sci circles, but more significantly, about extending our perceptions.

"When we come to an experience we've not seen before, we use tools that are fresh and unique about us to try to perceive. The means of communicating is a tool... and ... the tools that we use to perceive will affect what we actually see. The fountain becomes a new tool for investigating how we make images... Then we find things that are really unique at the other end of that."<sup>1</sup>

Thought and visualization are connected again and with an invigorating, bristly-light, yet mysterious media like falling water, Pevnick feels that by subtly altering its path via the computer, he is extending and adding to the mystery, thereby recaptivating and connecting directly to the inner self or eye of the viewer. This process transcends the usual reach for beauty in culture. It engages directly where the viewing of a known icon or painting, in a museum for example, requires a tradition and considerable knowledge to see or "read" according to our current dictates. Intellectuals and little children alike are fascinated with the fountain. A "suspension of disbelief", blended with the technological query "How does it work?" replaces the layering of thought and knowledge of the usual museum experience.

In a highly participatorial culture such as ours, technology can but does not have to erase the collective mythic quality of man's earlier experiences. When, at the turn of the century, a child opened a tap, the ancient question of "how?", the mystery that urban fountains of the past had always prompted, was answered and the mythic quality was lost. Pevnick hopes to restore that quality in his new fountain.

His research led to a modular design that can be altered depending on the height of the fountain. In one configuration, the grid has 2,300 valves and nozzles in groups of nine with 256 individual program channels of dropping water; four personal computers control one square foot, each sending out jets of water according to the given program and creating falling ribbons that spiral, forms that take on crystal focus as they fall, cubes and pyramids that metamorphosize into abstractions as they cascade down. Whatever geometry the program calls for, the viewer experiences in water, a kind of vertical mini-sky writing. This year, at the Chicago Navy Pier installation, the fountain said a visual, watery "Hello" in an array of different languages.

A work of art should not only catch one's interest but sustain it and, notwithstanding the revolutionary technological and perceptual advances,

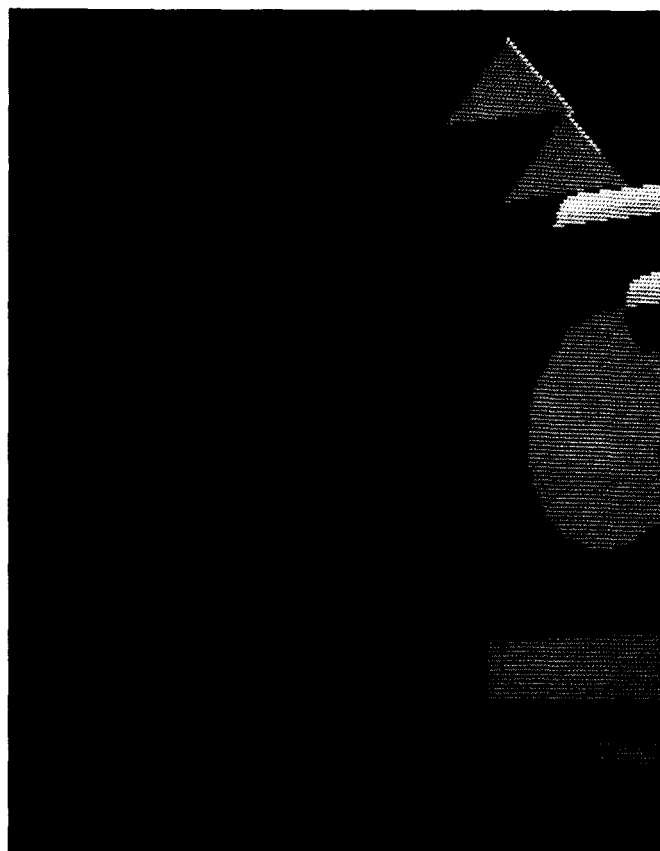
some viewers may still have reservations about the creative integration of all the mysteries involved. In the future, Pevnick hopes that the interaction of the surrounding people will be monitored by the fountain and that appropriate images will be generated for the mood of the group; also, that children will wave and be answered to. The potential as an urban communication media and tool seems unlimited, so we can expect to see his work before long in an increasingly international context.

#### Jon Fordyce: Direct Creations

Jon Fordyce likes to work openly with the computer as creator. Rather than enhancing perceptions and working traditions, he feels it better to use graphic dot-matrix printouts directly in generating new form combinations. By a kind of trial-and-error dialogue between ancient manual approaches to metal, and the hi-tech graphic images, he finally emerges with a three-dimensional sculpture.

As a carver and forger of steel, he has confidence to proceed in his ex-

Jon Fordyce, C.A.D. *Image for Mandala in Transformation I*, 1987.



plorations, though in 1981, when he began with the computer, he still had a lot to discover. Learning the craft skills of the computer and making the software entry required many months. The range of equipment has varied from Atari 800, to Atari 1040 ST with Antic Software CAD, 3D, 2D and Cyber texture, a Gemini 10 Dot Matrix Printer, Micro Painter, a video cassette recorder with camera combination and finally, stereo tek LCD 3-D glasses.

An interesting observation by Fordyce about the transformation from 2D to 3D is one that concurs with the late David Smith and his credos regarding gravity. Although welding offered "drawing-in-space" and many illogical-sense propositions, Smith would never violate the natural order of things; visually, the forms always stood up in a way that would not fool the eye. Fordyce has realized the difference between real space and computer imagery and has had to make the adjustment as he proceeds. His images do have a repetitional, pattern-like quality reminiscent of computer print-out, which is interesting, but they also sit solidly on the ground. Fordyce believes that "as

more fertile artistic minds take advantage of technology, and as that technology becomes even more capable and complex, we will see the evolution of styles and techniques that now exist only in our dreams."<sup>2</sup>

### Semiotics: The Generative Languages of Manfred Mohr

The week before the symposium, a visit to the New York studio of known computer artist Manfred Mohr, who has exhibited internationally and has held numerous Montreal shows with Gilles Gheerbrandt and two museum retrospectives in Germany, not only augmented the scope of the overall investigation but also raised and addressed the timeless issue of aesthetic standards, the parameters implied in this relatively new game of computers in its interaction with art.

Mohr began his work with computers<sup>3</sup> in 1969 and, being constructivist-based, like Snelson, he also deals with primary geometrics. An underlying desire of Mohr's is to not only investigate the inner workings of primary forms but to fracture their perfection and stability, to upset their inertia, and to release their dynamics to create new worlds.

For fifteen years, Manfred Mohr has disciplined his interest, much as Albers did with the square, to a logical yet poetic research on the cube. Where multitudes of artists have passed over such a basic research, Mohr has generated an endless variety of new propositions and visual statements of high aesthetic interest by staying within the confines of a single premise or form. As such, we sense his affinities with anthropologist/author Claude Levi-Strauss (*Elementary Structures of Kinship*) and deconstructivists such as Michel Foucault and Roland Barthes, all radical investigators of our compilation of cultural knowledge and its relationship to actual experience, and further, to language.

To Mohr, the stereometric cube as we know it is like a language, the English language, for instance. Once the underlying order and symmetries have been explored in an extended work period, an alphabet and a vocabulary start to make themselves available to the artist. When the cube has yielded its inner workings: points, lines, vectors, squares and its potential system of line relations, Mohr begins to compose, combining logic and flights of fantasy or fun; he begins to write poetry. In this instance, the poetry is English poetry. To extend the metaphor, after a period of perhaps two years, he will become restless with English poetry, or the cube's potential as English poetry, and he will move on to a second work phase in which the modalities of expression increase. He then turns to French poetry.

By combining his first work phase with French poetry, dividing the cube and rotating its separated planes on different axes, creating outer structures with inner signs, running lines of growth from one side to the other, superimposing frontal and rear views of structures and

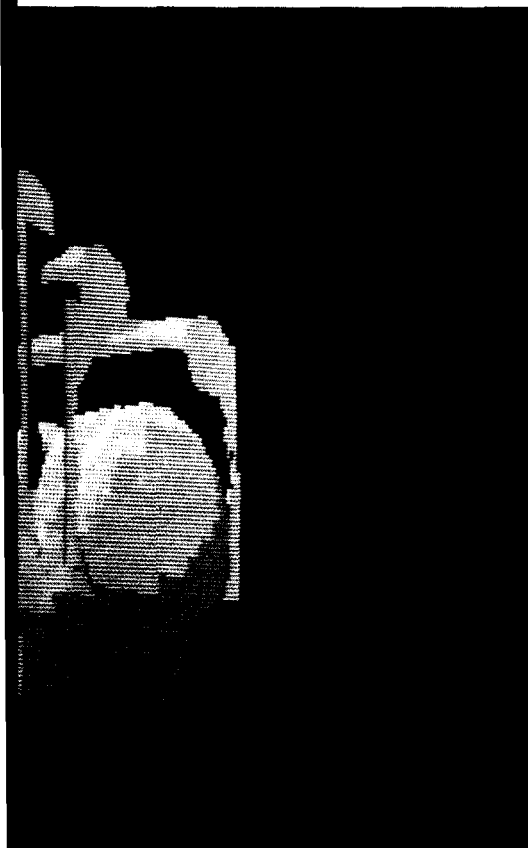


David Sorensen, *Gate which will contain computer controlled panel, 1988.* Granite. 26 ft high.

signs; by pursuing these complex manipulations assiduously and logically within the matrix of conceptual verisimilitude, Mohr ultimately finds himself in the sunrise zone of linguistic and visual disclosure. This language blend is directed through what he refers to as "aesthetic filters".

Despite the pleasurable aspect of such voyaging, Mohr is constant in his dedication to the logic implied by the computer. He does not interfere with the algorithmic aspect of the process; intellectual integrity always stands first. If the occasional result is visually less than satisfying, it is not necessarily removed but is seen as part of the true form of the program. To this degree Mohr consents to the attribution of "purist".

The fusion of poetry with mathematical accuracy is sec-

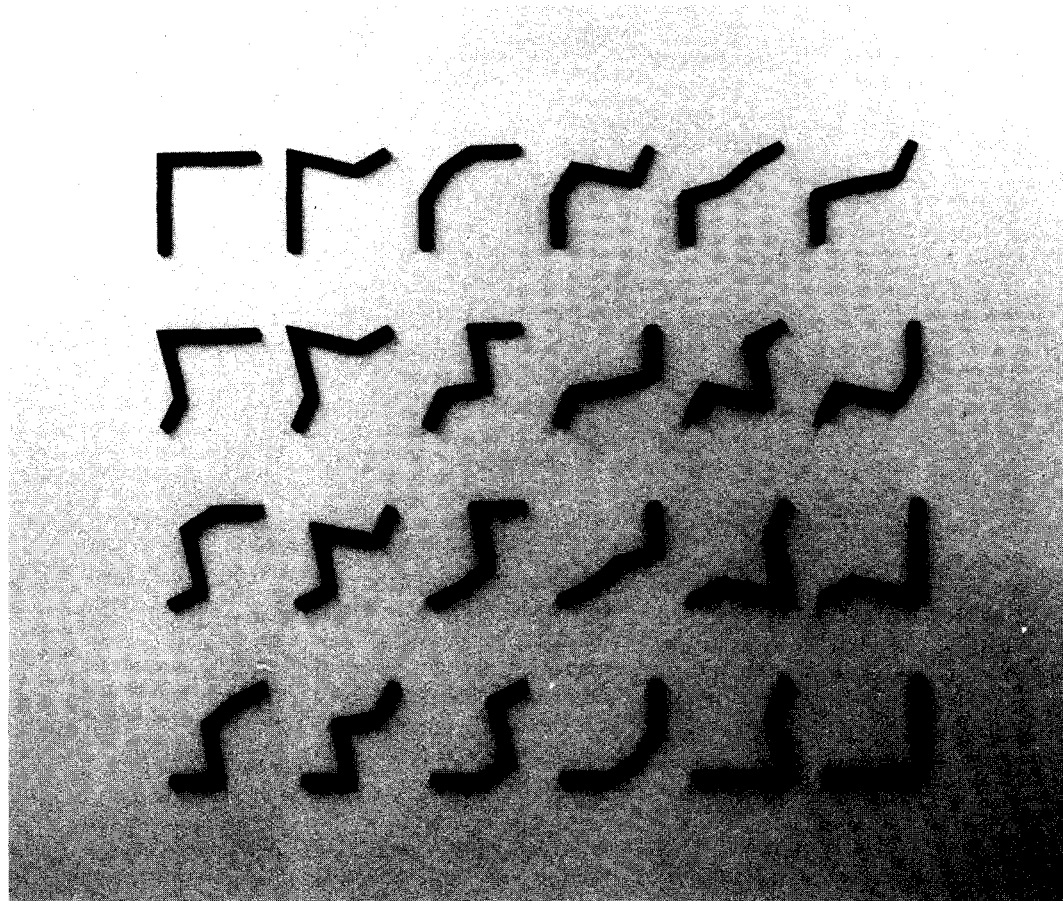


ond nature to Mohr due to his early involvement as a jazz musician (tenor sax and oboe) and his formative random-choice, gestural paintings. Jazz in its improvisational digressions treats rules and strict definitions as membranes rather than borders and walls; it explores with fancy the variations implied in a theme. With this approach, implicit before 1974, the time when he first made the cube his topic, it was natural for him to play through and beyond restrictions where a more austere or strictly scientific artist may have faltered.

He indeed has no laws to set or to demonstrate through solutions. "I don't create solutions. I create problems!", declares Mohr. His computer and its connected plotter, large enough to take on six-foot shaped canvasses, gradually draw or paint his discoveries, assisting in accuracy and relieving the artist of long hours of application. They have no part in the design or the creation but can do things – painting perfectly near the edge for example – that the human hand may have difficulty doing. Their real role is to generate and execute programs that Mohr creates from the beginning.

Of course, in his extended work phases, it is not unusual to reach a dead end and to put a problem aside for a year or two, finding the next step after an extended rest. He feels his approach is a personal way to guide his thinking about art and to further his thinking in general. All the little hang-ups are challenged. If he does not like a particular angle, say 30°, and would normally avoid it, the program does nothing to respect his idiosyncrasy. The 30° angle will appear from time to time in a given scenario and provide him with the needed therapy for a clearer view of the present.

Some of Mohr's working notes, paraphrased and abbreviated here, from a retrospective catalogue<sup>4</sup> give more specific insights into his approach between 1967 and 1987:



Manfred Mohr, P-229-A, 1978. Wood. 190 x 240cm.

1968: *Subjective Geometry*, Geometric elements influenced by electronic and other technical signs... Mobile and exchangeable signs creating abstract visual tensions in space.

1969 to 1973: *Early Algorithmic Works*, Hieroglyphics or magical formulæ... individual algorithms (calculations with cyclic, repeatable regularities<sup>5</sup>) invented and written as computer programs... All forms and structures generated solely from these... Meta languages, signs which reveal their own story... "Aesthetic filters" to build and compose algorithm.

1973 to 1977: *Cubic Limit*, Systems are fixed. The cube, later the n-dimensional hyper cube (superimposition of cubes in "mathematical" space... obeying mathematical laws... any number of vectors or sides radiating from a given point) provides a repertoire of elements for developing signs.

1973 to 1975: Second phase... division of cube by a cartesian plane... rotate opposite sides... project in 2D and clip (through flat cube window... 0,0,0 degrees)

1978 to 1979: Graphs, two dimensional cubes as basic generators of signs.

1980 to 1986: *Divisibility*, ...visual stability by diagonal repetition... growth... cutting into two and four... "outlines" used for rotation and production of new generations.

1980-1982: The four cut -- is the basic structure with which the "outlines" form shapes, and the "in-lines" create signs.

1982-1984: Decide which "outlines" of quadrants created in preceding generation will be used to produce the "4 cuts" of the new generation (molecular growth).

1984-1986: Contours of "4 cuts" seen as "shadow forms" or 2D visual history of cube growth... connect path of centre points of "4 cuts" and create spinelike black growth line.

1987: Four dimensional projection of the hyper-cube (a construction of eight simultaneous cubes) generates signs and shapes. Two dimensional projection of hyper-cube of given rotation fractured to square windows related to each of its eight inherent cubes. Front and back views respectively black and grey.



These notations, upon reflection, show not only the concern of a twentieth century scientist but that of an art adept: the rotations starting in 1987 with simultaneous front and rear view coded as black and grey acknowledge Picasso's cubism; the "clipping" in 1977, or framing of rotated cube parts through a window-like, "flattened" cube (0, 0, 0 degrees) pays tribute to Greenberg and the sixties. Mohr's attention to the dynamics of the canvas reveals an updated sensibility; his images take us far into the future.

Much in the way artists of the '50s and the '60s compiled libraries of forms, cut-out pieces for random arrangement, Mohr has extended the approach onto a new plateau. He has created an orderly systematization that contributes to a much larger library of pieces: visual, conceptual and linguistic.

When questioned about his pioneering spirit, the number of artists accompanying him on this path and the idea of an Academy of Computer Arts, Mohr mentions the highly sophisticated CAD and CAM<sup>6</sup> systems available, pointing out that what had started as perhaps a thousand serious computer artists has dwindled to a mere handful. The new artists seem, to a large degree, more tantalized with the "menu" than the meal. In the early days, it seemed that the possibilities for a new intellectual plateau were incumbent, but now, for now at least, a dispersion of ideas and directions preponderates. A manual-amplifier role rather than an intellectual one is currently the trend, but as Mohr's work and the demand for it are rapidly increasing, he has no regrets in a pioneer role and little doubt about the lasting quality of his contribution. As more efficient computers are developed and become accessible to artists for in-depth research and production, Mohr's early desire for an "intellectual calm in art", a period when technology allows man more leisure to investigate higher and presently remote issues, may still occur.

#### In conclusion

By overcoming their hesitation toward high-tech, some artists, frequently tool-oriented ones, have bridged from the haptic-visual mode to that of the computer. There are certain areas, figure painting for instance, where it seems unlikely that the machine can achieve appropriate values

and relations: from Rembrandt to Manet, the bond between the sensual and luminous quality of oil paint, applied with brush in hand and the lustre of real flesh, is immutable. (The media creation, Jessica Rabbit, half human, half "toon", seems the happiest figure resolution by computer thus far). Abstraction, and specifically constructivist-based abstraction, is best extended by computer because of its inner structural systems; forms, forces, and signs that can be explored and extrapolated endlessly. In addition, visualization and artistic presentation programs are many.

New areas of perception are revealing themselves but, at the same time, are not old and valuable ones being erased? As the symposium ended and some of the panelists lunched together, a conversation touched on this. Snelson's incredulity at the seemingly endless span of time it had taken for man to reach his present state of technology was answered by Ron Coleman: referring to the ancient Egyptians' strengths in this area, he agreed that the know-how, that which we have today, had always been available and added that we have lost a great deal of the earlier knowledge through ensuing and intermediate technologies.

So, not only is the mythic at stake, but also the logic matrix. Watches that relay and erase that which was once cyclic, typing machines that perfunctorily correct spelling errors, calculators that add, subtract, multiply and divide for us; this digital dependance threatens to lead to a vagueness of mind, once separated from individual purpose. In a more extreme scenario, the secrets of self-healing have been irradiated by the indifference of a surgical tool. Globally, the century bears witness to the devastation that a haphazard approach to technology can bring about.

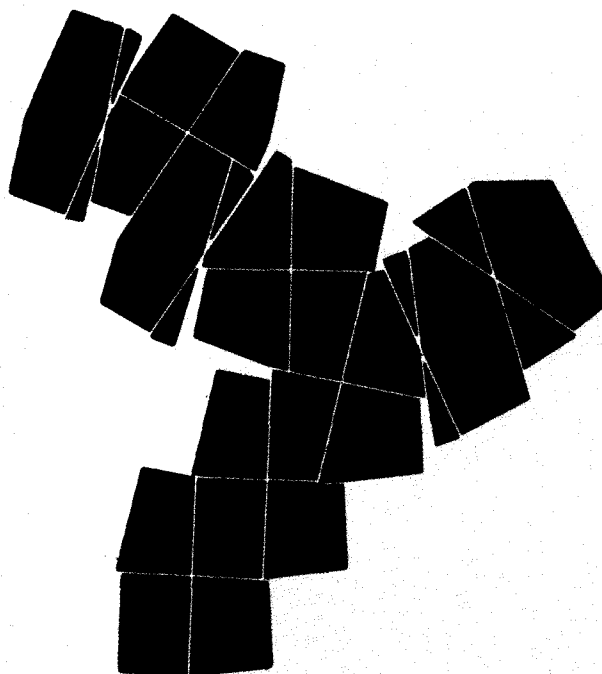
The Philadelphia Museum of Art has a room in the oriental wing with 13th to 16th century Ming Dynasty rosewood furnishings. As minimal as the best creations of Donald Judd or Robert Morris, these tables and benches are rich in color and reference. Their long, low polished tops lift graciously at each end like flat valleys coming to the foothills. Similar details at the foot of the legs pull the eye back with an inward motion, centering below the table. A cultural attitude reflecting human and natural values is deeply imbued. These seem centuries

distant, in a meaningful direction, from the computer's general accomplishments in the area of the arts thus far.

Arguably, one of the greatest revolutions afoot in our pluralistic, post-or neo-modern society is that of self-discovery. Eclipsing technology's many "miracles", the individual is beginning to emerge totally self-respecting and whole. If the machine can contribute in this direction, assisting through its objectivity and efficiency, it will indeed play a leading role in the formation of a new and more human being.

1. Paraphrased by author
2. Atari Explorer (Jan/ Feb '89)  
Pixel to Torch: Forging the Sculpture of Tomorrow by Jon Fordyce.
3. Computer. Digital. PDP 11-23. Plotter. Alphametrics. Alpha Plot II.
4. Fractured Symmetry. Algorithmic works 1967-1987, Wilhelm-Hack Museum, Ludwigshafen Am Rhein, Germany.
5. My note.
6. CAD - Computer Aided Design. CAM - Computer Aided Mechanics.

Manfred Mohr, *P-379D*, 1984-87. Acrylic/Canvas. 130 x 130cm Sammlung Rolf Detting, Pforzheim.



# CAREER OUTLOOK: THE VISUAL ARTS

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## Abstract

The author analyzes the current and emerging uses of computer graphic technology in the many different visual arts professions. This paper documents not only the state of computer graphics in the arts, as documented in current literature, but also provides first hand observations of many professionals currently exploring and incorporating computer tools into their fields. The author concludes with some reflections on preparing for these professions in the 90s.

## Introduction

Throughout history, humans have communicated with words and pictures. Our digital tools do not alter this fact. Computer graphics is neither wholly "the medium" nor "the message". Digital messages initially captivated us by their sheer brilliance. At the dawn of the 90s, we are no longer satisfied by effects alone — we are back once again to basics — **the message**.

The 80s, marked by great technological improvements in the quality and quantity of computational feats have been dubbed the "information age". We are told that the amount of data generated globally doubles every few years — causing "Information Anxiety" as we struggle to keep pace. We are moving toward the "visual information age". More and more we seek to minimize the time it takes us to digest the quantities of information we receive. Quality visual communication aids our perception and comprehension. Those who communicate with images will play many roles in the visual information age.

Let's start by looking at two key graphics markets: business graphics and electronic publishing. Next, I'll review design and arts professions, and lastly, animation.

## Business Graphics

While not the most exciting place to start, business graphics has and continues to be the largest and fastest growing segment of the computer graphics marketplace.

Just what are business graphics? Charts, graphs, diagrams — visual displays that help support presentations, training, marketing, corporate decision-making, data management, financial modeling and trend analysis.

Upper level management needs graphics. Presenters with graphics to support their viewpoints are considered more persuasive.

Less discussion is necessary when graphics are used, thus expediting the decision-making process, shortening meetings and making a business day more productive.

Graphics encourage consensus. Many more people are able to grasp complex concepts when graphic support is supplied.

Graphics don't alter the data presented — but rather make it more understandable, more interesting and more memorable.

Today, most business graphics are either slides or overhead transparencies. Although Desktop presentation and interactive graphics workstations are moving into this market sector as well.

Presently, about 15 percent of these graphics are produced using computers. By 1992, approximately half will be produced by computer. Sales of business graphics equipment (hardware, software and peripherals) is projected to grow at a rate of 40 percent per year through the early 90s.

And just who is producing these graphics?



Service bureaus can either produce the graphics from start to finished product for a client, or generate output from data sent by modem or disk. Lower costs have led many corporations to in-house production of business graphics. Free lance and independent designers are also involved in creating business graphics.

Graphics which previously cost thousands and took weeks to complete are being produced faster and more economically with computer systems. Additionally once data is entered into a computer graphics system, it can be modified quickly and easily.

Good business graphics are no accident. A million or so colors are of little use to someone with no color sense.

A computer graphic workstation offers an amazing array of tools and choices. But the workstation alone does not produce the graphics. A computer is no substitute for graphic ability and discernment. One critic noted that a good graphic designer can compensate for the shortcomings of lesser quality equipment, but the reverse is definitely not true.

## Electronic Publishing

Electronic or desktop publishing is predicted to be one of the fastest growing markets of the next decade, with PC based publishing systems predicted to at least quadruple between 1988 and 1992.

Traditionally, the publishing business has been labor-intensive and expensive. Over the past two decades, computers have slowly and steadily changed the publishing industry.

First it was computerized typesetting replacing the old hot type presses. Next, type could be positioned on the electronic page. Graphics and artwork whether created with or scanned into the computer, could also be cropped, enlarged, reduced, edited and incorporated into text on screen. Finally, high quality, camera ready documents and color separations are output on digital prepress equipment. Tomorrow, with color reproduction technology, the printing press as we know it might disappear completely — making the entire path from concept to product electronic.

Less than 10 years ago, the publications industry's own journals were criticizing the electronic advances as insufficient. These same journals are now filled with case histories of corporations large and small making the changeover to desktop publishing and electronic prepress systems.

Let's look at some of the industries that use electronic publishing.

The speed and cost efficiencies realized through computer usage are vital for the newspaper business. Dailies around the country are following the lead of USA Today, moving toward entirely computer page composition systems.

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*We are moving toward the "visual information age". More and more we seek to minimize the time it takes us to digest the quantities of information we receive*

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Newspaper advertising production is also benefiting from the computer graphics capabilities in ad design and layout. The Minneapolis Star & Tribune added two Macintosh workstations to its advertising art department this past April. In this short period of time the computer has affected production for the better: ad concepts for prospective advertisers in a fraction of the time, at a much lower cost. And most importantly, this improved visual product leads prospective advertisers to make buying decisions more quickly!

The effects of our information society are not only seen in the production but also in the content of newspapers. Infographics (information graphics similar to business graphics) are used in most newspapers.

A new breed of visual journalists with graphics as well as journalism training are not only being sought by newspapers across the country but are earning 50 percent more than their traditional counterparts.

The newshole (the amount of a newspaper's space dedicated to news as opposed to advertising) continues to get smaller. For this reason, the news must become tighter — more concise. Infographics are seen as one way to get more news in less space. The selection of graphics versus photos versus news articles will more than ever be based on the news-worthiness of the information — back again to that all important message.

Newspaper cartoonists are also making the move to microcomputer tools. Initially, newspaper cartoonists found the computer a clumsy, limited tool. Computer usage was seen as novel, yet artwork often lacked quality of content as well as style. Technological improvements have made the computer a more transparent tool. The proliferation of affordable, cost

effective and capable equipment make the "computer" itself secondary to the "graphic" goals.

Although the magazine industry lagged behind newspapers in embracing computer technology until quality issues could be reconciled, the success stories are the same.

In-house printing, technical publications and office automation are the three largest sectors of the electronic publishing market at present.

Typically, technical publications are not high-budget items. Clear graphics to help explain complex assemblies are essential. Computer production of these graphics, as well as the text, and the subsequent unifying of these parts with page composition systems have greatly reduced production time as well as cost.

Decreased production time does not in and of itself increase a product's quality; rather it provides the opportunity to put more quality into production. Artists, designers and others involved in document production determine how time savings are realized; more work done in less time, or a higher quality product produced more efficiently.

Increasingly, today's office environment churns out volumes of data in a variety of forms. Microcomputer desktop publishing systems offer charts, graphics, reports and proposals with a polished visual appeal, and quick cost-effective output from in-house laser printers.

Here again, the choice issue comes into play — does the person who was previously merely a typist take on design duties? How is production handled? Increasingly, graphics professionals are hired for part if not all of the graphic tasks. Yes, there are those facilities who do churn out all their own materials in house. And there are also those who learn after purchasing all the right hardware that the missing element is creative human visual efforts.

## Art and Design

I'd like to change gears and talk about Art and Design professionals. Just who do I mean when I say that?

The U.S. Department of Labor and Industry's *Occupational Outlook Handbook* recognizes the many arts professions under three main headings: designers, visual artists and photographers. In 1986, approximately 500,000 professionals were employed in these three groups. (These numbers are conservative

estimates). Steady increases in job opportunities for these professions are projected through the year 2000. This is consistent with present trends.

Let's take a closer look at these groups:

### Design

Graphic designers are artists who create communication tools incorporating graphic elements such as typography, illustration and photography to achieve appropriate impact and message. Creation of advertising and marketing materials, corporate documents, books, logos, package designs and signage are just a few examples of graphic design projects.

Computers with graphic capabilities were met with mixed reviews by graphic design professionals. Some embraced computers as valuable tools as soon as the first models were introduced. Regardless of clumsy software or limited hardware, these individuals saw the promise in computer tools and were quick to find ways of using these tools in as many aspects of their work as was feasible.

Others, while recognizing the significance of computer graphic advances, would not embrace the tool until it met their quality standards.

As with any new tools, the computer was met with fear: Would this tool interfere with or replace graphic design? How is an arts professional to keep up with the mechanical complexities? What will happen to designers who can't afford the technology?

The computer was met with skepticism: The tool was scorned as limited, and limiting; inadequate and lacking in quality.

The computer has also been praised: It's revolutionary, time-saving, cost-saving, energizing.

In the approximately 10 years since graphic computers have been introduced to the various design professions, all of these issues have been dissected and the resulting opinions and recommendations are as varied as the questions and issues themselves.

The consensus is that computers are an important tool for the profession and one to be reckoned with in one way or another. More and more designers are choosing computers—for ideation, for production, for management of their business. The acceptance of computer graphic tools turns the focus back to Design. Initially, many designers were disgruntled by the "homogeneous computer look" of everything that came out of a workstation: limited color choices, jagged lines, limited and low quality type choices, inability to incorporate photo-

graphs. Technology has and will continue to provide solutions for these problems. More than ever, a designer's work must stand on its own merits. Whether or not the work was developed with a computer is secondary to the resounding question — is it good design.

The computer offers designers ways to explore many more possibilities in shorter time frames. In the time it would take to hand render one idea, a designer can quickly experiment with many versions on a computer. More choices does not necessarily mean better choices — here again design principles come into play.

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*One critic noted that a good graphic designer can compensate for the shortcomings of lesser quality equipment, but the reverse is definitely not true.*

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In a recent issue of *Emigre Magazine*, devoted entirely to the Macintosh and design, a number of designers were interviewed. April Greiman noted that while a computer saves times, it's more important influence is in design aesthetics. "Rather than doing something quickly, we're looking at more possibilities. Instead of doing more work, we are seeing more options. Now we spent more time visualizing and seeing things, and before the Mac, we spent more time doing things."

Some designers caution that the computer's ease of use has led to a proliferation of lesser quality design. But others counter that every major shift in ideology has brought about a chaos out of which the excellent work will rise above the rest.

The computer offers designers more control — previously they relied on typesetters, keyliners, color separators and stat producers for materials now controlled within computer systems.

We've been talking strictly about graphic designers, who have some specific and common needs. But let's not forget others in design professions. Let's not forget industrial and product designers, designers of clothing, textiles, interiors, jewelry and others. All of these professions are also undergoing similar analysis, and exploration of computer graphic tools.

#### Photography

Photography is an integral part of many different professions: commercial photographers can be highly specialized: model photographers, product photogra-

phers. The scientific and technological fields also rely on specialized photographic talents.

Photography is not yet "computerized" in the same sense as other areas of the arts, though digital and still video cameras are making their way to the marketplace. And certainly computer-simulated imagery is closing in on photography in the competition for realism. All too often, we aren't sure any more if it is real — or computer reality.

Photographic retouching is overwhelmingly digital.

"In the past few months, I don't think I've shot one photo that has not been electronically retouched, notes one photographer. Sure, some of these would have been retouched by hand before—but now electronic photo retouching is used more than ever. Recently, I shot a model and a few hairs were out of place. Before they would have used the photo as is, but since it was being sent to digital color separation equipment anyway, the image was retouched."

Once a photograph is scanned into the computer, the retouching and manipulating possibilities are endless. Colors can be easily changed, areas of an image removed, added, cut, repeated, scaled and so on. Such techniques can not only compensate for what would otherwise be a darkroom disaster, but bring about experimentation and imaging unlike any previous technique.

Some photographers question such electronic transformations of their art. And others who the computer enhances their vision.

Electronic artwork and computer imaging resulting from the marriage of camera and computer must undergo the experimentation process. That process will include happy accidents as well as disasters. What's important is not the technology itself but rather how we use the technology in the creative process.

#### Visual Arts

The computer is an unprecedented tool for artists offering power to create and manipulate images with an infinite array of electronic "brushes".

*Visual Artist* is a catch-all term encompassing a broad range including but not limited to painting, drawing, illustration, cartooning, printmaking, sculpture, metalwork, jewelry, ceramics, laser displays, performance, interactive environments, holography, crafts, choreography, dance, and the many possible combinations of these and other media. This is not to mention film and animation, which I will cover next.

Author Stephen Wilson tells us, "Art is more about an experimental and exploratory approach to the world than finished objects. It is an eagerness to challenge common perspectives with fresh eyes and to create a new synthesis." "Computer developments, he goes on to say, especially need this kind of artistic attention."

Here are just a few of the many ways artists are using computers:

Illustration — renderings of images for clarification, enrichment and entertainment has long been a profession that is not defined by the medium the illustrator uses. The computer is merely the most recent tool to be

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*A new breed of visual journalists with graphics as well as journalism training are not only being sought by newspapers across the country but are earning 50 percent more than their traditional counterparts.*

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explored. Here as with all visual mediums, the image and its meaning or purpose, its quality and its ability to affect the observer's sensibilities are the measure of its success.

Science and computers offer a new opportunity for artists. Scientific computing has generated volumes of raw data — both numeric and graphic. Artist's visual sensibilities help scientists clarify the data, and create astounding visualizations of our universe from the innermost parts of cells to the outer reaches of the galaxy.

Fractals, graphic representations of mathematical and scientific formulae are but one example.

Where do we draw the line on what is scientific visualization and what is art? Will we be able to delineate between these two? Do we even need to?

Let's not neglect work created not by hand but rather by program.

It is rare that a painter can analyze and encode his artistic concepts in a program and have them come full circle as in the work of Roman Verostko. His early paintings of over 20 years ago bear striking resemblance to his most recent computer "paintings" generated by a plotter equipped with paint brushes and pens and driven by his programs.

More than ever today the computer offers artists in all fields the ability to render and transform elements of

our human reality and help give visual voice to the most remote of our fantasies.

## Animation

And finally we come to animation. I have only to mention the words computer animation and I'm sure pictures come into each of your minds, flying logos, brilliant objects twisting and tumbling, sports graphics, news openers, scenes from recent movies and much, much more.

"Blame it on TV". The daily doses of digital imagery have piqued our visual appetites. Advances in hardware and software are putting animation computing power within affordable reach of many more people than was ever possible before. Of those looking for jobs in the computer graphics, animation is one of the most desired.

Animation is still the smallest sector of the computer arts marketplace even though much growth is forecast for this area.

Use of computer animation by the commercial and entertainment media is increasing modestly. However, industrial animation is projected to grow rapidly — 40 percent per year through the early 90s according to Frost and Sullivan.

Typically when I talk with students who want to be animators, they envision themselves at the top: creating animation the caliber of Disney and Spielberg.

This is the very high end of the market, the competition is keen and — most important for all of you to recognize is this group represents a very small and localized sector of the market.

Production facilities, however, are all over the U.S. Video trade publications are full of articles touting the praises of computer graphic animation and predicting rapidly increasing opportunities. More people than ever before are considering computer graphic animation. Typically, when we refer to scientific visualization, we tend to think of research institutes, yet, we are seeing more and more visualization of complex data in more than just the pure sciences: visualization of complex and theoretical data has never been more vital for making all aspects of our world more understandable.

In a small and very localized sampling of the market, I found over a dozen production facilities in the Twin Cities alone — from the very small, independent production groups to some of the largest in the country —

with a healthy range in between. And though these firms seem to be competing for the same market, all reported that business is good and getting better all the time! Trade journals confirm the fact that this trend is not limited to large metropolitan areas, but across the country.

Production facilities are contracted to produce part or all of video material for a variety of clients. Production can mean the client has only a verbal glimmer of an idea. In which case, a production group develops a

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concept for the client, gets it to the storyboard stage and through to a final video.

A client may come in with a fully developed storyboard, and want a production company to execute all the specifics. In some cases, an advertising agency may come with a video that needs only the special effects.

In my visits to Twin Cities production facilities, I found the team approach becoming more and more common. Artists, art directors and animators are teamed with programmers, mathematicians, mechanical engineers to turn out a product.

There's just too much knowledge required to get a job done, and it's unrealistic to expect one person to know it all and do a good job at everything, explains Larry Lamb in talking about his company's team approach.

I also talked to Ralph Guggenheim, Director of the Animation Group at PIXAR. PIXAR is the offshoot of Lucasfilm responsible for such memorable works as Luxo Jr., Red's Dream and Tin Toy. Their animation group includes only seven people, in a company which employs 120.

At PIXAR, the animation groups' talents were varied: animation, math, computer science, even architecture but Guggenheim noted — everyone wears several hats. "The work we're doing is a marriage of the creative and technical" he said.

A portion of production facilities work on is seen on commercial or cable television: Logos, station IDs, parts

of television commercials. Much of what is created at production facilities we probably don't see: corporate training and marketing materials, educational videos for a variety of specialized audiences, and even some scientific rendering and simulation.

As in the business graphics market, large corporations have their own in-house video departments for specific media needs.

Computer animation will play an increasingly important part of our visual realities and pseudo-realities. Sources differ on whether the production facilities of tomorrow will be more like the large houses, with many and varied high-end speciality computer systems and the necessary creative and technical talent to drive these systems. Or whether the increasing capabilities of lower end workstations will lead to video service bureaus and more creative efforts by free lance individuals.

Today, we can walk into a service bureau with a disk and leave with color slides, film or print output. Tomorrow will we be arriving with a disk of key frames, and walk away with finished videos?

Use of computer animation by the commercial and entertainment media is predicted to stay at about the same level or climb modestly. However, industrial animation is projected to grow at a rate of 40 percent per year through the early '90s according to Frost and Sullivan. 3D animation is being used by engineers, architects and traditional CAD users to "test" mechanical parts on screen before the first models ever roll off the assembly lines.

## Career Considerations

Now that we've looked at the market, let's summarize with some thoughts on careers.

First and always of foremost importance in any of the artistic fields is creative ability. While professionals differ on levels of technical graphics, media and computer skills they'd like in prospective employees, all agree that creative skills are essential.

This is a tremendous challenge — to see with new eyes and bring about a new way of seeing in a society that is becoming ever more visually astute. An important part of creativity is giving birth to new ideas — not merely replicating what has come before.

To become actively involved in any creative visual field, you must be a discerning visual consumer. Learn all you can about the field you choose to be in — look at the works by your prospective peers — critique it your-

self — what do you like, dislike, what moves you, attracts you, challenges you — and why. Come to recognize what is unique and what is imitation. I teach at a liberal arts college, and often find myself arguing with students about the value of the art history and humanities requirements. These are essential in helping any arts professional develop visual perspective.

In addition to creative talents, you need to know your craft. Learn to use the tools of your chosen field:

- for designers, typography and graphics are essential;
- for photographers, the intricacies of cameras and lighting;
- for media students, courses in film, video, lighting, animation;

The arts marketplace is cross-disciplinary. If you're interested in more than one area, don't hesitate to take courses in several different media.

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Remember the computer is a tool — it's just the latest electronic paintbrush — but alone, it does nothing!! Don't be too concerned with learning a particular model, but rather gaining a conceptual understanding of what computer tools offer you in relation to not only the particular profession you choose, but in relation to the traditional tools as well.

Most schools are incorporating computers into their art and design curriculum, as well as exploring new cross-disciplinary majors. So by all means take advantage of this!

Evaluate educational institutions thoroughly. Don't be seduced by equipment alone. While technological changes are predicted to progress more slowly for the next decade, educational institutions can't possibly be expected to replace their equipment constantly to keep pace with the latest trends.

The curriculum and the faculty rather than the equipment should help you determine an educational institution's ability to meet your needs and challenge you to develop your own unique visual perspectives.

Talk to faculty. Find out their philosophies about your chosen area, about new and traditional tools, present as well as future perspectives. Look at work by both students and faculty which demonstrates creative exploration of not only computer graphic but also traditional and other emerging tools in context with your area of interest.

### How about programming??

With the proliferation of software packages, you don't need to be programming to be employed in the arts. But, remember software is developed by others who are making the determinations on how far their program will let you go. Many artists have turned programmers because they found the available software hindered their creative efforts. Graduate schools and larger educational institutions offer more opportunities for cooperation among arts and sciences departments.

Try to get internships throughout your education — whether paid or unpaid — internships let you explore the marketplace first hand. Employers like to see internship experience.

Portfolios are your unique statement about who you are. Portfolios should contain the visual aids you need to sell yourself, commented one professional. Carefully critique your portfolio — and if you are honestly not satisfied with its contents, do something about it! Employers know students don't have access to top-notch computer graphics equipment, and are not expecting high-end computer graphics work, especially from undergraduate students.

Employers with high-end computer graphic equipment have realized through trial and error that equipment skills do not equate with artistic skills. Visual creativity holds first place on the list of desired qualifications in prospective employees, but computer literacy is a close second.

**What is computer literacy?** It goes beyond strict step-by-step comprehension of one system or software package, to more broad-based understanding of possibilities with computer systems and software. Compare computer literacy to our more traditional notion of literacy as the ability to read and write in the spoken language. When one is literate, the words are no longer important as words but as vehicles for communication of thoughts and ideas. When one is computer literate, the computer is not the focal point, the concepts and visualizations are predominant.

Computer Graphics affords visual arts professionals an unprecedented opportunity and challenge to create — the choice is yours.

## BRAVE NEW VIRTUAL WORLD

NICOLE STENGER

In an irrepressible urge to see the unseen, humans are entering the Virtual Worlds of the computers. Will this new trespassing of the limits provoke the fall of our ancient notions of space, time and identity? Shouldn't we celebrate?

Just when travelling through the Solar System becomes a boring video, the magical doors of the Virtual Worlds are opening to you ;

Just when you are desperately running short of time, the computer delivers a slice of the "Real" one to your door ;

Just when you start adjusting to the bliss of being single, medical algorithms reconstruct your exact replica.

Don't worry about the soft fall of these antique notions of space, time or identity, a flashy world of replacement is ahead, at no cost, with few ethics, and for Eternity.

In 1945, the human species had found in the Atomic Bomb a collective means of committing suicide, as Jean Paul Sartre put it. Today, it is using the virtual world of the computer as a massive Emergency Exit.

Cities like Tokyo had already flirted with the idea, by introducing video screens almost anywhere in their urban texture. Walking in the streets would give you a strong impression of living on two levels of reality at a time.

But this is nothing compared to the huge cloud of virtual smoke that is forming from the innumerable graphic computers now at work, and changing the climate of the human mind.

We are entering BRAVE NEW VIRTUAL WORLD.

BRAVE NEW VIRTUAL WORLD is a synthesis of hallucination, God and graphic design.

It is endless, eternal, virginal, complete, desperate. And moreover, it is!

It is the product of this unbelievable urge in the human race today, to see the unseen, all the unseen, and nothing but the unseen, at the same time, and with the utmost acuity.

It can only make you think of notions of permeability, obscenity, circularity, sociability and eternity, as follows :

### Permeability

That there should be screens, does not prove that there are no leaks. Definitely some mind substance had started to ooze out of people's heads 25 years ago or so, and to take some shapes here and there.

Until recently, people would transfer the ghosts they had in mind, through primitive languages, into the virgin arena of the computer, and watch them skip.

Little by little, we got used to the fact, that holograms and stereoscopic videos could feel at home on our laps.

But today another barrier has fallen. Special gloves are literally leading you by the hand into the Maze of Virtuality.

The screen is still there, but it has become permeable. And so have we.

### Obscenity

Wouldn't the Virtual World qualify for the Helmes amendment ? For can you think of any material more indecent than the Immaterial ? That projects the inside of the mind out, that can only reveal its most sexually explicit functions, since brains produce hormones too ; that has no respect ?

Is the Virtual World a world of absolute obscenity, where everything becoming obvious, mystery dies ? Or as virtual spaces open on more virtual spaces, does mystery build up exactly where it is uncovered ?

Hackers break into codes, and computer viruses infect programs. What kind of vicious perpetrators would trespass into your virtual space ? Will you set a burglar alarm ? Will you be the alarm ?

### Circularity

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A human being used to be a self, or a self within itself, occasionally tripping out for ecstasy, or wearing its head under its arm, when it was a saint, but would certainly not exist outside itself on an everyday basis.

Becoming data inside a computer, be it through a special physical outfit, or through the 3D reconstruction of scanned pictures of your entire body ( including your flesh, bones, organs and veins ; a program developped by Professor Hohne from Hambourg ) , makes you both real and unreal, mortal and eternal at the same time. Inside the infinity of virtual space and time, you watch yourself become your own Gardian Angel. You become circular.

### Sociability

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Being circular today already means living through the four seasons with a sleeping bag under your computer desk and some potatoe chips, occasionally grumbling at some unseen interlocutor.

So will there be social life after Virtuality ?

Data gloves could of course shake hands and play cards as in a virtual Cezanne.

Maybe their rubbing will produce some Rock n' Roll.

But will ever spaced out individuals with data gloves and goggles ever meet in the Virtual World to bake a loaf of bread, and share the smell, the steam and the breaking crust ?

The human race is slowly adapting to the virtual world of the condom. Could the endless rapture of cloning oneself inside the computer be a danger to the species ?

A substitute for the hassle of human reproduction ?

While couch potatoes slowly produce meat, will Virtual World users produce milk ?

### Eternity

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Dying in the Virtual World would of course be very elegant, and clean as after a Neutron Bomb party. But will you be declared virtually dead, or else virtually eternal, and stored up forever in the computer memory of a mountain ?

Virtual Worlds have always been. Poets, gurus and even businessmen in their sleep, have been the Sacred Messengers of their existence.

We're only getting a new joystick to tackle them. A situation that Mircea Iliade had foreseen, when he talked of these enclosed areas of the Sacred, ready to be unsealed.

With a simple wire, a capacity to float in space, and a permission to dream one's head off, we're only going back to where we



belong. And, in a way, we knew we would from the start.

The more acute the vision, and the penetration of the vision into those worlds, the more vivid the feeling of "deja vu".

We may lose the sharp boundaries of our restricted identities, a notion that is enough in itself to deprive Cartesian Philosophers of sleep for ever. But we may gain a sense of our true selves, return to the Poetic and achieve fusion.

The computer has laid the Conference table for the True Reconciliation.

# FASHIONABLE COMPUTER WEAR

By

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## Abstract:

The argument this paper presents is that the shape and overall look of fashion will change as a result of fashion designers becoming more familiar with CAD workstations by which to design clothes. The paper gives a brief history of the traditional ways fashion has been created and then itemizes some of the newer technological innovations to impact on the apparel industry. Examples are shown to demonstrate the design capabilities of the CAD systems and the new visualization capabilities that are presently being developed are mentioned as material to support the argument. References are made of other designers using CAD systems and the psychological and sociological implications of CAD systems for the fashion designer are touched upon.

Do you ever wonder why you wear the clothes you are wearing on any given day? Do you ever wonder how fashion trends come into existence? If you don't, fashion houses around the world do, and its from these centers of fashion that garments find their way into the boutiques and shopping malls all over the world. However, something new has been added to the inner sanctum of fashion houses. That something new is the computer. But not just any computer, but ones you can design fashion on, do fashion illustration, pattern making, and can even weave or knit custom designed yarns or threads right on the computer screen. All this digitized fashion is then sent by modem to some factory in Hong Kong or Italy where all the fabrics and knits are then made as well as the garments with the assistance of computerized information. CAD and CAM are the key acronyms describing the computerized link up to produce these fashions. Computer-aided-design and computer-aided-manufacturing are also joined by CIM which stands for computer-integrated-manufacturing. So its CAD/CAM/CIM for the next evolution in fashion design. A curious question I always ask fashion designers who work on CAD/CAM systems is whether the computer as a design tool will alter the way our clothes will look in the 21st century. Most designers say no, but I say yes, and the reasons I see this happening are the ingredients for this article.

Traditionally hoards of designers would flock to the fashion runway shows in Paris with sketch pads in hand, and try to render the fleeting looks that pass them by. Then they would hop on a plane back to New York City and develop croquis in full color to pass along to buyers of the major stores to

determine if they should go to manufacturing. Many times hundreds of hours would be spent drawing plaids in multi-colors or developing new prints that would then have to be delivered to the mills where many more months would be spent dying the textiles and yarns and then experimenting with the weaves to come as close as they could to the designers art work. In order to get ready for one seasons line of clothes an entire year would be spent in advance designing and manufacturing the garments to be made ready for the racks and ultimately you the consumer of fashion. Believe it or not what once used to take a year now takes only

weeks and the fashion industry is in one of the most dramatic transitions in its long and historical trek through time.

The apparel industry was one of the last major industries to fully embrace the computer as a design tool, and now that it is growing in popularity there have developed some very interesting trends in computer-aided fashion design. In 1984 Steven Jobs brought to the world the first Macintosh computer with a whopping 128K of RAM. It also came with a software package called MacPaint as well as MacDraw. For the first time the masses could draw on the computer and PC became the alternative historical benchmark to BC...ie Before Christ and Past Christ. Likewise, with this play on words the computer also became a new religion for some people, and even spawned its first Saint who is known as Saint Silicon who can be found living somewhere in the hills south of San Francisco. In 1984 the world of the computer image was flat and very grey with black and white as the only color choices. The world of 2-D was all anybody was going to get. Within 5 years the 128K PC went to a gigabyte and 16.7 million colors in full 3-D. The computer that was heralded as the most sophisticated in its capabilities in 1984 is now looked upon as no more than a skate board in its capabilities. Indeed something so profound occurred that few even found the time to wonder what sociological impact this may be having on the users. So dramatic was the evolution that the Disney studios invented Tron to see if he could figure out what all the programming was about. Today the users of computers for fashion design are confronted with menu structures that would of never been dreamt of as they watched Haute Couture prance upon the Paris runways. When the first CAD packages were used for fashion design the initial requirement of the designer was to see if they could draw something on the computer which looked like the work they used to do by hand. At first the acceptance was quite dismal. Designers revolted. Fashion was fabrics and models, and jumping from one airport to another trying to chase the latest trend wherever it may be found. Why on

earth would the workstation, with a scanner and ink jet printer, an optical storage system, and disc camera, and digitizing tablets be used in a design studio?

What business was it of a designer to know about a geometry engine and a graphics accelerator with Phigs, and MIPs, and MFLOPS, and NURBS? It sounded like there were insects crawling all over the place. The language got more complex and functionality and connectivity and operating systems were taking over. Numbers became the pass word into the land of PC. Intel's 386 and 486 and Motorola's 68,020 and 030 became famous. Twenty Four bits per pixel was gospel, now its 32, and 1280 by 1024 was the sought after resolution. Then the systems developed names like Gerber, Lectra, CDI Technologies Inc., Investronica, and Microdynamics. Shortly thereafter, new systems appeared with names like ModaCAD, Haberdash, Ormus, Vision, Penelope and Preview. The family of computer systems for fashion design tripled in less than two years. Software developers were busy as well writing code that would run on all the new computer architecture. The more code the more memory was needed. The more memory the faster the system had to run.

So what can a designer do on a CAD system anyway? On the high end a fashion designer can create a full 3-D model and drape any kind of fabric on that model and can immediately make a 2D pattern from that 3D draped fabric and send it electronically to a computerized laser cutting machine where a machine vision robot will pick up the cut pieces and feed them into a computerized sewing machine. Then a robot will pick up the finished garment and put it in a carton and then place it on a truck or a plane. The time this all takes is two weeks. Honest! But now lets back up a bit and focus on the front end or the data input level. The X,Y,Z axis becomes an important concept for the fashion designer because these axes define 3 dimensional space on a computer screen. Not only is there virtual 3-D space, but the computer generated mannequin can be rotated in 360 degrees. Not only can the mannequin be rotated it can also be animated. Thats right, a moving model right on the computer screen. But it would be boring indeed to just see your latest cyber-model dancing in a black void so now lets create an attractive background. Perhaps a beautiful beach scene that was captured on video and then digitized into the computer. A fully realized computer reality. The interface of two distinct realities becomes a significant world to relate to. No longer does the designer go looking for fashion ideas in the real world, but can find them inside the computer. All aspects of objects, and of course fashion, can be changed immediately with the touch of a key stroke, the push of a mouse, the pressure on a geometry ball, or the movement of a stylus. Function keys are replaced by pull down menus and the world can be altered if the right algorithm has been written.

However, I would be overstating the ease of doing all of this if I would be giving the impression that these sorts of design changes could be done quickly. Some systems take as long as 8 months to become fully functional on. I enjoy this phraseology of fully functional because fully functional means that all the combinations of any one given system have been mastered. It has been determined that only about 10% of any of the systems are presently used by the apparel manufacturer as well as the designer. The reason for this is primarily economic. If an apparel manufacturer is only producing 8 colors in its line with only two variations in the basic style then its understandable why there is such a low

percentage of use of the CAD system. That sounds like the same percentage of grey matter we use as humans. Also since the CAD system is also a CAM system the machine is eagerly awaiting instructions from the front office. In other words, the designer also has to know if what is being designed on the

CAD system can in fact be made on the CAM system. This aspect of fashion design becomes mind boggling so I won't even begin to explain what a computerized loom can do or a computerized flatbed knitting machine or even a circular knitting machine. So lets stick with menus on the CAD level. At the fully functional level the designer has at his/her disposal a range of creative tools enabling a fashion design to take place. In the traditional method of design a series of sketches representing a line of fashion may take a few hours. On the computer it takes a few minutes. A full range of colors can be seen in seconds. A new silhouette can be seen instantly. Silhouettes are like shadows; they are the out line of our clothes. From a practical money level it would be impractical to cut the finest silk in any way shape or form to drape over a real world mannequin in order to see if the fabric does justice to the design. Not only would that be impractical it would also be impractical to add accessories such as plush velvet belts, or snake skin trim. However, with these items stored optically in the computer there is no waste and a perfect simulation can be achieved with out ever cutting one bolt of silk or killing one rare snake. The design process on the computer is just beginning to take hold in the minds of many fashion houses. After the designer learns what the system can do the creative process emerges. As an example of the computers flexibility lets take a simple polygon.

#### Evolution of the CAD "Tie Shirt"

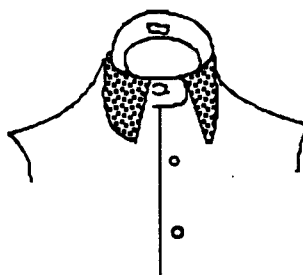
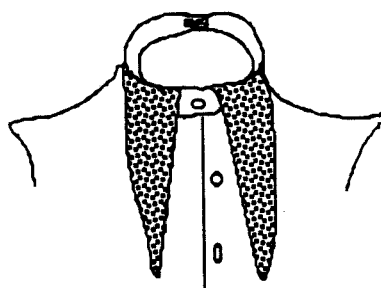
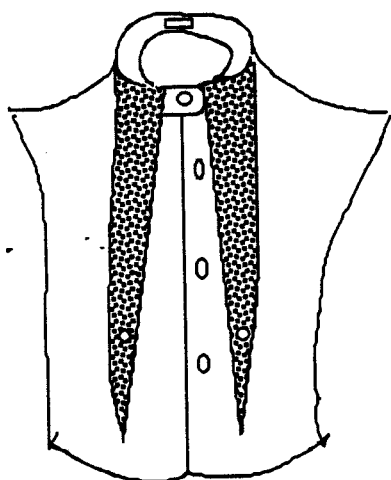


Figure I

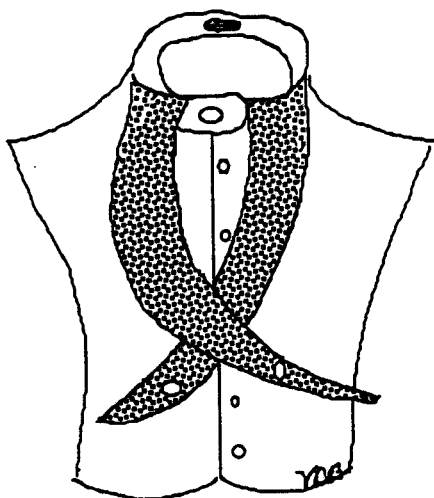
A shirt collar is a polygon.( figure I) If the cursor is placed on any of the control points on that polygon it can be elongated in any direction.(Figure II) Its possible to elongate the tip of the collar all the way to the waist if you so desired.(Figure III) The fact is you would not cut a shirt pattern with the collar of a shirt as long as the front of the shirt. However, with the computer it is then possible to move that elongated collar in any direction and it may in fact become a functional addition to the shirt.(Figure IV) The point is that this one menu function has provided a new design alternative. Perhaps nobody would buy a shirt with a collar extened the full length of the shirt, but the fact that it can be visualized is very significant. This new visualization capability can then lead to ideas and in (Figure IV) the new idea may be given a marketable name such as the "Tie Shirt". Our clothes are dictated by many influences and primarily by fashion houses. However, many sub-cultures have influenced fashion as well. When the



**Figure II**



**Figure III**



**Figure IV**

### **The Tie Shirt**

Beatles went to India they came back with the Neru Jacket. When Madonna started making fashion videos black lace took on a new sensual appeal. When Humphrey Bogart played in the film Casablanca the fedora became popular. When Buzz Aldrin walked on the moon the jump suit became popular. When Tom Cruise played in the film Top Gun the flight jacket became popular. The list is endless of the influences on fashion. The computer is also having its effect on fashion. Esprit of San Francisco creates many new geometrics in their computer design department. Itokin, Japan's largest

department store, developed the Mina line by Jackie Shapiro with the aid of the computer. The Paris designer, Elizebeth De Senneville, uses computer graphic prints designed on the Quantel Paint Box for her lines. Many of the sweater designs from Jantzen are designed on the Stoll Selectanit CAD system. Geometric designs and prints have become the predominant use of the CAD systems. Now, however, with the development of 3-D designing the designer has to learn how to think spatially when looking at the computer screen. This 3-D spatiality which the designer begins to learn is a totally new drawing board from which to create the next seasons line of fashion. Although the new computer tools greatly reduce the time to render new colorways and silhouettes it also permits the designer to engage in the creative process with a simulated 3-D reality. To maintain that design decisions as to what our clothes will look like will not have significantly new silhouettes attributed to CAD systems is in my mind not taking into account the affects of these technologies on the creative process. Each period of history clearly demonstrates new ways of dressing. Over the last 20 years,

and most recently in the last 5 years there has been a stagnation in innovations with fashion design. The exceptions are of course Christian Lacroix, Issey Miyake, Jean Paul Gaultier, and Thierry Mugler. There are more, but these designers stand out in my mind. The florals of Emmanuel Ungaro are note worthy for his use of color and the way he wraps fabric around a womans body. However, with all these designers none have used CAD as a design tool, but many of their techniques can be transferred to the CAD systems for further enhancements.

The algorithms hold the secret to screen magic. Mathematics gets turned into lines of code, and considering how many hours it takes to write a few dozen lines of code, some software is measured in the number of man years it took to write them. For example; in the CDI Technologies software package there is a function called the "sweep function". When several points describing a circle are placed on the screen outlining a sleeve, and subsequent circles are drawn the software will create a cylinder like shape to represent that sleeve. The path the sweep takes is determined by these circles. The ballooning of a sleeve can be seen instantly as well as any other variation in sleeve shape. My asserting the fact that CAD systems will change the look of fashion requires a personal experience in front of a CAD system to fully appreciate my fashion forecasting. Fashion is becoming a product not only of CAD design, but also CAM capabilities. Algorithms are continually being written, such as the new fur algorithm by James Kajiya of the California Institute of Technology or the new density function algorithm for texturing by Ken Perlin of NYU, and simulated fabric motion by Jane Nisselson of NYIT. Synthetic fibres are continually being invented, weaving techniques

are continually being developed, construction techniques utilizing bonding and fusing are being evolved and fashion is constantly undergoing stylistic changes. However, as more

designers create their designs with more complex menu structures so too will fashion become reflective of those technologies. A new sense of freedom of designing shapes is taking place. Naturally the buyers are concerned whether a garment will sell or not. This consumer constraint has held back a lot of design possibilities for the new CAD fashion designer. The old adage, "only produce what the market will bear", has limited many new designs from ever seeing the racks. However, all this is going to change. When a new Ford Probe zips by you on the freeway did you ever think of where that design came from? A computer. When a new circular glass building is erected did you ever think of how it was designed? On a computer. When a new perfume bottle hits the shelves do you ever think of where the shape originated from? A computer. Now the time is arriving when a distinctive look is emerging for fashion that has that CAD look.

### What is a CAD Look?

The areas of design the CAD look has a lot to do with are shapes, details, colors, textile and print designs. The introduction of new synthetic fibres is bringing many new clothing options to the retail outlets. High-performance fibres are ready to be used such as Du Pont's Kevlar and Nomex. Unitika another fibre manufacturer has introduced the world's first amorphous metal fibres. Bekaert of Belgium uses its Bekinox fine steel fibres in wovens, knits and felts. Spandex and polyester are now the rage. Bicycle racing suits are skin tight and brightly colored and look very aerodynamic. Imagine a spandex suit with leather trim or an 18 gauge sweater composed of a melange of 4 or 5 yarn types which wraps in three directions, and is chemically and heat resistant. Consider a velcro jacket where instead of one pocket you may have a dozen pockets of different materials with velcro backing that can be placed anywhere on the jacket. Even though these may sound like traditional design alternatives their variation in shape and color have first been seen on the computer screen. The unique aspect to fabric is its weight and how it stretches. Newer fabrics have very distinct material properties and it could take days before it was determined how to cut the material to conform to the body. Today software engineers with CDI Technologies in Grand Rapids, MI. have made it possible to drape any fabric on a mannequin in 3-D on the computer. Not only can the CDI system drape the fabric it can also create the fabric on the computer screen thread by thread. The specific material properties of the fabric can then be worked into any shape, and stretched in any direction. The ability to have a library of fabrics and trims on hand in an optical storage system is revolutionary for the designer. This aspect of fabric draping is for the exterior of the garment. With the function called layering, commonly used in architectural software, the inner linings can also be newly designed as well as new padding to effect the outer shape. Parabeam, another fibre manufacturer has developed three dimensional

double wall fabrics. Some of these fabrics are composed of 2-layer fabric with connecting yarns filled with styrene beads which is perfect for cold climate sports wear. Then all

these new inner construction elements can be hidden from view and a newly selected fabric can be draped over the inner construction. Ergonomically speaking the clothes we are presently wearing may not be the best suited for the way our body moves. It is ironic that the same design of clothing is the same for a 4 year old as an 80 year old person. This holds true in Western Culture primarily..the Couture set. However, large people need more flexibility in their clothes. Older people need easier clothes to put on. Handicapped people need clothes to assist them. Space technicians need clothes that support them in their weightless environment. The design options become endless and the ease of visualizing these unique clothing needs are now possible with fashion CAD systems.

Not only can CAD be used to design clothes but, as I mentioned, they can weave any yarn or thread on the screen in any color and in any weight. The intricacy that can be attained with zoom functions brings creation to the pixel level. The CAD system, however, is only one component in the entire CAD workstation. Probably one of the most significant peripherals is the color scanner. These scanners are appropriately called capture devices. You can go out into the back yard and grab up a bunch of fall leaves, place them on the scanner, and behold the rich variation of fall foliage is on the computer screen. So what? Well if you place a grid over the image you can see what a sweater would look like with these shapes and colors. You may want to select only one corner of a leaf or two colors in the leaf and make repeat images out of it for a new printed fabric. The Haberdash system from San Francisco has a strike map function which automatically creates stripes of all the colors no matter what the source is, and from here ensembles of colors can be mixed and matched. AVL Looms from Chico, Ca. is doing similar things for weaving. Another device which stores the captured image is the optical storage system. Coupled with this peripheral, and windowing software, you can now look at say a dress from the 14th century, and an original sketch simultaneously on the computer screen. If say a button or a piece of lace is found to be attractive on the 14th century dress it can be isolated with a cut and paste technique, and put into a favorite library of parts and used at a later date or used instantly.

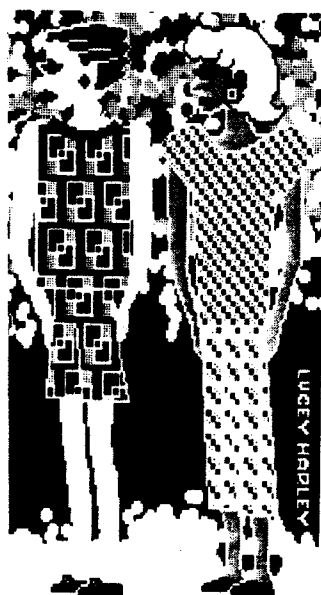
Newer technologies are on the horizon such as data gloves. These specially designed gloves can alter the image on the screen by merely moving the gloves in the air, watch the monitor, and interact with the image in real time without ever touching the computer. Perhaps virtual environments of fashion studios will replace traditional studios and all the designers will be wearing head mounted displays and there will develop virtual environment workstations complete with animated models who can even talk. Designing in virtual realities will be the most dramatic development for designers in the 1990's. The personal computer will then

become the personal simulator. Also on the horizon is phase measuring profilometry (PMP). This technology optically scans a standing person in less than a second and produces a 360 degree output. Imagine being able to obtain any dimensional parameter of any individual and then make made to measure garments which take into account a persons unique body shape. When the PMP system is applied to the foot all the necessary digital information is then ready for the robotic shoe manufacturer, and never again will you have a shoe that won't fit. The PMP can be updated regularly

for each member of the family and for the duration of their lives. The perfect fit will always be seen by their neighbors and friends. Mycrodynamics, a CAD apparel turnkey Co. in Dallas now has a Footwear Design system (FDS) utilizing CIMTECH's 3-D software. Now you can design 3-D last data for perfect prototype visualization.

### **21st Century Fashion**

So back to the original question. Will computer-aided-design for the fashion designer alter the way we will look in the 21st century? It is obvious to me it will. Not only is it obvious to me, but if you go to New York City and see a flash of red hair going up fifth avenue chances are its Lucy Harley one of the top knit designers in the world and a designer who has no less than three CAD systems in her studio. Figure V, is an example of how Harley incorporates geometrics and custom fill functions for fashion design. Harley is living in the 21st century and has made some interesting predictions about fashion which I feel are worth relaying. Harley feels there are four types of clothes which will make up our wardrobe in the future...ie Mental, Physical, Spiritual and Leisure and colors will be divided into atonal color families. On April 11th 1989 Harley was in Frankfurt, Germany for the well known Interstoff show and it was here she formulated her new ideas. Fashion of the future she feels "will not be designated as French, Italian, American, but instead as clothes to wear for different earthly activities. The ethnic boundaries of clothes will be torn down as travel and communication increases to warp speed. Third world countries will be jettisoned into the 21st century.



**Figure V**

Silhouette styling will be a collection of the best ideas of futurists throughout this century with the addition of 90's technology....stretch will be a factor in almost every fabrication as the demand for performance and constant neatness increases. Comfort in our clothes, both mental and physical, will also be a prime factor. Fabrics with a brushed inside and smooth outside will have great comfort acceptance. The predicting of seasonal trends..is coming to an end...and is replaced by seasonal updates and the evaluation of the evolution of fibre, chemical, production, finishing and construction technology as well as how color is used and worn".

Once fashion designers learn the full capabilities of these CAD systems there will be a popularization of the computer

look. Through new ways to send CAD images via electronic graphic interchange (EGI) design houses will be able to compare images world wide. The separation of the apparel manufacturer, the retail store and the consumer is ending. Today people are evolving mentally at a very rapid rate. This mental evolution is also affecting the intuitive responsiveness as to what clothing image best represents a persons psychological frame work. These subtle changes in mood are then translated into taste and the responsiveness of the designer with a CAD system can design and produce clothes for this new cultural sensitivity. The changes we are about to witness are so profound that only a handful of designers and retailers are aware of the change. People have not really considered clothing as an important sociological issue nor as an out growth from the virtual reality of the computer. The most significant event which will occur for the consumer will be appropriate styling and production of apparel for their particular needs. It will not be inconceivable for a person at home to design a garment on their computer using the apparel data base from their favorite specialty store and through EGI (electronic graphics interchange) communicate with the in-store CAD designer for all the refinements, and within a matter of weeks have their desired garment delivered by express mail. So if you would like to talk to the new breed of CAD designers you can find them working in several cities. In my travels I have talked to many and I leave it up to you to find them. If you are a CAD fashion designer please contact me and we can establish a new forum for exchanging fashion ideas as a result of CAD/CAM systems. ' © 1989 WVDB

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**IT'S GETTING BETTER ALL THE TIME:  
INTELLECTUAL PROPERTY LAW AND COMPUTER-AIDED ARTWORK**

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**Abstract**

As a result of recent changes to the U.S. Copyright Act, and several court decisions, the protection afforded American artists has increased over the past year.

This paper will briefly review the nuts and bolts of securing copyright protection under the present law, and will discuss specific problems facing artists, especially those that employ computers. The word "you" is used often because you, the reader, can take many of the steps necessary to protect your work.

\* \* \*

**U.S. Copyright Law**

After more than 100 years, the United States has finally joined most of the rest of the world in a copyright treaty generally referred to as the "Berne Convention." While European countries that are members of the Berne Convention still afford their artists greater rights than those enjoyed by artists in the United States, there has been a warming trend in the United States.

The best part of joining the Berne Convention is that any work protected by the U.S.

Copyright Law will now also be protected, automatically, in the dozens of other countries that are also members of the Berne Convention. Until this past March, the owner of a copyright who wanted copyright protection in Europe would publish the work simultaneously in the U.S. and in a Berne Convention country, such as Canada. This extra step is no longer necessary.

The basics of the U.S. Copyright Act are little changed. The U.S. Copyright Act protects works that are fixed in a tangible medium of expression. The term "work" includes sculpture, performances, writings, computer programs and two- and three-dimensional objects. The term "fixed in a tangible meaning of expression" means that the work has been preserved in some manner. Thus a computer program is fixed in a tangible medium of expression when saved to a disk or printed on a piece of paper. An improvised performance work may be fixed in a tangible medium by videotaping the performance in progress.

The Copyright Act automatically protects the work as soon as it is fixed in a tangible medium of expression. The artist or creator of the work -- called the "author" -- need not do anything more to protect the work. The

protection will last for the life of the author plus fifty years. If the work is anonymous or pseudonymous, or is initially owned by an employer as a "work made for hire," the protection lasts for seventy-five years from the date of first publication, or one hundred years from the date of creation.

Having created a work, you may rest on your laurels, or you may exercise two options that will increase your remedies.

#### Copyright Notice

The first option is the placement of a copyright notice on the work. Under prior law, a copyright notice was required for all works that were "published" or distributed to the general public. The law is now different.

Under the present law, any work first published on or after March 1, 1989 does not need a copyright notice. However, it is still recommended that all authors place copyright notices on their works because it helps the author should the author later have to sue an infringer (see below). Works published for the first time prior to March 1, 1989 still need to bear a copyright notice, even in reprints, or risk losing all copyright protection. The copyright notice consists of three parts:

1. The word "Copyright", the abbreviation "Copr." or the letter "C" in a circle (" © ");
2. The name of the copyright owner, or a unique abbreviation; and
3. The year that the work was published, but only if the work is published.

You should place the copyright notice somewhere conspicuous on the work, such as the welcome screen of a computer program, the base of a

sculpture, or the front of a two-dimensional work. The term "All Rights Reserved" is added to gain copyright protection in South and Central America under another copyright treaty called the Buenos Aires Convention.

#### Copyright Registration

A second option available to you is the registration of your copyright with the Register of Copyrights. As noted above, the work is protected by copyright law as soon as the work is "fixed" or preserved. Registration provides additional goodies should you later have to sue an infringer. The registration process is simple and inexpensive.

The Copyright Office provides forms consisting of one piece of paper, both sides of which are filled out. Different forms are used for computer programs or literary works (Form TX), visual works (Form VA), performance art (Form PA), and sound recordings (Form SR). The completed form, a check in the amount of \$10, and a "deposit" is mailed in one envelope to the Register of Copyrights, Library of Congress, Washington, DC 20559.

The type and amount of material deposited with the Register depends on the type of work registered. The deposit for a published literary work is two complete copies of the work. For a computer program, published or unpublished, the deposit consists of one copy of the first 25 pages and last 25 pages of source code. For three-dimensional works, a photograph or a drawing may suffice as a deposit.

If there are no mistakes or problems with the application, the Copyright Office assigns a unique number, photocopies the approved application onto a special form, and returns the



form as the Certificate of Copyright Registration. If there are any problems or mistakes, the Copyright Office may return the form, explain the problem and how it may be corrected, and give you several months to try again at no additional charge.

Copyright application forms and guides (called "circulars") are available at no charge from the Copyright Office by calling (202) 707-9100. A low tech answering machine will take your order, and the forms will arrive in about six weeks. If there are still any questions, a call to the Copyright Office at (202) 479-0700 should be helpful. The Copyright Office will not provide legal advice, but can otherwise explain which form to use and how to fill it out.

### Hi Ho, Hi Ho, It's Off to Court We Go

There is a reason that the law protects certain works. There are people out there who will copy the works of others without permission. While such people might be called scoundrels, villains or bad guys, the law calls them "infringers." So what can you do with an infringer?

First, you can tell the infringer that he or she is infringing. Of course, if your copyright notice is already on the work, then the infringer is deemed to have notice of your copyright and cannot claim to be an innocent infringer. An innocent infringer may be forced to pay reasonable royalties for the use of the work. An infringer who is not innocent may be held liable for a great deal more.

Second, you may register the work with the Copyright Office if it is not already

registered. While registration is not necessary to secure copyright protection, a copyright registration is necessary to file a copyright infringement lawsuit with a court. Further, the three-month long registration process can only be speeded up upon the payment of an additional fee of \$100 to expedite the application. Thus, it is easier and less expensive to register the copyright early.

Once you have a Certificate of Copyright Registration, go to court. At this point, if you have not done so already, it pays to speak with an attorney. A copyright owner is more likely to prevail in court with the help of an attorney than without one.

Once the suit is filed, you may seek an immediate end to a continuing infringement by asking the court for a temporary restraining order and a preliminary injunction.

Upon proving your case, you as the copyright owner may recover any damages that you actually suffered as a result of the infringement (lost sales or royalties), plus any profits made by the infringer. Other available remedies include injunctions, the destruction of the infringing items, and the court costs.

If the work was registered with the Copyright Office prior to infringement or within three months of the date of first publication, then you have the option of asking for "statutory" damages and the award of attorney's fees. Statutory damages are awarded by the judge at his or her discretion from \$250 to \$20,000 per infringement. If the infringer knowingly infringed, then the judge may award up to \$100,000 per infringement.

### Work Made for Hire

One area of concern recently has been the ownership of commissioned works, including artwork. For several years, a series of court decisions held that an independent contractor commissioned to create a work may be deemed to be an "employee" for copyright purposes, effectively transferring the ownership of the copyright from the author to the commissioning party.

This mess resulted from a misreading of the Copyright Act, which has two definitions of the term "work made for hire." If a work is a "work made for hire" under the Copyright Act, then the "author" of the work is not the artist, writer or creator of the work, but, rather, the employer of the artist, writer or creator of the work is deemed to be the "author" of the work.

The first definition of a work made for hire is "a work made by an employee within the scope of his or her employment." An artist employed by a design studio may create copyrightable works, but the design studio will be deemed the "author" of the works. The artist never owns the copyright; the initial copyright owner will be the artist's employer.

Of course, if an artist who designs widgets for her employer goes home at night and paints landscapes, then the artist will be the "author" of the landscape paintings. The artist's landscape paintings are not within the "scope of his or her employment." The scope of employment is the key, because it should not matter whether the artist designs widgets for her employer at the employer's office or at her own home.

Unfortunately, the first

definition of "work made for hire" is somewhat different than under prior law. Under prior law, the term "work made for hire" was not defined, and judges took it upon themselves to develop their own tests. In several courts, a "work made for hire" existed whenever a work was commissioned by another person.

A second definition of "work made for hire" applies to the creation of a collective work, audiovisual work, translation, instructional material, supplementary material (charts and materials added to an existing work), an atlas, a test, and test answers. The second definition applies only when the parties sign a written document that states that the work is a "work made for hire."

The requirement for a written document has all but eliminated confusion over the second definition of work made for hire. Indeed, the only way by which a copyright can be transferred is by a written document, except in cases of work made for hire, because the employer is deemed the "author." Naturally, whenever a dispute arises over ownership of a copyright -- and there is no formal agreement between the parties -- the commissioning party might claim that the work was a work made for hire under the first definition. Several cases illustrate what happened next.

Aldon Accessories, Ltd. v. Spiegel, Inc. The president of Aldon Accessories visited several factories in the Far East. The factories commissioned artists to sit down with Aldon's president and design unicorn and horse figurines, which were later manufactured by the factories and sold by Aldon. Aldon, the

factories and the artists were all independent contractors.

Aldon sued when Spiegel started selling copies of the figurines. Spiegel replied that Aldon didn't own the copyrights in the design of the figurines because the artists were independent contractors. Aldon responded that it controlled and supervised the work of the artists.

The appellate court sitting in New York City held that Aldon's control and supervision (really the giving of specifications) was sufficient to make the artists "temporary employees" of Aldon, so the artists' works were works made for hire, and Aldon won the suit. The artists may not have been aware that any copyrights they owned were the subject of litigation.

Evans Newton Inc. v. Chicago Systems Software. Evans Newton Inc. ("ENI") commissioned a seven-person company called Chicago Systems Software ("CSS") to prepare a number of programs in BASIC from specifications provided by ENI. When a copyright dispute arose, the parties went to court.

The appellate court in Chicago, citing the Aldon Accessories case, decided that CSS "merely applied its programming skill," and that ENI's supervision and control were such to make CSS the temporary employees of ENI. ENI won the suit.

Easter Seal Society for Crippled Children and Adults of Louisiana, Inc. v. Playboy Enterprises. Easter Seal Society ("ESS") staged a Mardi Gras parade inside the studios of New Orleans' public television station, and then forwarded some of the edited video for inclusion in the Jerry

Lewis Telethon sponsored by the national Easter Seal organization. Some of the Mardi Gras participants were later surprised to see parts of the same video edited into "Candy the Stripper," a soft porn movie produced by Playboy.

ESS sued claiming copyright infringement, but Playboy replied that the copyright to the video was owned by the television station, and not by ESS. The appellate court in New Orleans refused to follow the Aldon Accessories and Evans Newton cases. Instead, the court held that the video was a work created by the television station and its employees (as a "work made for hire"), not ESS, so the television station owned the copyright.

The first definition of "work made for hire" separates employees from independent contractors, and does not serve to make independent contractors "temporary employees" of commissioning parties according to the court. Playboy won; case dismissed.

Community for Creative Non-Violence v. James Earl Reid. The Community for Creative Non-Violence ("CCNV"), founded by Mitch Snyder, helps homeless people in Washington, D.C. CCNV conceived the idea of a modern Nativity scene in which the adults and infant figures would appear as homeless people huddled on a steam grate. CCNV contacted Reid, who agreed to sculpt the figures. CCNV agreed to pay Reid's expenses, and Reid donated his services.

CCNV provided additional specifications and suggestions, which Reid incorporated. Reid spent about six weeks in his Baltimore studio working exclusively on the figures.

After the sculpture was displayed, a dispute arose

between the parties, each claiming ownership of the work and the copyright. The trial court held that CCNV had controlled and supervised the creation of the work, as in the Aldon Accessories case, so Reid was a temporary employee and CCNV owned the copyright.

The appellate court disagreed, and reversed the decision of the trial court, citing the Easter Seal Society case. The U.S. Supreme Court, which had refused to hear the Aldon Accessories, Evans Newton and Easter Seal Society cases, agreed to hear this case.

The Supreme Court agreed that the question of whether a work is a "work made for hire" under the first definition depends on whether the creator of the work is an independent contractor or an employee. The sculptor won, as did all artists who take commissions for their works.

The Supreme Court confirmed that a settled area of the law, known as agency law, determines whether an artist is an independent contractor or an employee. A number of factors are considered, including the following:

- the hiring party's right to control the manner and means by which the product is accomplished;
- the skill required;
- the source of the instrumentalities and tools;
- the location of the work;
- the duration of the relationship between the parties;
- whether the hiring party has the right to assign additional projects to the hired party;
- the extent of the hired party's discretion over when and how long to work;

- the method of payment;

- the hired party's role in hiring and paying assistants;

- whether the work is part of the regular business of the hiring party;

- whether the hiring party is in business;

- the provision of employee benefits; and

- the tax treatment of the hired party.

While the first factor, the right to control, is the most important factor, the above list is not exhaustive, and no factor is determinative of the result.

As with almost all questions of copyright ownership, a written agreement between an artist and a commissioning party can resolve a dispute before it begins.

### Droit Morale

One of the highlights of the Berne Convention in Europe -- the "droit morale" or moral rights provisions -- has yet to find its way to these shores.

In most of Europe, an artist can sell her work and all rights to it, but still keep the right to determine the manner in which it will be displayed, as well as the right to have her name removed if the work is materially altered. These moral rights are inalienable; the rights cannot be given or sold away.

In the U.S., the creator of a work may have some limited rights under the federal Trademark Act, not the Copyright Act. The Trademark Act prohibits the false designation of the origin of a good or service in interstate commerce.

Thus, if a work is materially altered, the artist

can, under certain circumstances, demand that the her name is removed from the altered work. The same statute prohibits the removal of the artist's name of the work, or any passing off of a work by one person as the work of another.

This area of U.S. law is still new and undeveloped. While several bills have been introduced that would provide artists with a more complete set of moral rights, the opposition remains very strong. It is likely there will be more court decisions that will help delineate the limited moral rights available under the Trademark Act. It is not likely that the statutes will be changed in the near future.

In the meantime, an artist may use written agreements to define the relationship between her and any licensee or assignee of her work.

## THE MIDI SEQUENCER AS A MULTI-MEDIA CONTROLLER

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### Abstract

This paper explains how a MIDI sequencer can be used to control a multi-media performance, which might include lights, lasers, slide projectors and kinetic sculpture. The hardware required is discussed and applications are suggested.

### Overview

A MIDI sequencer, used to control musical instruments, can now control multi-media devices. The circuit that makes this possible is a MIDI Trigger. This device examines a MIDI signal and produces an output signal when note data on a predetermined channel is detected. The output from the trigger can control relays or drive circuitry which in turn controls audio-visual devices. These audio-visual devices can then be treated as if they were MIDI controlled instruments, to be "played" from a master keyboard and "recorded" in synchronization with other instruments or effects.

A small computer running a MIDI sequencer program is an extremely powerful tool for musicians and composers. A MIDI sequencer which controls lights, motors and lasers can now be used by multi-media artists, kinetic sculptors and musicians who use visual effects in their performance.

Artists who use (or wish to use) computers to control their sculptures or performances can now use off-the-shelf sequencer programs. Complete MIDI sequencer packages are relatively inexpensive and much less expensive than control systems with custom software.

I have designed a MIDI Trigger which is hardware based and has 16 expandable gate type outputs. The outputs stay high for as long as a note is held down. My circuit has been adapted for use by artists and musicians.

The output of a MIDI Trigger is digital--either on or off. Even though it is digital, it can still control continuously variable events. For example, a series of pulses could be used to gradually decrease the setting of a digital potentiometer which controls audio. Even a single trigger could control a variable device. As an example, a trigger could start a ramp generator causing a bank of lights to increase intensity.

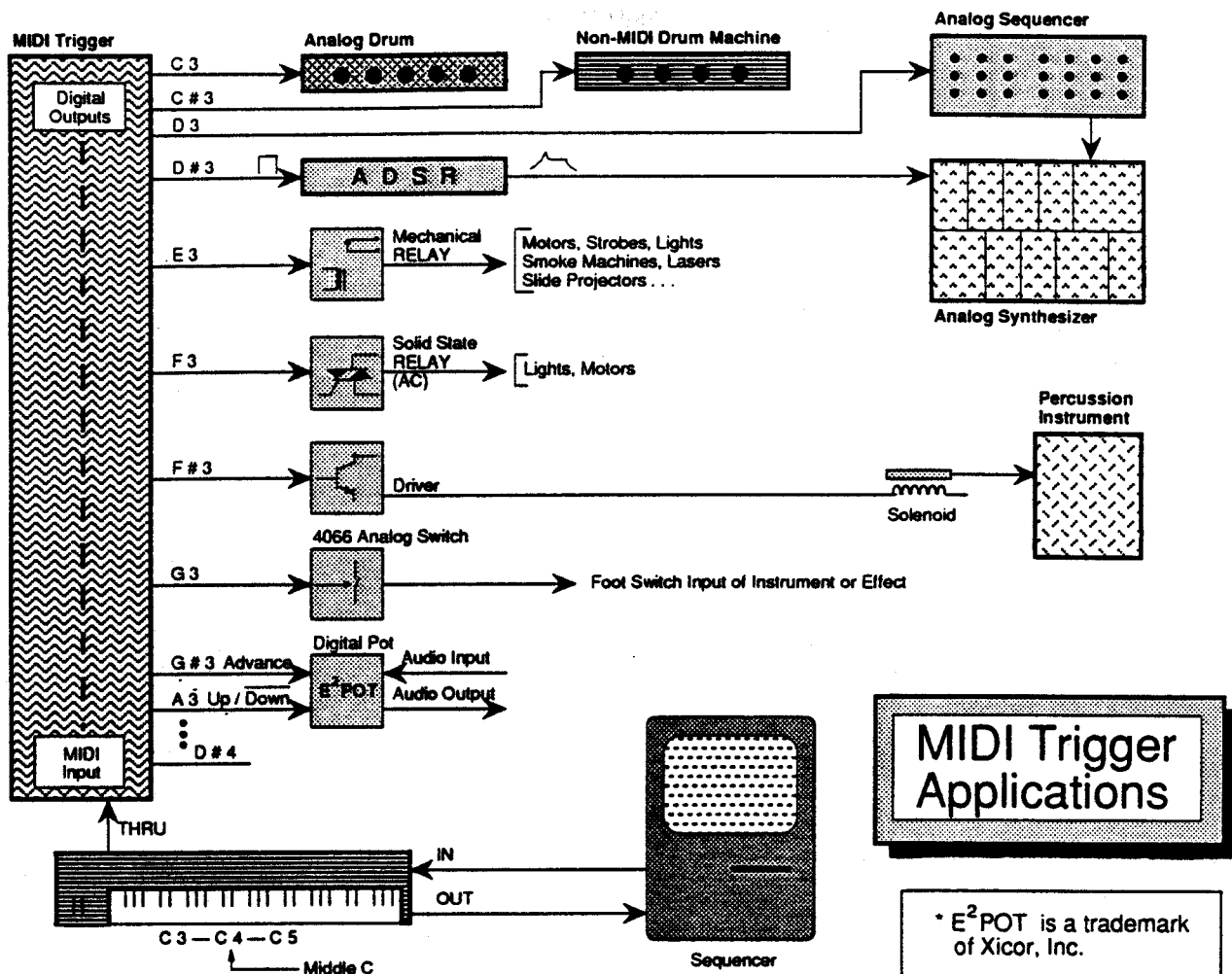
These triggering systems could be used to control events in real-time from a master keyboard. However, the real power of a MIDI Trigger is realized when used with a MIDI sequencer. With a sequencer, events can be recorded and played back like music tracks. During the creation of a work, one track can play back triggered events while another track records a second line of events.

### Driver Circuits

The figure below shows some of the devices a MIDI Trigger can control with appropriate driver circuits. The block on the left represents a Yewell MIDI Trigger. Some devices, such as an analog sequencer, can be directly controlled by the output of the trigger. Many applications though, require driver circuits such as those shown as square blocks in the figure.

A mechanical relay circuit is simple to design but is slow and prone to mechanical failure. However, if the relay is replacing a switch which was previously manually controlled, it may be fast enough.

A solid state relay is usually made from an opto-isolated Triac circuit, which can only control AC current. It allows for fast control of incandescent lamps and AC motors.



A power transistor can be used to control many low voltage circuits. In the figure, a power transistor is used to control a solenoid.

An analog switch is an IC which acts somewhat like a relay. It is designed to pass a signal when a specific logic level is applied to its control input.

A digital potentiometer simulates the action of a mechanical potentiometer. Pulses applied to its control inputs change the effective setting of the "pot".

Other control devices include stepper motor controllers and light dimmers.

#### MIDI Controlled Devices

Alexander Scriabin developed complex theories for the relationship between color and music. His 1915 score for "Prometheus: A Poem of Fire", could be realized with an expanded MIDI Trigger

controlling a bank of colored lights. Imagine lights changing hue and saturation and intensity in complex relationships with the musical score played on a MIDI synthesizer.

The traditional electronic color organ uses the output of band-pass filters to control SCRs or Triacs (which control lights). This produces a monotonous "Mickey Mouse" mimicing of the music. A MIDI Trigger controlled light show would allow for complete synchronization with music and more importantly, complete asynchronization with music. This would enable the creation of visual counterpoint. At times lights might echo the rhythm of a past melody.

A simple way to use a traditional electronic color organ in a less monotonous way, would be to turn the color organ off for specified intervals using a MIDI Trigger.

Many laser scanning systems are controlled with modular analog synthesizer type systems. These systems could easily be controlled with a MIDI Trigger. Laser manipulations could be controlled from one or more MIDI channels.

Slide projectors can be controlled by replacing remote control units with MIDI Trigger controlled relays. Not only can forward and reverse be controlled, but some projectors will allow for remote controlled focus. The most desirable system would include a dissolve unit. This too could be MIDI Trigger controlled.

With separate triggers for forward and reverse and one for the lamp, a series of slides can be shown nonsequentially. This would allow individual slides or sequences to be repeated during a performance.

Video switchers and special effects generators can be controlled with analog switches and digital potentiometers. The MIDI Trigger could also be used to control circuits in a modular video image processor, such as the Sandin Image Processor. Video effects could be orchestrated by controlling one effect at a time on a MIDI sequencer.

Motors and kinetic sculpture and robots can be controlled with relays and motor control circuits. Stepper motor controllers can be directly controlled from a MIDI Trigger's pulse output. The motions of a sculpture or robot can be carefully choreographed by recording each action separately. After all tracks on the sequencer are recorded, the entire sequence can be played back. If this were performed manually, it could require a dozen operators.

A MIDI Trigger could be used to control the routing of signals to speakers. Precise control of speakers would mean complex spatial modulation effects which would go far beyond simple stereo panning.

### Compositions

Because non-musical events can now be recorded on a MIDI sequencer, notation of events can be printed with scoring programs. This would aid the media artist in composing new works and archiving previous works. Interactive works could be realized using popular algorithmic programs. A performer or viewer could interact with a work by entering MIDI data into the system. A

MIDI controlled work might include sensors which send MIDI data back to the sequencer. The data could then be processed and sent to triggers and drivers, creating an interactive sculpture or environment.

Now the composer and media artist may control a vast array of instruments and devices with inexpensive small computer systems, using the MIDI sequencer as a multi-media controller.



point of view and therefore both perspective and directional illumination as well as literary narrative. Furthermore, most of these programs had their roots in important work intended for applied uses and not for artistic exploration.

A static abstract or three dimensionally illusionistic painting may be executed with a ready-made paint program; its miniature size, its lack of scale, detail, and gesture make it a paltry imitation of another medium (paint on canvas) itself greatly amenable to serious investigation. There is an unavoidable historical lag between the programmers of art software for general use and the needs of research artists. There may become available software for all that an investigative painter might need; but I have doubts.

The advanced guard of the visual arts (painting) has long since completed the all-important groundwork of perspective, shading and directional illumination as well as other forms of three dimensional illusionism. This groundwork was built on the basis of ancient parallel projection. Painting has also sufficiently established the language of visual narration. Now the advance guard of thinking in the making of pictures moves to new explorations dealing with relative space, color and light. Now mathematicians continue to build on and refine the language of perspective and shading to better serve technical design and other applied visualization methods with or without use of a computer.

From these same researches of painting have grown also the principles of lens based picture making machines. These new technologies define and invite new areas of creative exploration. Thus, photography, film-making, and video are now full fledged areas of both creative and technical exploration. It would be backward to the extreme for painters to laboriously keep using oil or acrylic paints to pursue perspective and shading while computer aided design (CAD) and photography and film-making and video -- all children of painting -- are more productively exploring these forms.

Having a research orientation as our central goal does not make painters better than designers or other technical users of CAD programs. The only difference between our creative efforts and theirs is the relative distance to the production of commodities. Their work is more immediately useful to society than ours as so called 'fine' artists. Their creative search directly aids production and technological advancement and is more focused in scope. Yet our work, though more wasteful, is ultimately just as useful. It is as though the social project of solving visual problems is first attempted by the research artists (the fine arts) who cast about wildly in the dark and make many more mistakes than useful guesses. Because of the diffuse focus of artistic work its byproducts are often exploited as objects of amusement and fashion by the bourgeoisie. Creativity is very expensive. The broader the boundaries of investigation the more social waste there is.

## USEFULNESS OF PAINTING

The rare few worthy discoveries made by painters (research artists) penetrate our society with a surprising speed. The good idea is infectious and has a tendency to permeate the social fabric very quickly if it is not blocked. It travels from artist to artist to the larger visual consciousness of the community. It moves with a speed similar to currency and is refined in the process becoming more and more symbolic and gathering more and more social agreement as to its precise meaning. Finally a few generations later it finds its way into the useful technologies of our time.

If we trace the history of shading from its earliest uses in the Ajanta caves (about 200 B.C. to 200 A.D.) of northern India and in ancient Greek murals to its development in the Italian Renaissance (which gave it its art studio name of *chiaroscuro*) to its entry into photography and ray-tracing and CAD programs; we will have examined an example of how visual ideas begin as vague explorations then how they become gradually more symbolic and more precise and more useful until they become reliably predictable and thus technically applicable directly to production. Whereas CAD programs are directly related to production, painting, its most significant parent, remains distant from production.

Painting, as a research art then, contributes to the spiraling development of new technologies. As part of these cycles of cause and effect it too must incorporate some of the effects it caused. While painting is one of the many parents of computer graphics, contemporary painters must use the computer as a modern technology to remain connected to our economic and social growth. That is painters must incorporate and learn the technologies of their time which the history of painting had a part in spawning.

With this consideration in mind it becomes obvious that to explore the visual formal (pertaining to form) language of pictures I cannot use ready-made art software. Such software is based on a pictorial formal language that can but be ancient history to the research artist. This does not mean that genuine discoveries cannot at all be made with ready made art software. I believe there is a very narrow possibility for discovery in such methods. But I see it as an unjustifiably narrow limitation on exploration. Would you expect contemporary space scientist to limit themselves to the language and scientific methods of Isaac Newton? Yet using the principles and methods of Isaac Newton may yield some discoveries.

Why should I be afraid to learn to program if Leonardo dared to dissect a dead human body. Think of the fear a man or woman of Leonardo's time had to overcome in order to dissect a human body. What if a spirit emerged out of the cadaver and said "boo" to poor Leonardo. In Leonardo's time progressive thinkers had to suffer the existence of the reactionary priest Savonarola and his bonfires of the vanities and other more serious attacks.

Learning to program seems far easier. The "bogey men" of contemporary conservatism are more laughable than scary.

#### TECHNIQUE + FORM + CONTENT = MEDIUM

To program or not to program is an even more substantial question than technical modernization. The heart of the issue is the relationship of media to the content of art. It questions how the content of our art work reflects the forms of thought of our contemporary society as well as our willingness to accept the fresh winds of the healthiest ideas of our time.

An often invoked issue questions whether the computer is a medium. Some may argue that it is not and others, myself included, think that it is. Clearly, it is a versatile new technology which was not invented for art. But then neither was the pencil and it is also extremely versatile and very useful for art. And it is well to remember the medium of wall relief of ancient Egypt with its myriad content. Like the modern computer the ancient bas-relief encompassed numeric data, contemporaneous scientific notation, writing, and pictures.

What is a medium and how can we explain the computer as a medium? Media first of all have material existence. The materials of a medium are manipulated in recognizable ways to express ideas or to perform useful functions. The material of a medium, be it ink on paper or color on canvas or bricks and steel and concrete, require information on how to control the particular material. This is called technique.

The material is manipulated with technical skill and technical knowledge to embody a tradition of symbolic forms such as witting or perspective or shading. This tradition of symbolic forms is a collection of rules and methods which manipulate a material in a way which will communicate ideas. For example shading is a form which conveys directional light and volume; while cross contouring is a form which conveys roundness. Form is entirely separate from technique. Several different techniques can serve the same formal language. Oil or acrylic painting or a CAD program can all be used to execute a perspective drawing. While oil and acrylic painting strictly as techniques without formal method may be used to paint the walls of a room. Wall painting is a technique but perspective is a form which contains ideas about depth and three dimensional space.

The ideas contained in form are a reflection of those things in reality that are to be communicated and this information is called content. Form and content are mutually dependent though separate. For example a CAD program is a form which may be used to manipulate many different types of information such as automotive design or financial charts or educational entertainment. All these are different categories of content. Conversely, similar content can be held by different forms and different technologies. For

example a speech may be recorded by film and video or audio tape. A landscape might be rendered in oil or acrylic or computer. A lesson about quadratic equations might be on television or in a book. Yet we all recognize even in these examples the powerful interdependence of technique, form and content. A regeneration of ideas generally involves some development in each of them.

Media has all three attributes of technique form and content joined together to make it usable as a bearer of our thoughts about reality. The materials of a computer are several but we agree that the primary and most significant one is electrons. The knowledge and skill of material manipulation of electrons then is the technique of computer as a medium. The form it takes is digital at the basic level and encompasses programming at the more complex levels. Digital information and programming are methods applied to the material of electrons to hold ideas. (1) These formal ideas are separate from the electronic material of a computer. Electronics can serve other than digital ideas and conversely digital ideas may be executed with materials other than electrons. The content that the formal language of digital information and programming can bear is extremely versatile. The computer as a medium is extremely versatile and useful yet it conforms to the principles of media we have, in our human history, found to be most useful.

Our thinking and the content that we seek to explore and externalize should of course be more important to us than the medium we use to express those ideas.

#### PRACTICE EXPOSES WHAT IS POSSIBLE

How do I measure what is possible with this medium and what its limitations are? One important consideration is what as a painter I can explore with the computer that I could not explore with other media. I should consider how this medium might reflect the most advanced contemporary ideas to serve our future needs. It is not possible to answer these questions without actual practice directly on the computer in an open and exploratory way. But it seems clear that it is inappropriate to make the computer mimic old media. In a research setting we should move forward.

Since new technologies usually make things easier -- our time more productive -- they are often used to imitate old labor intensive forms. This is appropriate for useful applications but not for exploration. This co-optation accompanies a hesitancy to accept the new technology with its bold brash rough-hewn qualities. For example when vinyl sheeting was first manufactured it was colored and textured to imitate leather but it was also considered brash and gauche. Early photographic portraits imitated oil painting portraiture. Are those computer artists, who do not program, using the computer as a new medium? Or, are they imitating old techniques and old forms and therefore other media. I think users of painting software are to the most imitating other media.

Did I just say the computer is bold brash and rough-hewn in its qualities? Am I crazy? I am. When I compare my small monitor with its limited number of rectilinear pixels to my large lead-primed canvases I suffer. Yes this new medium is rough-hewn indeed. Compared to my large canvases it seems small and ineffectual, lacking in the potential for either monumental gesture or intimate detail. I see no lush material which invites loving touch but rather a snapping static dirty miniature monster. If I approach to inspect the details with my love of pictures, it zaps my eyes.

#### WHAT THE COMPUTER NEGATES: TACTILITY EXPRESSIVENESS & MISCONCEPTIONS

Often my fellow artists and guests bring up the question regarding the manufacture by hand of 'fine' arts. I am sometimes accused of not having exerted tactile influences on the work of art and therefore, the accusers think, it must be devoid of feeling. How can you express your feeling using the keyboard? I do not make art to express my feelings. I leave that to those who are in a narcissistic forever loop. As a painter I investigate and this investigation, if worthy, will then provoke a soaring feeling from me and then hopefully from others. And maybe I will have contributed something to the reservoir of human knowledge in pictures.

Tactility as well as gesture are considered by many to be an important part of the formal language of painting. What is important to remember is that the formal language of painting, or of any other area of thought, is not static for all time. As in abstract pictures, perspective and shading have been negated so in computer-painting the issues of physical tactility are negated. As to gestures, the formal ideas there involved are changed not just reduced in size. In a shifting image there is not only gesture but rhythm in time. It is this changing and expanding of the formal language of picturing that is undergoing creative investigation. The intrusion of a new technology pushed by new social thinking has the potential of adding new dimensions to old form and subtracting from it what is no longer essential. The negation of what is no longer essential is not a waste. Rather, the process resembles cell division and what is negated in one area of thought may become a separate new area of thought. This division of intellectual work is parallel to the division of labor and is part of the growing complexity of human culture.

The transformation of painting gesture to an unfolding rhythm of abstract shape in time is precisely the kind of creative investigation that is provoked by the computer. The translation of both negative and positive shape from place to place in time is a gift from Cubism and Constructivism. When I consider the privilege of investigating these ideas on the computer with kinetic images and sound accompaniment, the notion that art is narcissistic self-expression or caressing tactility become ridiculous to the extreme.

The grossest misconceptions about programming computer art have to do with the notion that computer art is somehow a push button art and that the computer makes it not the artist. There are those who want to program the computer to fulfill this misdirected fantasy. Such programs might provide pleasure and entertainment and education but they do not replace genuine artistic investigation.

#### THE COMPUTER MIRRORS REALITY

The computer as medium mirrors our contemporary reality. This makes it imminently useful for describing contemporary life. Since the subject matter of research painting is the motion of contemporary life, the computer is a perfect medium with which to extend this research.

I cannot help but see the term 'hardware' as a wonderful metaphor for objective reality while 'software' represents our thoughts which are based on reality and tested by practice. Like our thoughts software has a solid basis in hardware and is tested by successful application to hardware. After all, the test of the pie is in the eating. Input and output, other than resembling our bodily functions, reflects how we gather information, then organize it, then think about it, then extract ideas, and finally perform a task based on it. Input and output is what a doctor does when he intakes our complaints and outputs a prescription. Computer memory is like our libraries and books with their various organizational divisions. Bits are manipulated between the CPU and the various parts of memory in a manner like our transportation systems -- they are bussed; or like our blood corpuscles they are driven by a constant rhythm (our heart or a clock). Program loops reflect daily living and working routines on both the personal and commercial or social levels. I can see a year as a 'for' loop where  $i = 365$  days and  $m = 12$  and  $wks = 52$ . Program functions are like factories and offices, they require certain types and quantities of data and give an end product and various byproducts. A function call is like a factory order. Program logic is a primitive reflection of the logic of a city with its multiple levels of organizations, transportation, information exchange and storage, financial currency and personal living.

#### MY WORK WITH COMPUTER

The only computer software I use is computer languages. I began with Basic and switched to C because it gave me more versatile control over my particular computer. The keyboard is my only input device.

The way I work with the computer is the same as with other media. I begin intuitively and type some initial program commands. I compile and link this initial small program and run it to evaluate. This first step may take from ten to thirty minutes. After judging it artistically I react intuitively and make minor adjustments or major

deletions. I repeat this cycle of programming, compiling, linking, running, judging and changing until the art work becomes a complete idea. Each repetition of this cycle may take three to thirty minutes. Sometimes I divide the program and work on the parts separately. When I am lucky it takes three days to complete a program. If I am unlucky and the painting refuses to become a recognizable whole, then this artistic process might take three weeks or more.

The end result is a program which when run creates a painting on the monitor which unfolds in time and possesses a stereo sound accompaniment. To me the medium is the computer and therefore electronic and digital. The program is like a recipe which can recreate the art on demand. It is cheap and light and has the potential of rapid distribution. It's potential is much less elitist than an oil painting. Hard output from the computer such as prints and videotape and photographs and slides are a natural efflorescence of this medium. I view the program and its performance on the monitor as the primary material of my computer paintings.

When any particular one of my programs is finished it will run in a predictable manner. My interest does not lie in programs which do not run the same way twice. I do not rely on chaotic chance to make art but rather on intuition. I attempt to shape each part of my programs.

Formally, what has happened in my work on the computer is that the form of digital information and programming have, with natural ease, borne and even promoted the formal language of abstract pictures. I am only at the beginning of what expands before me as an exciting and challenging area of investigation. Some of the important new ideas that computer as medium has shown me are: one, the combination of sound and visual form; two, gesture as rhythmic development in time or kinetic painting; three, a new more complex concept of surface and the picture plane.

#### SOUND AND SHAPE

I have listened to erudite lectures by those who do very methodical experiments attempting to find a relationship between music and pictures. Some dream of finding a system where a musical composition may run and create a set of moving pictures natural to it alone. I believe this is misdirected experimentation. The source of our ideas is material reality. It cannot be replaced by a methodical correlation of subjective feelings about the meaning of shapes and the meaning of sound.

The computer has given me the ability to begin to imitate the general principles of motion not only through how things look but how they look and sound. This work is primitive to the extreme in painting but exciting. When we pick up an object it makes a sound. We associate its look and its sound along with its many other attributes. Sound in my kinetic pictures is not intended as music. Rather it is intended to accent or to signal or to

betray the visual rhythm. My ability to manipulate sound is primitive. But there is a marked difference between a kinetic computer painting which runs with sound and one which runs without sound. The soundless paintings make me feel deaf - as though a window had been closed and I have become a step removed from reality. The sound gives life and vividness to visual rhythms. It is like the first day of spring after a long winter when you open the window and hear the sounds of the street long since muffled by winter.

In terms of programming the sound statements and the visual statements are interdependent. Often the duration of sound is used to delay or to time a visual change. And conversely, visual activity is used to control the duration of sound. Occasionally I use the same variable within bounds to measure both the sounds and the shapes. I do my utmost to control every aspect and detail possible. There is nothing mysterious about sound and shape cooperate. My goal is to imitate the rhythms of contemporary life.

#### GESTURE AS RHYTHM

One of the most exciting lessons of twentieth century painting is the treatment of objects in motion by Cubism. The Cubists believed, appropriately, that they were evolving a better method of making illusions of reality than earlier painting. They focussed on still life objects and the figure while the Futurists focussed on the dynamism and motion of city street. Their paintings are a historical step toward a view of space and time in relative terms. If we walk around a still life or notice the motion of the street around us we can see shapes between objects and the surfaces of objects being translated from shape to shape. They fluctuate and stretch and shrink and disappear and jingle their sounds. Finding a language to describe this modern perception of reality was the great gift of Cubism. On this basis abstract painting builds its ability to convey the general motion of things rather than their particular appearance at one time from one spot -- as though frozen in time and space.

With the computer we are able to expand this investigation. We can express gesture and rhythm as we allow shapes to grow and shrink and interpenetrate and gradually or abruptly change colors. We can invoke our viewers experiences with reality during the unfolding of the picture. Visual gesture, unfolding in time rather than on the surface of a static picture, will be recognized by viewers as a parallel to their own experiences of contemporary rhythms. But, some viewers of my kinetic paintings regret the passing gestures and often want me to freeze a frame for them to contemplate. They are troubled by the transitory nature of the painting. But this transitory quality is just one more imitation of reality. It is only in romantic memory that the orchard is always in blossom, frozen and disconnected from reality. In reality the orchard undergoes spiraling cycles of growth and change and it never stops for us.

## THE PICTURE PLANE

The third very exciting quality is the new electronic picture plane with its shifting and its complexity and its mercurial qualities. It is impossible for hard copy or traditional painting to compete with the actual luminosity of the monitor and its wonderful colors. In contrast to traditional painting's shading and directional light, we have always described abstraction's color and light as being self luminous. The monitor fulfills this beyond the maddest dreams of the first true abstract painters, the constructivists.

This picture plane has a memory. There is a magic in the way things return to the screen after they disappear. We are provided with a fast pace of changing images and huge amounts of data in a way that imitates our experience of the pace of modern cities and most information media. The speed of an elevator from the top of the trade towers to the first floor, the speed of shifting shape as we view the concourse below from an over-fast escalator, or the changing imagery of plate glass shop windows, the hum of the big escalators descending to the Jersey trains, the commotion and gaiety of the lunch hour crowd, the neon light and the moving letter signs can all comfortably live on a monitor screen as picture plane. Their mercurial rhythms are at ease here as they can not be in any other medium.

In conclusion, the computer has helped me move forward in painting in the three significant areas of investigation. These are: the combination of shape and sound, the gesture of shapes unfolding in time, and expanded concepts of the picture plane.

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(1) M. Morris Mano *Computer System Architecture* page 1: "A digital computer, as the name implies, is a digital system that performs various computational tasks. The word *digital* implies that the information in the computer is represented by variable that take a limited number of *discrete* or *quantized* value." Then on page two he continues: "Binary information is represented in a digital system by physical quantities called *signals*. Electrical signals such as voltages exist throughout a digital system in either one of two recognizable values and represent a binary variable equal to 1 or 0. For example, a particular digital system may employ a signal of 3 V to represent a binary 1 and 0.5 V for binary 0."

(2) The creative leap from Cubism to abstraction in picturing was accomplished by the constructivists during the creative intellectual surge based on working class revolution in the Soviet Union during the first decades of our century.

Samia A. Halaby "Lines/6"



"Constructivist/10"



These single images are like details from a larger whole: a kinetic painting with sound. These paintings can be reproduced in video but are best seen in the original medium of computer.







