SCAN '93

The Thirteenth Annual
Symposium on Small Computers in the Arts

November 12-14, 1993
The Franklin Institute Science Museum
Philadelphia

Program
&
Proceedings

Sponsored by:

Small Computers in the Arts Network, Inc.
The Franklin Institute Science Museum
Pennsylvania Council on the Arts
Dock Street Brewing Company

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Welcome to SCAN '93

We hear a lot about the electronic highway and its promises for bringing people closer together through computer networks, cable TV channels, picturephones, electronic conferencing, etc. Certainly some SCAN attendees are on the forefront of this field. And, of course, we use faxes, phones, modems, networks and email to organize SCAN. However, I can't (yet) imagine a SCAN Symposium where people don't physically get together. As the old timers at SCAN know, the "getting together" is what our Symposium is all about... the contacts made, the socializing, the 3-day immersion in technology and art without distractions.

I became much more aware of this in the past few months. Talking to old friends and making new ones in the course of putting together this program was, for me,. like a mini-symposium in itself...the new things I learned from Bryan Shuler's "DNA as Art" project, the laughs writing Tim Anderson's biography, the clowning on the phone with PIXAR's Dr. Bill, talking to friends I hadn't seen in a while and the excitement I sensed in all those calling to ask about registering.

SCAN is different from many other events that cover computers in the arts. SCAN is organized and run by volunteers who are as excited about the field as those who attend. We focus the program on what we feel are the trends in the field. We have no pressures from outside to force us one way or the other. We also have no money...which means every speaker pays their own way and is here because of their commitment to the field and to our cause.

In retrospect, it has been through the support of a lot of individuals that SCAN has kept going strong for 13 years. Every Symposium has been a success in terms of gathering an exciting group to share their experiences. Past participants have ranged from the famous (Timothy Leary, Bob Moog, Tod Rundgren) to the infamous (Bill Kolomyjec, Walter Wright, ...). However, we need your help to keep it going. If you have ideas, tell us. If you have time, help us. (If you have money, give it to us.) But most of all, enjoy SCAN, learn and have fun. Tell others about us and come back next year.

So take advantage of a unique event!

Dick Moberg
SCAN '93 Program Chairman

SCAN '94

Start thinking about next year's Symposium. If you want to help out or have a suggestion, please contact us. For now, use the address for the 93 Symposium: SCAN, Box 401, Ambler, PA 19002. We will keep you posted as to dates, tmes, etc.

Special thanks to:

The SCAN Staff: Mark & Misako Scott, Tom Porett, Steve Beuret, Julie Shay, Howard Byer and anyone else who came to our meetings throughout the year. **Technical support:** Steve Beuret. **Art Show:** Ann Seidman. **Franklin Institute:** Ed Wagner. **Lots of others:** All the speakers and performers who gave their time and talent. My fellow employees at Moberg Medical who answered the phone, processed the mail and did other tasks.

SCAN'93 was produced by the Small Computers in the Arts Network, Inc., a non-profit, volunteer organization. Contact us at: SCAN, Box 401, Ambler, PA 19002.

Contents

Part I

SCAN '93 Overview

Presentations
In three days we have packed over 40 presenters and performers in one continuous stream of events. This is a departure from our concurrent sessions. Let us know how you like it. The schedule is on the next few pages. Descriptions of the talks follow this section. All events will be in the Choices Forum at the Franklin Institute.

Performances
Saturday night is the 15th Annual Philadelphia Computer Music Concert held as part of SCAN. The concert will be held in the Choices Forum at the Franklin Institute. See Part II for a description of each performance.

Social Events
Thursday is the opening reception at Dock Street Brewing Company. We will provide some munchies and will have a cash bar. **Friday** is the video bar reception at Moore College of Art. Bring slides and videotapes of your work. Music and other sounds will be provided by our longtime friend and supporter, Walter Wright, of TrueVision. Numerous breaks will be held to socialize with friends and colleagues.

Computer Art Show
Works from over 30 artists will be on display in the gallery outside the Choices Forum. The gallery is open to all Museum attendees and the show will continue into December.

Computer Art Store
As always, we will have books, tapes, CDs, post cards and back Proceedings for sale at the Computer Art Store. The Store will be open during the hours of the Symposium. Checks and cash are accepted.

Rules & Regulations
People without a badge will not be allowed into Choices Forum. Please wear it. It is the only way we can tell you apart from others at the museum. Thanks for your cooperation.

Public Presentations

SCAN is sponsoring presentations to the public visiting the museum during the weekend of SCAN. The presentations will be given both Saturday and Sunday as follows:

Walter Wright	10:00 AM	TrueVision
Herb Deutsch	12:00 PM	From Moog to Mac
Howard Byer	1:00 PM	CD Comics
Richard Block	2:00 PM	Typography - From Manuscript to Macintosh
Walter Wright	3:00 PM	TrueVision

The Franklin Institute Science Museum

While at SCAN, visit the Franklin Institute's Science Center and Mandell Futures Center, where hands-on science exhibits originated. Participate in everything! Stroll through a giant heart or learn about the environment while exploring a rain forest. Take a ride on a locomotive or climb aboard a model space station. Watch as your face ages 25 years on a video monitor! Grapple with the issues shaping the 21st century in the Musser Choices Forum equipped with video wall and a computer key pad audience response system. Catch a movie in the Tuttleman Omniverse Theater, with a four story domed screen that puts you in the middle of all the action. In the Fels Planetarium you can explore space and astronomical phenomena. The Institute houses 15 permanent exhibits and the Benjamin Franklin National Memorial.

Food

SCAN will provide coffee and other stuff as our budget allows. If you need coffee or food and we don't have it, try one of the following places.

The Franklin Institute There are two restaurants in the Museum: Ben's, serving homemade soups and sandwiches, and the Omni Cafe, serving sophisticated salads and pasta for lunch and dinner. **Dock Street Brewing Company** (496-0413) 2 Logan Square, between 18th & Cherry Sts. Good freshly brewed beer, innovative menu, medium prices. **Cutter's Grand Cafe** (851-6262) 2005 Market Street. Very fresh seafood, well stocked bar, medium prices. **The Fountain at the Four Seasons Hotel** (963-1500) Logan Square, between 18th St. and the Parkway. Fancy food, fancy desserts, fancy prices. **Mace's Crossing** (564-5203) 1714 Cherry Street, 17th St. at the Parkway. Tavern with good burgers, medium prices. **Marabella's** (981-5555) 1700 Benjamin Franklin Parkway, at 17th St. Good, updated Italian, reasonably priced. **Morton's of Chicago** (557-0724) 19th & Cherry St. Big wonderful steaks, lobsters, lamb chops...tabs. **Restaurant Callowhill Street** (557-6922) 19th & Callowhill St. Upscale, French-American, nice ambience, medium-high prices. **Rose Tattoo Cafe** (569-8939) 19th & Callowhill St. Good international food, moderate prices, cute place. **Swann Lounge & Cafe** (963-1500) Four Seasons Hotel, between 18th & the Parkway. Elegant lounge, creative menu, expensive.

Part II
Presentations & Performances

Schedule

Day 1 Friday, November 12

9:00	Opening Remarks *Dick Moberg*
9:15	Casio vs the United States: Defining Musical Instruments *Herb Deutsch*
	Caffeine
10:30	Electronic Publishing: What, How & Why *Paul Peacock*
11:15	Digital Smoke Sculptures *Michael O'Rourke*
	Chow
1:00	Some Interactive Models and Devices for Music Making *Richard Povall*
1:45	State of the Art Art (in NYC) *Rachel Gellman*
2:30	Lateral Imaging *Steve Berkowitz*
	Caffeine
3:30	Art for Technology's Sake *Tim Anderson*
4:15	The Multimedia PC as an Artist's Medium *Robert Kendall*
5:00	OpCode's Studio Vision *Ben Austin*
	Chow
8:30	**Videobar Reception** *Moore College of Art*

Day 2 Saturday, November 13

9:00	Multimedia Design Practicum *Dr. Bill Kolomyjec* ***Separate registration required for admission to this event***
	Caffeine
10:15	What Comes Next? The A-to-D Dilemma *Connie Coleman & Alan Powell*
11:00	The Hidden Mona Lisa *Lillian Schwartz*
	Chow
1:30	Sculpture Panel *Rob Fisher, Tim Duffield, Steve Porter, Michael O'Rourke and Helaman Ferguson*
	Caffeine
3:45	How to Make Your Own CD ROM *Judson Rosebush*
4:30	Expressive Devices or Devices of Expression *Terry Mohre, Lily Diaz, Gene Perla, Alan Moore*
	Chow
8:00	**15th Annual Philadelphia Computer Music Concert** *Bruce Wands & Nick Spencer* *The Luminists - Charles Cohen, Eric Scheftler* *LifeFormz - Ranjit Bhatnagar*

Day 3 Sunday, November 14

	Continental Breakfast
9:30	Facial Animation *Catherine Pelachaud*
10:15	Creating the Virtual Art Gallery *Bruce Wands*
11:15	Thinking Big in the Real World *Nancy Freeman*
	Chow
1:00	Like Telling Dreams *Mary Beams*
1:45	Song of the Helix *Bryan Shuler*
2:45	Closing Remarks *Dick Moberg*

Descriptions and Biographies

Day 1 Friday, November 12

Casio vs the United States: Defining Musical Instruments

Herb Deutsch
19 Crossman Place
Huntington, NY 11743

At first glance, the trial of Casio vs. The United States represented nothing more esoteric than the question of import duties imposed on a manufacturer. In pleading its case for lower duties, Casio claimed that its keyboards and synthesizers were "electronic devices" rather than "musical instruments". As an expert witness for the U.S. International Trade Office, I found myself exploring the definition of *musical instruments* - in fact, of *music* itself - particularly as these terms reflect digital technology, our contemporary society and, I think, the very future of our art. To my surprise, Casio's principal expert witness was Bob Moog (with whom I collaborated in 1964 on the first Moog Synthesizer) whose testimony *also* was based on defining musical instruments!

Herbert A. Deutsch has had an eclectic career as a composer, author, educator and marketing consultant. A Professor of Music at Hofstra University, he directs the Music Business Program, the Electronic Music and Recording Studios and teaches composition. A composer of music in various media, his work has been widely performed and commissioned works have been featured at MENC national and regional conferences. He co-founded and is Vice President of the Long Island Composers Alliance, and is a recipient of several *Meet The Composer* awards and a 1992 and 1993 *ASCAP Award.*

His interest in electronic music led him to collaborate, in 1964, with Robert A. Moog on the development of the first Moog Synthesizer, and, in September of 1965, his "New York Improvisation Quartet" gave a New York concert which included the Moog's first live performance.

He was Director of Marketing and Sales at Moog Music, and has been a marketing and development consultant to Multivox Music, Norlin Industries, Passport Designs Software and Jim Hensen's Muppets. He is the author of *Synthesis*, (Alfred Publishing Co.), in its second edition and published in Japanese and Korean, and *Electroacoustic Music; Its First Century* (CPP/Belwin). he is active in the *Society for Electro-Acoustic Music in the United States, Small Computers in the Arts Network,* was co-founder, Educational Consultant and feature writer for *The Music & Computer Educator* and a reviewer for *The American Record Guide.*

Electronic Publishing: What, Why & How

Paul Peacock
FPI, Inc.
POB 2084
Hoboken, NJ 07030

In this talk, Paul F. Peacock will explain what electronic publishing is, review the current state of the electronic publishing industry and show you how you can publish electronically on regular 5 1/4" or 3 1/2" disks. The talk should complement Judson Rosebush's talk on CD-ROM.

Paul F. Peacock is an Englishman with seventeen years experience in computing who is also a poet. He started an electronic publishing company two and a half years ago and has been gratified to see himself turn from a pariah into a visionary. His company, Floppyback Publishing International, has been featured in numerous magazines from both the PC and book publishing industries. he is on the Board of Directors of the Digital Publishing Association and is currently looking for investors to take his company to the next level.

Digital Smoke Sculptures

Michael O'Rourke
44 Tompkins Place, #1
Brooklyn, NY 11231

Over the course of about two years, I did some work for the artist, Frank Stella. The work involved using a high-end 3D computer modeling system to model very fluid and irregular forms which were inspired by the shape of smoke rings and whorls -- the way smoke floats and drifts in a room when there's no breeze to disturb it. These forms were then built, through a variety of digital-to-physical techniques, cast into various metals and finally incorporated into two series of sculptures that Stella did. The process was very complex and sophisticated (if I may say so myself) and very successful artistically as well.

Michael O'Rourke trained at Harvard (Ed.M., Education) and the University of Pennsylvania (MFA, Sculpture and Computer Graphics). His artwork is in a variety of media, both computer aided and traditional. He has an extensive international exhibition record. He worked for New York Institute of Technology Computer Graphics Laboratory where he worked on numerous television openings and spots, including a Clio award winning spot for NBC. He is presently an Associate Professor at Pratt Institute in New York as well as a freelance artist. His book *The Principles of 3D Computer Animation* will be published by Deisign Books in the fall of 1994.

Studio Vision

Ben Austin
OpCode
New York, NY

A musician's tour of OpCode's Studio Vision and other software will be presented.

Ben Austin is OpCode's East Coast guru.

Some Interactive Models and Devices for Music Making

Richard Povall
iEAR Studios, DCC 135
Rensselaer Polytechnic
Troy, NY 12180-3590

This presentation describes some of the current trends in music and media interactivity, discussion the ways in which various models for interactivity affect the final musical product. Of these models, the Mattel™ Power Glove will be demonstrated used as a control input device for an interactive music score and to control a video disk, and a videotape will be shown of one or more motion sensing devices in action. The various models of interactivity include:

- the conducting model: the Mathews Drum and Buchla's Lightning
- the motion modeler: the Arizona State system, and Mark Coniglio's MIDI Body suit
- alternative input devices: Power Glove, Lightning and others
- software models: OpCode's MAX and HMSL, used as algorithmic composition tools and shape editors

Richard Povall is a composer, video artist, and educator, currently on the faculty at the iEAR Studios at Rensselaer Polytechnic Institute. Povall has been involved in computers and music for almost 20 years, and with video for more than 10 years. He has worked within a number of interactive and collaborative frameworks, most recently working on small scale solo works with a variety of interactive devices, and on a large scale multimedia work involving a large interactive Computer music and video system, *The* Last *Garden*. Povall *lives* in rural upstate New York with artist Nancy Sinclair, wife and sometime collaborator.

State of the Art Art (in NYC)

Rachel Gellman
192 Bleeker Street, #21
New York, NY 10012

This presentation will include the work of New York artists using the computer in a variety of interesting ways. As of press time, the following artists' work will be shown: Paul Davis, Ellie Dickson, Roz Dimon, Rachel Gellman, Rodney Greenblat, Les Jorgensen, Sandra McLean/Robert Stratton, Joanna Morrison, Barbara Nessim, Barbara Bert Silbert, Annette Weintraub. There will be additions by the date of the presentation.

Rachel Gellman is an artist, illustrator, and teacher, who has used computer paint systems since 1979. A graduate of Cornell University, she has been teaching at the School of Visual Arts since 1982, when she taught the first "art" class in the Computer Art department. Gellman created the Computer Art Lab for Long Island University in 1984. Gellman has exhibited her artwork internationally, has been included in various books and magazines, and has lectured extensively. She is a co-founder of the artists' group **PICTURE ELEMENT.**

Lateral Imaging

Steven Berkowitz
Lateral Imaging
61 East 8th Street,
New York, NY 10003

An overview of Lateral Imaging as a philosophy that links our sensation, emotion, and conception, enabling us to view the world as a field of coincidental events, each affecting all others, everything connected in an intimate way. Organic structure is examined through strategies of extended time and macroscopic space. Relative, multiple and lateral perception leads to the building of visual models with photography, their conversion to mathematical models through the use of computers, and finally the translation into acoustic models. The trans-sensuality of simultaneous presentation of many views of the same subject produces synaesthesia and a resonance between artist and audience. The bottom line is to show how we are integrated with our world.

Steven Berkowitz became involved with computers in the early 1 .1970's when he began writing programs to translate his drawings from the visual to the aural domain. Subsequently the world handed him a camera and a synthesizer. He received an MFA for his Photography / Computer Graphics / Sound installations from Tyler School of Art in the late 70's after doing independent research at Princeton and the Imperial College of Science and Technology, London. He now resides in Greenwich Village where he owns Lateral Imaging Digital Imaging Studios and continues to teach for Tyler in Philadelphia. His most recent piece is the release of Displacement / Reconfiguration on compact disc for Fluid Music, Inc.

Art for Technology's Sake

Tim Anderson
Lab for Manufacturing and Productivity
MIT
Cambridge, MA
robot@mit.edu

I will show slides, video and rave self-indulgently about works in progress and regress. These include the G-force chair, Bio-Beefwhack techniques, Van Gogo the oilpainting robot, the Fuck-Bach-Up-O-Tron music generator, Kitty the elmer's glue-kitty litter rapid prototyping machine, Kiko the robot monster, the "Lasers and Music" installation at Liberty Science Center, and the status of rapid prototyping research at MIT. Send email to robot@mit.edu for invitations to my Cambridge pseudocultural events.

Tim Anderson was born in St. Cloud, Minnesota where he spent the bulk of his life. In fact, he would like to hear from anyone who has heard of St. Cloud. He had a business selling bras for cows and previously ran a used car lot. He missed a few years of high school living in Japan...but it was OK since his mom wrote him a note. Mr. Anderson attended Marine Officer Candidate School in Quantico, Virginia, where they heaped on the abuse and had the candidates running through fields yelling "Bang, bang" while attacking imaginary enemies. He traveled through Germany on a motorcycle where he was arrested in both East and West Germany. He preferred being arrested in East Germany since they weren't as well organized, the computers didn't work and they weren't as ambitious. Everybody misses the wall.

The Multimedia PC as an Artist's Medium

Robert Kendall
11 Willow Street
Cranford, NJ 07016

Interactive multimedia installations on the personal computer are opening up new possibilities for artists. Visual and video artists, writers, and composers can all use the multimedia PC as a new medium for their work—a medium that can expand their artistic horizons as well as their audiences. Many artists use PCs for creating work that is then presented in another medium, but the potential for using the PC itself as the vehicle for presenting the work is only beginning to be exploited. This presentation will discuss examples of what has been done in this area, as well as unexplored possibilities.

Robert Kendall is a multimedia artist, composer, and poet. His multimedia installations which combine visual art, music, and literature—have been widely exhibited. Kendall has written over 150 articles about computers, multimedia, music, and the arts for *PC Magazine*, *Electronic Musician*, and many other national publications. His poetry has been widely published in magazines and anthologies, and his book *A Wandering City* won the Cleveland State University Poetry Center Prize.

Videobar Reception

Moore College of Art, Atrium (next to Museum counter clockwise around circle). Bring slides, videotapes and whatever. Bring your own booze. We will furnish munchies and bar facilities.

Day 2 Saturday, November 13

Multimedia Design Practicum

Bill Kolomyjec
Pixar
1001 West Cutting
Richmond, CA 98404

Separate registration required for this tutorial.

A one hour lecture/demonstration that will focus on using Pixar Typestry to produce a variety of design and visual effects for both print and multimedia applications.

Dr. Bill Kolomyjec has been the RenderMan Marketing manager in charge of international marketing at Pixar since September, 1992. During a sabbatical from that company he was a founding member and Senior partner of The VALIS Group, a RenderMan accessory company. His responsibilities at Pixar have included being a member of the technical marketing staff as well as RenderMan Evangelist.

As a computer image designer, Dr. Bill Kolomyjec has been involved in the Computer Art/Computer Design field since 1969. He has written many papers on related subjects including a chapter in Ruth Leavitt's *Artist and Computer* published in 1975. Kolomyjec has exhibited his plotter drawings world-wide. Kolomyjec collaborated with Ann Seidman while at OSU in 1985 to produce a short 3D computer animation entitled ghoti that is part of the ACM/SIGGRAPH video review. Kolomyjec taught computer graphics/computer art subjects at the post secondary level for many years.

From 1985-1989, Kolomyjec was associate professor and director of the Electronic Media Design program in the School of Art at Northern Illinois University, DeKalb, Illinois. Other previous academic positions include: Assistant Professor of Engineering Graphics and Art Education(Computer Graphics Research Group) at The Ohio State University, Columbus, Ohio and, lecturer in engineering and computer graphics at Michigan State University, East Lansing, Michigan. Kolomyjec holds three degrees from Michigan State University; a Ph.D. in Education, a MFA in Graphics Design, and a BFA in Industrial Design.

What Comes Next? The A-to-D Dilemma

Connie Coleman &
Alan Powell
834 Corinthian Ave.
Philadelphia, PA 19130

Coleman and Powell will discuss their experiments in digital audio and video sampling using a work-in-progress titled "Automatic Writing" which they have been developing for the past five years. this new work will ultimately be an interactive computer piece utilizing either videodisk or CD-ROM technologies when completed. The work encompasses a collection of stories told by people from real life experiences and which are currently recorded on HI Band 8mm videotape and DAT audio tape. "Automatic Writing" will focus upon personal memory and selective compression of experience into planes of poetic experiential remembrance.

Connie Coleman and Alan Powell have been working together in the electronic arts for over fourteen years, co-producing works that range from single-channel videotapes to sculpted, multi-channel video installations. They have also produced audio-only works resulting from several commissions from New American Radio and have been venturing recently into the design of interactive digital pieces. Their videographic works have been shown widely across this country and abroad...they have been the subject of many media art reviews. including pieces in "Art Forum", "the Independent" and "Afterimage", and they have received significant recognition through national video festival awards. Connie Coleman holds undergraduate and graduate degrees from the Rhode Island School of Design and is currently a member of the Media Arts Department at the University of the Arts, Philadelphia where she is an Associate Professor teaching Computer Animation. Alan Powell began his video career in 1874 with the formation of the video art group "Electron Movers" in Providence, Rhode Island. He received his BFA degree from the Rhode Island School of Design and an MFA degree from the Mason Gross School of the Arts of Rutgers University . he is currently an Associate Professor in the Radio, Television, Film Department of Temple University.

The Hidden Mona Lisa

Lillian Schwartz
AT&T Bell Laboratories
600 Mountain Ave.
Murray Hill, NJ 07974

Computer Pioneer, Lillian Schwartz, will disclose conclusive evidence (using morphs) that Leonardo started the Mona Lisa with Isabella, Duchess of Aragon. which he later painted over using himself for the celebrated Mona Lisa we all know. Morphing algorithms are used to demonstrate these findings. Videotapes and discussions will be included in Schwartz's presentation on the Hidden Mona Lisa as wellas her more recent discovery of the identity of Shakespeare.

Lillian Schwartz is best known for her pioneering work in the use of computers for what has since become known as computer-generated art, including graphics, film, video, animation, special effects. Her work was recognized for its aesthetic success and was the first in this medium to be acquired by The Museum of Modern Art.

Schwartz began her computer art career as an offshoot of her merger of art and technology, which culminated in the selection of her kinetic sculpture, Proxima Centauri, by The Museum of Modern Art for its epoch-making 1968 Machine Exhibition.

She then expanded her work into the computer area, becoming a consultant at the AT&T Bell Laboratories and for IBM's Thomas J. Watson Research Laboratory. On her own, and with leading scientists, engineers, physicists, and psychologists, she developed effective techniques for the use of the computer in film and animation.

Besides establishing computer art as a viable field of endeavor, Schwartz additionally contributed to scientific research areas such as visual and color perception, and sound. Her own personal efforts have led to the use of the computer in the philosophy of art, whereby data bases containing information as to palettes and structures of paintings, sculptures and graphics by artists such as Picasso and Matisse are used by Schwartz to analyze the choices of those artists and to investigate the creative process itself. More recently, her contributions to electronic art analysis, and restoration, have been recognized, and adapted, specifically in Italian Renaissance painting and frescoe.

Schwartz's education began immediately after World War II when she studied Chinese brushwork with Tshiro in Japan. Over the following years she studied the fine arts with professionals such as Giannini, Kearns, and Joe Jones. She is self-taught with regard to film and computer interfacing, and programming.

Schwartz has always had close ties to the academic community, having been a visiting member of the Computer Science Department at the University of Maryland; an adjunct professor at the Kean College, Fine Arts Department; an adjunct professor at The Rutger's University Visual Arts Department; an adjunct professor at the Psychology Department, School of Arts and Sciences, New York University; and is currently a member of the International Guidance Panel, under the co-sponsorship for The Society for Excellence Through Education, Israel, Teachers College, Columbia University and S.A.G.E., the International Chairman to the Comitato Nazionale per il quinto centenario della morte di Piero della Francesca, Italy, and a Member of the Graduate Faculty of The School of Visual Arts, NYC. She has also been an Artist in Residence at Channel 13, WNET.

Schwartz's work has been much in demand internationally both by museums and festivals. For example, her films have been shown and won awards at the Venice Biennale, Zagreb, Cannes, and The National Academy of Television Arts and Sciences. Her work has been exhibited at and is owned by museums such as The Museum of Modern Art, The Metropolitan Museum of Art, The Whitney Museum of American Art, The Moderna Museet (Stockholm), Centre Beauborg (Paris), Stedlijk Museum of Art (Amsterdarn), and the Grand Palais Museum (Paris). Representing the United States, Schwartz has been a guest lecturer in over two dozen countries, ranging from the Royal College of Art in London to the US/China Cultural Relations speaker in the People's Republic of China.

Schwartz has also had numerous other fellowships, and honors conferred upon her, including a Doctor of Humane Letters Honoris Causa from Kean College, New Jersey, and grants from the National Endowment For The Arts and The Corporation For Public Broadcasting. Most recently she has been elected a Fellow in The World Academy of Art & Science. She has been the subject of numerous articles, books, and television news and documentary programs. Schwartz is the author (together with Laurens R. Schwartz) of The Computer Artist's Handbook, W.W. Norton & Company.

Sculpture Panel

Rob Fisher, Tim Duffield, Steve Porter, Michael O'Rourke and Helaman Ferguson will show new work and host a panel discussion.

Rob Fisher
Studio for Creative Inquiry
Carnegie Mellon Univ
Pittsburgh, PA 15213
rnfl@andrew.cmu.edu

My work demonstrates a symbiotic, synergistic approach to creating sculpture via computer technology, and proves the efficacy of this approach by realizing these projects in realtime and realspace. Several years ago, as a result of a commission to create a huge sculpture for the exterior of the Carnegie Science Center in Pittsburgh, I directed the development of unique hybrid software that combined a full range of computer applications, from scientific visualization to CAD and architectural simulation. Utilizing a Silicon Graphics IRIS Indiqo Elan, and working closely with an expert programmer, a dramatically different process was engendered by my desire to create sculpture that would be as much Science as Art.

My current research at Carnegie Mellon University focuses on the development of software tools which enable me to take the roughly shaped products of the original software and refine these objects to the point of production. This has led to innovations in stereo 3-D enhancements, and an array of menu options that permit the subtle shaping of wireframe images that represent the spaceframe structures from which the sculptures will be constructed.

Rob Fisher is well known as a sculptor whose monumental public works based on nature are at the cutting edge of the application of technology to art. He has received many commissions throughout the United States, Japan and Saudi Arabia. Articles on his computer—aided sculpture have appeared in Sculpture, Leonardo, Technology Review, Newsweek, Science, New York Magazine, Der Speigle, Espace, and Nikkei Architecture among others. He has also been featured in several CNN reports. He has been appointed a Fellow at the STUDIO for Creative Inquiry at CMU where his research is focused on the development of software tools to support the creation of a new form of polycrystalline spaceframe sculpture.

Tim Duffield
1551 Johnny's Way
West Chester, PA 19382

No information available at press time.

Steve Porter
RD 4 Box 85
Bellefonte, PA 16823

No information available at press time.

Michael O'Rourke
44 Tompkins Place, #1
Brooklyn, NY 11231

For bio and description of Michael O'Rourke's work, see Day 1.

Helaman Furguson
10512 Pilla Terra Court
Laurel, MD 20723

No information available at press time.

How to Make Your Own CD ROM

Judson Rosebush
Judson Rosebush Co.
154 W. 57th St., #826
New York, NY 10019

Judson Rosebush will present a soup-to-nuts course with everything you need to know to affordably turn your ideas into a CD ROM.

Judson Rosebush is President of Judson Rosebush Company in New York and editor of Pixelvision Magazine.

Expressive Devices or Devices of Expression

Terry Mohr
Lily Diaz
Gene Perla
Alan Moore

Of means and methods for art articulation of thoughts, feelings, opinions, knowledge and ideas. Utilizing the cognizant interplayof humanconputers and nonhuman computing devices.

Terry Mohre, Lily Diaz, Gene Perla, Alan Moore

Performance

The 15th Annual Philadelphia Computer Music Concert

Bruce Wands & Nick Spencer

Bruce Wands and Nick Spencer will be performing original music that combines jazz, blues and new age using MIDI instruments, piano, organ, 12 string guitar and bass. They have performed at NY SIGGRAPH, the ISDN Trip '92 event which was performed in New York and broadcast over the ISDN network to Paris, London and Los Angeles. Bruce Wands' musical background includes 31 years of live performance experience. He has also written film music for AT&T, the Killington Ski Resort in Vermont and several television commericals. Nick Spencer has performed widely on the east coast as a club musician in various musical venues. He has also written original music for the Motion Picture Association, World Bank and the Department of Defense. They have a band called the "Thrillseekers" that performs throughout the New York area.

The Luminists

The Luminists area an audio-video duo -- Charles Cohen, music, Eric Schefler, video -- who perform live electronic sound and video improvisations.

The Luminists generate mesmerizing LIVE video and audio that suggests a dream-state alternate reality. They immerse the audience in a multisensory invironment created by their structured audio/video jams. Audience members ar surrounded by swirling stereo sound. Chaotic, colored phosphorous light emitting from video monitors is the only source of illumination in the performance space. Sound and image fill the senses and pull the audience into the world created by the two performers.

For video, they utilize an Amiga computer with a LIVE video digitizing board, image processing software, and a video camera to generate and control live video feedback signals. For audio, they use the Buchla Electronic Music Performance System for music and processing. Both the audioand video systems are geared towards real time control. The images are dynamic, colorful abstractions with a stron organic feel. The sound is atmospheric and mulitlayered with ritualistic overtones.

Charles Cohen can be reached at, POB 189, NJ 08077.

LifeFormz

LifeFormz is a group of artists/engineers working to bring character and life to inanimate forms using various media such as puppetry, computers, video animation and whatever else we find laying around. At SCAN we will bring our puppetry improvisation and interactive technology that we have used in our videos to live performance for the first time.

Brian Stokes: producer, director and a performer
Ranjit Bhatnagar: co-producer, custom software and a performer
David Kury: animation and design
Brian Flumen and Jean Haldeman: performers
Laura Scolnick: design
Mike Baltazar: assistant
Jeff Bechtel of the Franklin Institute: video wall programming and technical assistance

Day 3 Sunday, November 14

Facial Animation

Dr. Catherine Pelachaud
Computer Graphics Lab
University of Pennsylvania
Philadelphia, PA 19104

Catherine Pelachaud will demonstrate her work in computer modeling the way facial muscles determine expressions and how it can be applied to produce realistic facial animations.

Creating the Virtual Art Gallery

Bruce Wands &
Furry Nardone/Sabato
School of Visual Arts
209 E. 23 St.
New York, NY 10010

This presentation explores the process of creating the virtual gallery and the issues surrounding it. Creating the virtual gallery using a 3D modeling and animation program will be described. The process includes a site visit, creating architectural sketches, building a three dimensional model of the gallery, giving it surfaces and lights, and rendering views of the gallery. The placing of art in the gallery is done by scanning slides of the art and texture mapping them onto polygons placed on the walls. The curatorial process is now assisted by giving the curator access to this gallery from a virtual perspective. This enables one to move the art around the gallery and to change lighting conditions interactively. The larger issues of the virtual gallery as a forum for digital art will be discussed. Ideas for virtual art and the challenge of computer art in a virtual world are addressed.

Bruce Wands is the Director of Computer Education at the School of Visual Arts in New York. He also teaches graduate and undergraduate courses in 3D Animation, 2D Animation and Multimedia. He is an award-winning independent producer/composer who has produced animation, live action and music for such clients as AT&T, United Technologies, General Motors, the Air Safety Foundation, Quotron Foreign Exchange and others. His fine art interests center around creating abstract 3D computer images and animation by working with the MIDI (Musical Instrument Digital Interface) data from music that he has composed. In 1989, he was awarded an NCGA Educator Scholarship. He became involved with computer animation in 1976 when he was an animator for the Spectacolor billboard in Times Square, New York. While there, he designed the computer animated opening for NBC's "Saturday Night Live". He has a BA from Lafayette College and an MS from Syracuse University.

Fury Nardone/Sabato is currently an MFA student in Computer Art at the School of Visual Arts. Her thesis project involves creating a virtual gallery in which to exhibit her own work, as well as using a virtual gallery to curate art exhibits. Her background is as a Sr. Interior Designer for The Grad Partnership in Newark, New Jersey. While there, she worked on such projects as the Martin Luther King Federal Court House, Seton Hall University Law School, the Prudential Insurance company and others. She has a BFA from the New York School of Interior Design and a BA from Jersey City State College.

Thinking Big in the Real World

Nancy Freeman
Annandale, VA

Nancy Freeman will discuss her "experiments with going to pieces in a big way." She will describe working with large scale archival image output on an artist's budget. A description of the methods will be given and samples of the outputs will be shown.

Nancy Freeman is an independent computer graphics artist living in Annandale, VA.

Like Telling Dreams

Mary Beams
School of Art
Northern Illinois University
DeKalb, IL 60115-2883
mary@art.niu.edu

Having a personal computer can be like telling someone your dreams: at first you don't understand the imagery, but as soon as you speak the words which describe the pictures, you realize the dream was about something very personal. It's obvious to both of you what the dream means, and you know you never meant to reveal yourself that deeply. But there you are. You might as well hang out there, because you can't go back. Whether you're working alone, or working in collaboration, a personal computer affords a personal approach to your work. Examples from works-in-progress explore the possibilities and piffalls of getting personal.

Mary Beams is currently Assistant Professor of Electronic Media at Northern Illinois University, where she is working on a series of video songs. She comes from an independent animation background, in which she produced several films which won international recognition. She taught animation at Harvard University before moving to New York to pursue a freelance career. Beams became Director of Videotex and later Director of Presentation Graphics in the Media Department at McCann-Erickson. During the 1988 presidential campaign season she was Creative Director of Media Ink, a company which supplied animated political cartoons for NBC's *Sunday Today* show, as well as the *Today* show during the two nominating conventions. Since returning to academe, she taught at University of South Florida before settling at Northern Illinois University in DeKalb.

Song of the Helix

Bryan T. Shuler
POB 320952
Tampa, FL 33679

The "SONG OF THE HELIX" was composed as an exercise in interdisciplinary approaches to music, and as a challenge to my requirements for using numerology and patterns from extra-musical sources as the basis and inspiration for my compositions.
The composition was based on the genetic information of the HIV virus RNA and the DNA of the T4 cell of the human immune system. Using a Macintosh computer, Mark of the Unicorn software, and the Ensoniq EPS, I translated the data into a rather unusual piece. Together with Florida State University Dance Professor, Richard Sias, and F.S.U. graduate dance student, Darryl Jones, this musical exercise became a multi-media performance using choreography based on E.A. Poe's "MASQUE OF THE RED DEATH."
As a result of this composition and the later collaboration with Sias and Jones, "SONG OF THE HELIX" has demonstrated the impact that computer-aided creations can have on the international community through its performances and world-wide media coverage.

Composer **Bryan Shuler** completed his Bachelor of Music in Piano Performance and Music Theory from The University of Tampa and his Master of Liberal Arts in Humanities and Master of Music in Electronic Composition from The University of South Florida. Bryan just completed his year as a Fulbright Scholar in Ghana, West Africa as composer In residence for the National Dance Ensemble where he wrote a work for the Gala Opening of the new National Theatre in Accra. He is currently a Ph.D. candidate in the Humanities Program at The Florida State University specializing in Ethnomusicology. As a composer, Bryan has written for dance and film. He continues to be an accompanist for the Tallahassee Ballet and the F.S.U. Dance Department. Among others, Bryan has worked with Tommy Tune and Ann Reinking, and was guest artist with the Star Dancer Ballet Company of Tokyo In 1987.

Part III

Papers

Electronic Publishing: What, How & Why.

Paul F. Peacock

President, Floppyback Publishing International
PO Box 2084 Hoboken NJ 07030
(201) 963 3012 email 71702.154@compuserve.com

This article grew out of some of the interchanges that I saw on the Internet having to do with electronic publishing (ep). I thought that an article giving the perspective of somebody who is within the industry at ground level (or perhaps, more appropriately, ground zero) might be of service to people interested in ep. From a philosophical standpoint section 1.1 is the most important.

Two caveats: One, this article is a short version of an article which appeared in its entirety in Grist Online, available by anonymous FTP from etext.archive.umich.edu/pub/Poetry/Grist. Two: If you are reading this more than four months from September 1993 it's out of date. Contact me for an update (see Resources, section 5.0).

1.0 About the author, by the author.

I am a poet. I am also a computer person and have been involved with computers for over sixteen years. I started in ep focusing on publishing on regular 3.5/5.25 inch disks - what is now known as disktop (as opposed to desktop) publishing. We started up in March 1991. The name of the company is Floppyback Publishing International and we have 35 titles in our catalog ranging from six books we did for Rutgers University Press to poetry by Norman Rosten (librettist for the opera Marilyn at the New York State Opera this fall) to a thriller by Matthew Paris, originally published in 1973. We also do consulting on ep. We are looking for investors.

I started in this because I saw in ep three things: 1) a way to make a living 2) a way to allow (immediately) good work that was not commercially viable to get out and 3) a means to work towards a better world through a universal availability of ideas.

I am on the Board of Directors of the Digital Publishing Association and am a US representative for "The Electronic Author", a magazine published by the UK Society of Authors, the trade-union for authors in the UK.

1.1 Why does ep mean choice?

Quite simply because the phrase "electronic publishing" contains within it the word "electronic". This lets the computer industry into the game. This means that everything that applies in a general way to the personal computer software industry applies to the electronic publishing industry. This means:

a) for the first time there is an alternative, proven method of distribution of multiple copies of the work of an author or editor (this is how the PC software industry makes its living). This is a biggie.

b) The cost of making copies of said work is very low and, theoretically, infinite (this is how the PC software industry makes its big money).

c) Improvements in technical aspects of production and display of the work will come extraordinarily rapidly (in 1982 the first IBM PC was introduced - it had two diskette drives, no hard drive and cost $5,000. Today, ten years on, there are tens of millions of pcs in use, all highly developed) driving down costs even further. IE electronic publishing will move at the speed of the PC industry, not the printed publishing industry.

d) The cost barrier to entry into the business is very, very low, low enough to be met by an individual. This is another biggie. In essence, any person who has a PC and a little software can write a book and distribute it to potentially millions of people (via electronic bulletin board systems or the Internet). Assume for a moment that it is something everyone wants to read and is so distributed. Millions of people read it. Before the advent of the personal computer this was simply not possible.

These are the reasons that this is such a powerful thing with number four the main reason. Number four changes pretty much everything in the long run.

2.0 Electronic publishing today

I have tried as far as I am able to piece together the state of the industry today and not to wander into the future.

2.1 Production

I believe that the easiest way to think of ep today is as a ladder. As one goes up the ladder cost of production increases but so does the gee-whiz factor. Therefore:

2.1.1 First-rung

Disktop (not desktop) publishing. Publication of material on 3.5" and 5.25" inch disk for IBM and compatible PCs and Apple machines. Lots of different software available. One starts with plain ASCII text and then adds graphics.

The advantage of this market is that there is a massive installed base of "players" ie personal computers - estimates range from 40-60 million machines. Mike Weiner, President of Microlytics thinks this is a sleeper market - the cost of goods is good for anything less than 20Mb of text/graphics. (On one 3.5 inch disk we can easily fit a 1000 page book -text only, no graphics).

The disadvantage is that once graphics are introduced you simply run out of memory if you intend the electronic book to run from the diskette. If you are happy to have people download onto their hard-drive it's a different story. Knowledge Adventure published a $45 interactive encyclopedia for kids which sits on the hard drive and expected to sell 500 in three months. They sold 5,000 the first day.

This then naturally leads you to the next rung:

2.1.2 Second-rung

CD-ROM (or Read Only Memory). Can store the equivalent of 1800 regular 5.25 inch diskettes. Thus entire encyclopedias can fit on one CD (as indeed they do). Standards are coming together. A much smaller installed base, but growing all the time. But the massive storage of the CD-ROM allows for sound and video clips. Prices are also dropping - Compton NewMedia sells some CDs for $29.95.

Portable devices. Use smaller CD-ROMs than regular sizes or credit card-size memory cards (e.g. Franklin) which can hold up to 45Mb of compressed data.

The best example here is the new SONY DD-20B, to be released in the US on October 1, 1993 with a suggested retail of $399, packaged with an encyclopedia and a translator. It plays 3" CDs which can hold up to 6 hours of audio, 100,000 pages of text or 32,00 graphics. Frequently it will combine written material with the sound - so the translator disc allows you to find frequently spoken phrases and then speaks them out loud to you, in three or four different languages. The device can be connected to a TV set. Clearly this is too expensive for everyone to have and the screen display is too small but SONY is ploughing on in the right direction. Xerox has just created a 600 dpi resolution screen and when this is combined with a slightly better designed SONY hand-held device at a lower price point - watch out. SONY has leap-frogged Franklin Electronics here.

2.1.3 Third-rung

CD-I. Interactive CD that plays in its own player hooked to the TV. Other esoteric devices.

2.1.4 On-line delivery services

The latest Steve King short-story was available only from the online Internet bookstore for two weeks prior to its publication in paper. Viking, his publisher, intended it as an advertising gimmick but it's dangerous for them. If Mr. King makes money from the online downloading service he has got to be thinking that maybe for some work he won't go through his publisher for at all - he'll just cut a deal with the online bookstore directly...

2.2 What kind of books are suitable now?

2.2.1 First-rung

Disktop publishing on floppyback: Disktop publishing is ideally geared to the publication of the single book translated from a printed book. One book fits on one disk with its associated software. To use a CD-ROM for one text-only book is overkill.

I think that these are the type of books we will see on disk right now:

1) Books that are commercially unviable any other way.

The good thing about disktop publishing is that it is inexpensive to produce a quality product on disk. Once produced it never goes out of print. Production cost from a final manuscript is generally less than $1,000. Cost of reproduction is tiny (less than $1) and so break-even can be down at the 80 copies level. If you sell directly there is no warehousing cost - as orders come in you just pull another copy off the disk - and since it never goes out of print you can expand your horizon for those 80 copies to, well, theoretically forever, but let's say 10 years.

So if you have a book that you think will sell 8 copies a year for ten years you now have a way of publishing it (and of course the break even maybe even less). Big trade publishers may not want to do this but I don't think this is the case for smaller presses and individuals.

This category includes poetry which is why I got into this business in the first place.

2) Books that are out-of-print that you want to make available again (really a subset of 1.)

3) Books for which the new medium offers advantages - such as global searching or linking to existing systems (better help documents) etc.

4) Books which ARE commercially viable but for which the new format allows for a better price-point.

This is particularly true of scholarly works which have only a small audience, so have a small print run and go out-of-print quickly, so are expensive, so have only a small audience ad infinitum.

5) Books marketed by their authors.

6) Mainstream books after they come out in paperback.

At this stage therefore the paperback best-seller will not appear on disk. The number of players (either personal computers or hand-held or CD-ROM) is not (yet) large enough to match the market.

2.2.2 Second-rung

Because of its immense storage capacity, and the power of the personal computer to manipulate data, reference works which usually require some kind of search were a natural for CD-ROM. Now you can whip through the entire twenty-six volume encyclopedia and find all references to the word "mammal" in about 1 minute and so on. So big reference works are good for this medium. As are how-to books where animation, sound and video clips are all useful. This is where multi-media got its name. Not just words, but sound and moving pictures. Multi- media projects are being put together which did not start out as books but were conceived as electronic products. All of this production cost is, however, still fairly expensive and the bigger the project the less easy it is for the average consumer to download material (because of the length of time.)

2.2.3 Third-rung

We are now out of the realm of converting books into another medium and talking about projects which could be considered only electronically. You certainly could put text alone on these mediums but what's the point?

2.2.4 Online delivery services

Currently I think all the types of book that are suitable for disks would fit here as does anything interactive: ie where it's not downloaded but just interacted with.

2.3 Whose buying this stuff...?

In the main, libraries, schools and businesses are buying CD-ROM. Eg. Dartmouth College Library spent 2.5 times as much on CD-ROM as books last year. Home computer users are buying CD-ROM drives mainly for their kids. The Optical Publishing Association (OPA) says the average CD-ROM duplication order has grown from 460 copies in 1990 to over 20,000 today, although this last figure is anecdotal.

Franklin has sold 6 million handheld integrated devices. The Apple Newton (an indicator of how many SONY machines may sell) is rumoured to have sold upwards of 50,000 units. The OPA estimates

5 million CD-ROM drives will be sold in 1993. 26 million Americans have home computers (more than own audio CD players).

2.4 ...and why would I want to?

Currently:

1) Because it's not available any other way. 2) Because you can do things with it that a book can't do for you. 3) Because it feels more natural -the current generation that is in K6 education (the IBM personal computer was introduced in 1982) and well-versed computer literates (many of those at college). 4) Because it's more convenient - less weight, less space.

See also the note on the new SONY above in section 2.1.2. Obviously as time goes by the reasons will increase as resistance based on difficulty of use or cumbersomeness decline as the technology improves.

3.0 Why should print publishing inherit electronic publishing?

I hope that by now you should be able to see the answer - there is no overriding reason at all. Print publishing has the potential to inherit electronic publishing but so does the PC software industry and that industry is moving faster than a speeding bullet while the print publishing industry is sitting on its hands.

What the print publishing has which the PC software industry lacks is content. Just like fossil fuels the copyrights that the print publishing holds are, potentially, only a one-time resource. For example - Microsoft Publishing approaches Mr. S. King (or in fact his agent) and says "we would like you to do your next novel on CD- ROM. We will give you the best editors money can buy (and believe us we have lots of money), more money per copy so that your take will be larger than if you went into the printed word, even if the total sales are smaller. We will even coordinate the release of this work onto many other different platforms - Franklin, CD-I and so on. And you can include pictures and scary noises. And if you want to release it in hardcover in six months go ahead." What is Mr. King going to say? And what will he say in five years when the technology is even further advanced? And what will all the other authors have to say? (NB: I left this last paragraph in because I wanted to pat myself on the back. I wrote it in early 1993 way before anyone knew what Mr. King was going to do on the Internet. Call it my reward for this article. PFP. 9/19/93)

Currently the print publishing industry has access to content and good editing/preparation skills and a distribution system. The giants have money, the others none. I predict that the current crop of electronic publishers will work with print publishers on licensing deals until they understand the acquisition of content and then that will be it. And let's not forget that an individual can release a work to millions of people for next to nothing.

Print publishers MUST learn how to publish electronically - how to create the physical object and distribute it. Or they will eventually bear as much relationship to the publishing business as hand-letter presses do to the publishing world today. They have a slight advantage now (if they can hold onto them and it is not at all clear that they can) and that is their intellectual property rights. They are essentially sitting on a fossil-fuel reserve of material and are preaching caution. I cannot understand why SONY or someone just doesn't buy a small publishing house, beef up the editorial staff, shut down the printing end and just get cracking at publishing its own material.

I agree entirely with those who say that printed publishing will never entirely disappear - this point of view misses the point. Printed publishing will gradually become just a tiny piece of the publishing industry.

5.0 Resources:

Floppyback Publishing International
PO Box 2084
Hoboken NJ 07030

Voice:	(201) 963 3012 9-5 EST
Fax:	(201) 420 8751
E-Mail:	Compuserve 71702,154
Internet	71702.154@compuserve.com

Digital Publishing Association
R. Albright, Director
1160 Huffman Road
Birmingham Road AL 35215

Voice:	205 853 8269
Fax:	205 853 8478
BBS:	205 854 1660
E-Mail:	Compuserve 75166,2473
MCI Mail R	ALBRIGHT
GEnie	R.Albright (the DPA has a roundtable here)
Internet	75166.2473@compuserve.com

THE IMPORTANCE OF HAVING BUGS

A Sculptor's Perspective on 3D Modeling Software

Michael O'Rourke
Pratt Institute

The by-products of process have often been a source of creativity for artists. In Chinese brush painting, the artist pays close attention to, accepts and builds upon the slight irregularities of the ink stroke as the brush glides across the paper. In much of African art, the broad, flat blade of the adze leaves a mark which is intentionally incorporated into the final look of the piece. In Modern art of the West, the turbulent brush strokes of Van Gogh, the blocky wood cutting of Brancusi, the scratched surfaces of Moore, the forged and hammered steel of Smith — all attest to the artists' desire to work with, and receive inspiration from, the process.

It is in the nature of the processes which I've chosen to cite here that they introduce a level of unpredictability into the visual results that you will get. When Henry Moore filed and chipped away at his plaster models, the process of filing and chipping left marks which, while Moore could have predicted their broad patterns, he could not have predicted in detail *exactly* the configuration of each scratch and chip. Jackson Pollock was extremely adept at controlling his drip-painting technique, but beyond the overall pattern, breadth and density of his stroke, he could not have predicted precisely where each individual drop of paint was going to hit the canvas. This unpredictability was deliberately sought by the artists, cultivated, honed and eventually used to great effect.

But the sort of cultivatable, process-derived unpredictability that Pollock had with his paint or Moore with his plaster tools is almost wholly lacking in today's' 3D computer modeling software. Computer graphic researchers have painstakingly and successfully developed a wide array of modeling tools which allow the user to very precisely develop a desired form. Realizing that precision doesn't satisfy all possible modeling needs, they have stressed the importance of randomness in the modeling process, as witnessed by the development of fractal and stochastic modeling procedures. But the process-based unpredictability that artists have valued for years is not captured fully either by techniques based on precision or by techniques based on randomness. Pollock's brush stroke is both, and simultaneously, precise and random. It is the simultaneous combination of control and lack of control which has historically been so fertile to the artist — perhaps because it echoes the control and absence of control of our human existence, the order and chaos of all existence.

In my own experience as an artist working with three dimensional computer modeling software, the closest I have come to finding modeling tools which incorporate this kind of simultaneous control/lack of control has been when I have stumbled upon certain software bugs. Odd as such a statement may sound, I have seen this happen more than once and it raises some interesting questions. What is it about these bugs that has made them so useful as artistic tools for sculpting? Could the positive aspects of these bugs be deliberately replicated to produce a different type of, perhaps a better, software modeling tool?

Programmers tend to want their code to work a certain way. When it produces unexpected results, and especially when it produces inconsistent and unpredictable results, they wince, label these results "bugs", and do their best to ferret them out. But unexpected and unpredictable results may be precisely what the artist seeks. If the results are completely unpredictable, of course, they tend to be useless. But if they are some nice combination of the somewhat (whatever that means) predictable and the somewhat unpredictable, they may capture very effectively the creative flexibility the artist enjoys with many traditional artistic tools.

surface irregularities had the serendipitous effect of giving the final form a very natural, lifeform-like look — as if the form were some unknown and as yet unclassified organism. This was very much the feeling I

Within this simple exterior form, we see the much more complex "smoothed" form. Notice the large spike at the top of the crescent's hollow and the smaller spike at the bottom. Notice also the ripples on the outer, convex

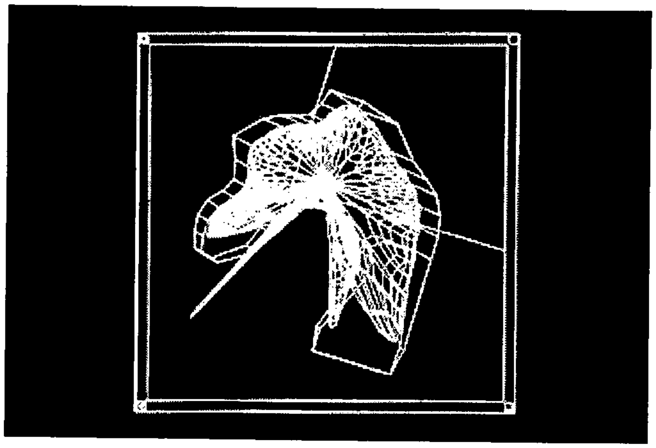

Figure 1. The simple initial exterior form, along with the complex, irregular form caused by the bug.

Figure 2. Several forms, all generated with the same bug, combined together.

The first time I encountered this sort of creative modeling bug was while making a 3D computer animation at the New York Institute of Technology in 1985-86. Within the proprietary NYIT 3D modeling software there was a function for "smoothing" a form. This function would round off the edges of a three dimensional form through a series of beveling processes. For example, if a cube were repeatedly "smoothed", it would eventually take on an approximately spherical shape.However, the procedure, I discovered, had a bug. If the original form had an extreme concavity — for example, the inside of a crescent moon — the beveling process produced unexpected spikes and ripples, rather than a gentle, overall smoothing. These unexpected

was after in my animation, and I diligently "studied" this bug.

I found that, as with an ink brush or a broad-bladed adze, it was never entirely possible to tell exactly where or how large the surface irregularities created by this bug would be. But, with practice, I also found that I could predict and control approximately where and what sort of result I would get.

Figures 1 and 2 illustrate this process and its result. In Figure 1, we see a wireframe rendering of both the original form and the "smoothed" result. The original form is the simple hatchet-shaped form in the center of the image. It was modeled by drawing a deliberately provocative crescent shaped curve and then sweeping that curve back into space.

side of the form. Figure 2 shows a shaded rendering of several similar forms which were generated with this technique and then combined to form a larger object. This final configuration, which would have been impossible without my bug, became the central motif in my animation.

An interesting side note to this account is the fact that, when I pointed out this bug to the NYIT programmers, they promptly "fixed" it. At my request, however, they left two versions of the procedure on the machine — the fixed version, which everyone else used, and the original, buggy version, which I continued to use.

A more recent example of the importance of this kind of bug arose in a series of sculptural forms which I modeled for the artist, Frank Stella. Stella was interested in the forms that smoke takes on when it drifts and floats in the air. The challenge was to model something which would be build-able (whether as a fabricated or cast object) but which retained the fluidity and irregularity of smoke.

The starting point for each "smoke sculpture", as we called them, was a set of photographs of a particular smoke configuration. Using these as a guide, a simple tubular extrusion was developed which followed the principle lines of the smoke. An example of this sort of structure can be seen in Figure 3, which shows one of the tubular structures as seen from four different points of view.

It was at this juncture that the critical software bug came into play. One of the modeling tools of the package we used for this work allowed the user to change the shape of a surface by transforming a network of the surface's control points. The bug, it turned out, was that if you scaled the control points and then un-did the scaling operation, the points did *not* return to their original positions as they should have. The location of each control point, after undoing the scale operation, was offset by some unpredictable amount. This resulted in a very irregular and unexpected deformation of the surface. Sometimes the final surface looked very similar to what the original surface had been, sometimes it acquired a bump or swell here or there, sometimes it ended up turning completely inside-out and going through itself.

What made this bug useful was that, while it was extremely unpredictable, it was not *entirely* unpredictable. There was a direct relationship between the magnitude of the original scale operation and the severity of the final deformation after de-scaling. It was also possible to restrict the surface area affected by carefully choosing the size and location of the network of control points. Still, within these controllable parameters, there remained the fact that when the scale operation was undone, one never knew precisely what the form would be.

This was a *great* bug! The unpredictability of the transformation effects allowed us to capture the feel of the irregular and unpredictable deforming effects that air currents have on smoke. Un-scaling the control points had the effect of twisting and yanking them about in much the same way that particles of smoke might be pulled and pushed by air. At the same time, since the bug's effect was directly related to how *much* the points were scaled and where, one could exercise some control over the degree and location of deformation. Like a stick of charcoal, an ink brush or a plaster chisel, this tool afforded a delightfully creative unpredictability, while at the same time allowing control of the broader effects of the modeling changes.

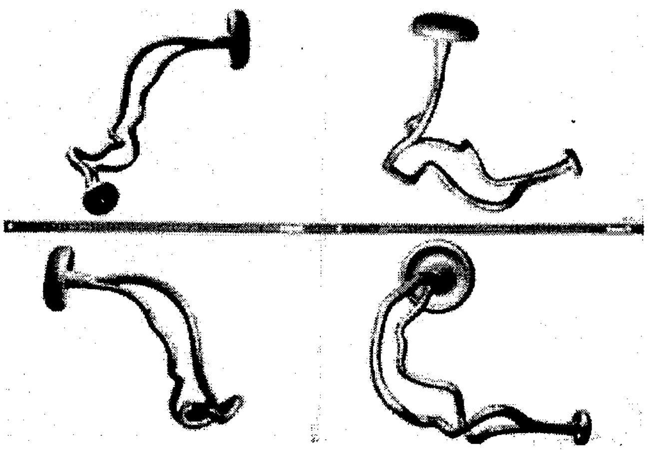

Figure 3. The simple tubular form for one of Frank Stella's "Smoke Sculptures".

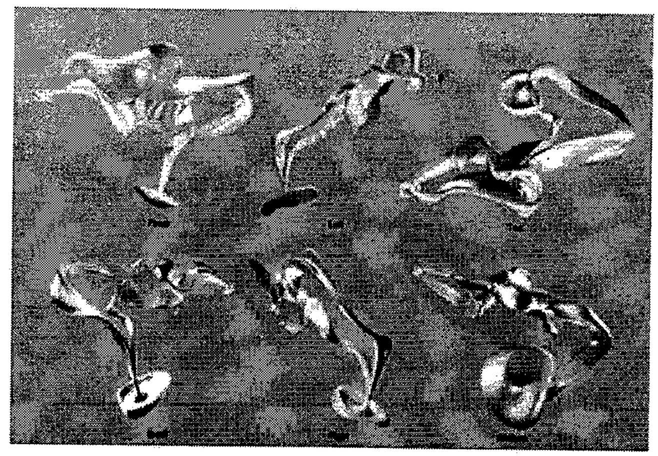

Figure 4. The same form twisted and deformed by the critical software bug.

Figure 5. Frank Stella, Zimming, 1992. Stainless steel, bronze, and aluminum. 16"x13"x12".

An example of this scaling deformation bug can be seen in Figure 4. The form we see here, represented from six different views, began as the same tubular structure we saw in Figure 3. Figure 4 shows the result of repeatedly using the bug just described to deform the tubular structure until it had a much more fluid, "smoky" feel to it. Figure 5 shows one from the series of Mr. Stella's sculptures which incorporated this sort of deformed "smoke sculpture" form. The form in the lower right of this photo, protruding from the bottom of the sculpture, is the same form we see illustrated in its digital incarnation in Figure 4.

The kind of bug I have described here can be extremely useful to an artist. It can, in fact, cease to be a "bug" in the artist's mind, and become a "tool". I believe that this kind of tool could be, and should be, deliberately developed by computer graphics programmers and researchers. Currently available modeling tools tend to be either too precise or too random to suit the needs of many artists. There is a need for tools which, like the bugs I have described, have a bit of a mind of their own, but still remain controllable by the artist in a broad sense.

The artistic endeavor is an inquiry, an attempt to understand what has not yet been understood. One of the ways artists do this is to abandon control and allow the process, within constraints, to generate unforeseen shapes, marks or colors. The artist then reacts to these, attempting to find order and sense in them, modifying them if possible, repeating them where appropriate. In 3D modeling software to date, this kind of controllable lack of control is rare. It is usually called "bug" and eradicated before the software gets to market. We may learn a lot from studying our bugs. And in so doing, we may produce a powerful, and different, type of modeling tool by incorporating some of the features of our "bugs" into our "tools".

Michael O'Rourke is a sculptor and animator who works with computer graphics. He is also an Associate Professor at Pratt Institute, Brooklyn,, NY. His book, Principles of 3D Computer Graphics, *will be published by Design Books in the Fall of 1994. His studio address is: 44 Tompkins Place, Brooklyn, NY 11231.*

Layout by Chuen Choi

Some Interactive Models and Devices for Music Making
a primer

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Abstract:

This presentation describes some of the current trends in music and media interactivity, discussing the ways in which various models for interactivity affect the final musical product. Of these models, the Mattel™ Power Glove will be demonstrated as a control input device for an interactive music score and to control a video disk, and a videotape will be shown of one or more motion sensing devices in action. The various models of interactivity under discussion include:

- the conducting model: the Mathews Drum and Buchla's Lightning
- the motion modeler: the Arizona State system, and Mark Coniglio's MIDI Body suit
- alternative input devices: Power Glove, Lightning and others
- software models: OpCode's MAX and HMSL, used as algorithmic composition tools and shape editors

Philosophies of Interactivity

The widely varying philosophies and conceptual bases of the nature of interaction between performer and instrument, between composer and computer, between dancer and musician, are too convoluted to explore in depth in this paper. I will however attempt at least to outline what some of those philosophies are and how they have been realized in recent years as interactivity has become a hot buzzword, and as technologies have proliferated.

However "hot" interactivity is, we should not consider interactivity to be a new phenomenon, even in the relatively short history of electronic and computer music. Since the earliest days of electronic instruments, one of the overriding issues has been how to translate artistic intention and artistic expression into electronic action. Keyboard controllers were not, in fact, the initial means of interaction, and only became widespread with the adoption of the 1 volt per octave (1 v/o) standard in the mid-sixties. One of the better known, and most enduring interfaces is the *Theremin*[1], a performing device invented in 1919 by Russian scientist Lev Termen. It uses two antennae, one controlling pitch, and one controlling vibrato, and its sound source, a simple tube-based oscillator, is built in to the instrument. As a hand is moved towards or away from an antenna, the characteristic of the sound changes: e.g. pitch will go up or down depending on the proximity of the hand to its antenna. The Theremin was a surprisingly popular instrument, and can be heard as the wailing "spooky" sound in many science fiction films of the 1950s and 1960s. More surprising was the degree of control that can be achieved by waving two hands in front of two antennae. A performer by the name of Clara Rockmore became famous for her performances of the popular classics, performing with symphony orchestras and chamber orchestras around the country in the 30s 40s and 50s. A few years ago her work was re-released on compact disk, and is a strange testament to the expressivity and control that can be achieved on the Theremin, with no physical touch at all.

The advent of MIDI in the early eighties created a revolution in the standardization of computer interfaces. The keyboard became even more dominant than in the analog age, and the proliferation of MIDI keyboards, MIDI drum controllers, and other keypad-type devices had a profound effect on so-called avant-garde and experimental music — almost as much as it did on popular music. MIDI can, in many ways, be considered a backward step in the development of computer music. On the one hand, it provided a degree of compatibility and market availability that had never been experienced before; on the other hand, the domination of keyboards and sequencers, and the increased complexity and difficulty of the programming environment, dulled the experimental nature of computer music for a large segment of composers, particularly younger composers. This negative wave halted a great deal of hardware experimentation (it was now cheaper, or at least possible, to buy "off the shelf" devices), and temporarily halted bold experimentation with the medium, except in a small number of academic institutions and amongst rare groups like San Francisco's "The Hub", throwbacks to an earlier, less compliant generation.

In recent years, however, a much broader range of composers have started experimenting with new ways of interacting with the computer. Hardware and software developments have exploded within the last decade, leading to a new freedom and new paths of experimentation within the computer music and electronic media fields. The almost total switch to working in the digital domain has

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[1] The Theremin, named after the Gallicized version of the inventor's name, was originally called the *Aetherphone*.

enhanced this trend. I have divided these developments roughly into four categories, but, like all attempts at categorization, my divisions rarely work 100%.

MODEL I -- SOFTWARE

Programs like MAX, HMSL (Hierarchical Music Specification Language), Interactor, and Symbolic Composer have had a profound impact on the musical landscape.

MAX, by far the most dominant of these programs, is in essence an object-oriented programming environment for composers, providing a simple, graphical interface comprising "objects", which contain hidden code written in objective C, and which perform a specific task, and "patch cords" that are clicked-and-dragged to join the objects together. The program was originally developed at IRCAM, but was purchased by OpCode a few years ago, who now market it as a (copy protected) commercial product. The packaged program comes with a large library of objects that can be built into "patches" quickly and easily. There are many more objects constantly being developed and distributed through the internet and through bulletin boards and other non-traditional distribution methods. Acquisition and distribution of data via the serial port and via MIDI is easy and straightforward, and there are patches available to drive such devices as CD-ROMs, laser disc players, and even a patch to support data acquisition from the Power Glove. This kind of freedom to create unique environments has not been available to non-programming composers since the days of analog synthesis and guerrilla electronics, and the free interchange of ideas and patches is a wonderful turnaround from the commercial and conservative atmosphere of the 1980s.

HMSL, under development since the early eighties, and now distributed through Frog Peak Music[2], is another unique programming tool for the composer. It demands greater programming skills than MAX, and is written in a FORTH environment. It is truly a musician's environment, however, dealing largely with interactions between composer-drawn shapes, or "morphs", and is a model of the objective style of programming, allowing concatenation of an increasingly complex set of objects. The later versions of HMSL include extensive digital signal processing capabilities, something that is only peremptorily supported in the MAX environment. HMSL was developed at Mills College by Larry Polansky, David Rosenboom, and Phil Burke.

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2 Frog Peak Music, Box 5036, Hanover, NH 03755, USA. Tel/fax 603/448-8837

MODEL II -- CONDUCTING AND SCORE FOLLOWING

Another model in the development of interactive devices has been the arrival of affordable, although not yet cheap, instruments that are essentially conductors. These devices allow the performer to "conduct" or step through a pre-programmed score in a musically expressive way, unencumbered by electronic metronomes and the other time constraints of sequencers. One of the most notable and successful of these devices was designed and built by Max Mathews and Robert Boie. The Mathews Radio Drum looks like a tablet mounted on a music stand. Attached to the tablet are two sticks, looking rather like drum sticks, but with one orange and one yellow foam ball attached to the striking end of the stick. These two sticks send realtime information about their location and proximity to the tablet, and the Drum is configured to follow a score with "beats" played on the Drum's surface (or, in actuality, near to the Drum's surface). There are, however, other controls available to the player, and s/he can send complex information to control any number of realtime parameters. Because the drum is able to sense the distance and the velocity in the air of the sticks, the Drum is capable of being a very human, articulate musical instrument.

Score following has its critics, who argue that the very concept of making a score, and then playing it back in performance, defies the basic concept of building an interactive environment. Yet score following can be built into a greater whole, and the two most recognized exponents of the Radio Drum, Andrew Schloss and Richard Boulanger, do just this. Their pieces are a combination of simple (in actuality, score following is not simple at all) score following and live control of complex instruments and processes.

Buchla's *Lightning*[3] is another device that can easily be used as a conductor for a pre-programmed score. The receiver, a small box that can again be mounted on a stand, responds to positioning information from a variety of infrared devices, one of which is a pair of wands containing infrared emitters, looking much like conductor's batons. The receiver is divided into eight cells, which set up a series of virtual spaces that radiate out from the receiver. These zones can be programmed to respond to information in a variety of ways, sending out MIDI information such as note on/off, program changes, and controller data. The interaction between the zones, and the information gathered within the individual zones, can also make an extraordinarily complex expressive musical instrument.

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[3] Lightning is available directly from Buchla & Associates, Berkeley, CA. 510/528-4446

Both the Mathews Drum and Lightning also fit well into the next model, which discusses gesture mapping devices.

MODEL III -- GESTURE MAPPING

There are an increasing variety of devices available with the ability to sense human gesture in realtime. I have drawn a distinction between gesture mapping devices, in which I include the Radio Drum and Buchla's Lightning, as well as the Mattel PowerGlove, other higher end virtual reality controllers, and less well known devices such as the Polhemus Tracker, made known as a musical controller by composer George Logemann.

Gesture mapping, for the purposes of this paper, is the local interaction between performer and instrument, usually in a one-to-one relationship, and usually involving close proximity (say, within 10 feet or so) to the instrument, or its receiving unit. This contrasts specifically to Model IV, Motion Sensing and Modeling, which I define as devices that track motion on a larger scale, often involving groups of people as well as individuals. Of course, there are crossovers even here. Lightning is flexible enough that it could easily be used (and has been used) to track movement gestures of a group of people moving in space. In that sense, Lightning belongs as well in Model IV as it does in Model III and Model II.

Gesture mapping allows the composer/performer to control a sound environment through physical gesture, in close relationship with the sending and receiving device. The Mattel PowerGlove, and the Mattel U-Force controller, both originally designed as video game controllers (and both removed from the market after miserable sales) are now used by a small group of composers and low-end VR experimenters who haunt chain toy stores looking for Mattel's leftovers. The Power Glove's use has increased since the advent of the Power Glove object for MAX, which gives easy access to the data from the Glove into an algorithmic environment. The most noted, and probably the most long-lived user of the Glove is Mark Trayle, who hooks his Glove directly to an Amiga computer, generating all sound internally within the Amiga. MIDI be damned.

The Glove sends realtime data representing X, Y, and rotational axes, and send continuous data from pressure sensors on four fingers (the assumption being that noone is able to control the little finger independently enough to be useful). The U-Force controller reacts to movement in an infra-red pattern above it, similar to, but far less complex than Lightning.

Finally, there are a set of devices that are able to send motion in a much broader context, and these devices have been most popular with composers working extensively with dance. The ability to translate human movement to data that can be used to control a musical instrument has been an elusive one for many years. Light-sensing devices, infra-red beams, video mapping, and other approaches have all had varying degrees of success.

Two video-based systems, *Mandala* and a system from the Institute for Studies in the Arts at Arizona State University in Tempe[4], are capable of looking at the individual pixels of a video signal, and sensing degrees of change. As I have no personal experience of Mandala, but extensive experience with the ASU system, I will concentrate on the latter.

Based around the Amiga computer, but recently transferred to the high-end and therefore higher resolution, Silicon Graphics platform, this system is capable of mapping motion in a very broad sense. It is difficult for any video-based system to gather enough information to interpret small body motions of one dancer on a stage of many, but it is easily possible for such a system to interpret pace, spacing, velocity, direction, and gross body motions, choreographic gestures, if you will. The strength of a video-based system is, of course, that the dancers are unencumbered by any kind of wires — they have no kind of physical link to the system and can move within space as they usually do. The ASU system is software configurable, and divides the screen into a number of virtual triggers that can be as small as four pixels, and as large as the entire screen. As the image of a dancer moves through the virtual trigger, data is sent, via MIDI, to any number of devices. Because the video system is based around a single camera, and because the typical video camera lens has an increasingly larger point of view as you move away from it, these triggers are cone-shaped rather then tubular — a significant problem for the dancers until they get used to it. The system, as used by its original designer, John Mitchell, and, later, by myself, is used in conjunction with a number of MIDI instruments, and with one or more Macintoshes running MAX. The use of MAX allows the gestural information to be reinterpreted in any number of ways, building complex algorithmic interactions between mover and final musical output.

This complex relationship is common to almost all interactive devices, and is at the core of the composer's use and interpretation of gestural data. A straightforward relationship between motion

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4 The ASU system was developed by composer John Mitchell, and dancer/computer programmer Rob Lovell. It is not currently available commercially.

and output is rarely interesting, and devices limited to these kind of interpretations are doomed to failure as expressive musical instruments, unless of course you live in ToonTown.

The MIDI Body Suit, developed at CalArts by composer Mark Coniglio takes an alternative approach to mapping the gestures of a dancer. In many ways, it is in actuality a gesture mapper rather than a motion sensor, in that it's very precise information is literally able to recognize the individual motions of a dancer. The suit is a series of pressure sensors attached to various body joints of the dancer, including knees, elbows, shoulders, and pelvic area. As each joint is moved, continuous data is sent into *Interactor*, a software environment also developed at CalArts by Coniglio and Morton Subotnik. Interactor, once again, allows a complex interpretation of the gestural data. The main drawback of the Body Suit, as wonderful an instrument as it can be, is the physical constraints placed on the dancer, and the fact that it is, in essence, a solo instrument.

COMPOSITIONAL IMPLICATIONS

Writing music for interactive environments is as complex an issue as the hardware and software that support those environments. I use the word environments advisedly: creating music for interactive devices is more a case of creating a sonic and structural environment that allows the interactive system itself to create the piece. The more successful the original materials, the better the final outcome, or, to coin an old hacker's aphorism: garbage in, garbage out.

My definition of a well-designed interactive compositional environment involves a "what if..." scenario. What if the music created were simply recorded on tape, and used, say, as an accompaniment to this same performance: would it work as well? If the answer is yes, then the interactive environment is not working as well as it should, it is not *intrinsic* to the music, to the musical environment. Giving away this much control, allowing the system itselt to take on a creative role, is a challenge to the traditionally trained composer whose ethos has always been one of total control. After all, how can a composer compose if s/he does not have total control over the final product?

My first experience in writing for an interactive environment was shocking, revolutionary. Never before had I been forced to work truly in collaboration with a system, in this case, a system comprising four dancers, a motion sensing system, another composer, and two algorithmic environments driven by data from the motion sensing system. But it was wonderful, too. When all the parts are in place, the organic whole emerges, a compositional *gestalt* that I had never entirely experienced before. Learning to bring raw materials to a workshop rehearsal and mold them there and then into a finished environment was a big step, and is a technique that bleeds over into my solo interactive environments, where I am the performer as well as the composer.

There is a great deal of misunderstanding of the true nature of interactive music. Rarely do traditional compositional models belong, all too often are they applied. The increasingly ubiquitous use of MAX is causing an explosion of so-called interactive pieces that are nothing more than traditional instrument-and-tape pieces dressed up in trendy clothing. More theoretical study of the nature of the interaction between composer and interactive systems needs to be undertaken as composer spend an increasing amount of effort working in this challenging realtime environment,

SUMMARY

The desire to interact more perfectly with their instruments has been the goal of composers and performers since the earliest days of electronic instruments. Custom-designed controllers, pitch and envelope followers, realtime processing devices, bio-sensing devices, and a large variety of software environments have come and gone over the last fifty years. Interactivity is clearly a central focus for many composers, and this new-found freedom has shaken much of the conservatism of the 1980s. The burgeoning of performance devices has also, mercifully, continued the trend away from tape-only "performances", towards more responsive and compelling live performances. The continuing development of computers that can process data at ever-increasing speeds for ever-decreasing cost, and the inevitable standardization of platforms will continue to lure more experimental and avant-garde composers into the fold of interactivity. Whence follows popular music — always. Now what will *that* be like?

November 1, 1993, East Greenwich, NY

LATERAL

Lateral imaging is a way of seeing the world. It is a philosophy that links our sensation, emotion and conception, enabling us to view the world as a field of coincidental events each affecting all others, everything connected in an intimate way.

IMAGING

steven BERKOWITZ

ORGANIC STRUCTURE

Somewhere between the contrived geometries of man's invention and the randomness of chance reside the patterns of nature. By examining this realm one can gain an insight into how the world works, and thereby improve oneself and contribute to improving society in general.

EXTENDED TIME

The environment of lateral imaging is extended time, the time between the ticks of the clock. The world is continually changing, moving, and there is no clear way to define the beginning or end of any event. Closely examining the dynamic shifts within small segments of change provides access to an intimate view of nature.

MACROSCOPICS

Following the holographic paradigm, every minute piece of the world carries the structural information of all else. Adopting a strategy that is analogous to temporal extension, one can study very small pieces of the world and learn a great deal about the universality of organic structure.

RELATIVE PERCEPTION

No single sensory organ, if any, gives us a true picture of reality. In the same way, each artistic medium also presents its own unique vision. Even more important, the viewing system physically alters that which is being viewed.

MULTIPLE PERCEPTION

Only by displaying many images in varying media can the viewer move closer to the essence of the subject. Comparisons of the many perceptions must be made to come to some consensus about how the images communicate.

LATERAL PERCEPTION

When we use the physical, emotional, and conceptual disciplines to examine our experiences, they do not act in a linear way. It is the interaction of all our resources that makes it possible to perceive. Every aspect of an artistic work affects the way all other aspects are perceived. Lateral imaging is a model of human function.

VISUAL MODELING

One can use photography to capture small pieces of the natural world in the form of patterns of growth, movement, distribution, etc. Sequences, series, and arrays of photographs combine pictures to build *visual models* of the underlying organic structure.

MATHEMATICAL MODELING

Scanning these images into computer systems converts the description into a mathematical model. Once numeric, the forms can easily be manipulated without destroying the internal relationships that define the source.

ACOUSTIC MODELING

Translating the data into a musical vocabulary generates an acoustic model of the original subject. What is presented is the same image of the same organic patterns, available now to a different sensory organ.

T R A N S - S E N S U A L I T Y

The ultimate value of a set of inter-media images is not how any part looks, thinks, or feels, but how all interact to provide a compound vision of the source organic structure. This is the way we gather knowledge about our world. The expansion of an image across the boundaries of sensory input moves the viewer to a more receptive attitude.

S Y N A E S T H E S I A

The simultaneous perception of the same image through multiple senses can create a profound experience known as synaesthesia. It is a lateral, self-referential system. Ultimately the audience is seduced into a hyper-aesthetic state of ecstasis.

R E S O N A N C E

An intimate linkage is established between artist and audience when they share experience through lateral imagery. This sparks the realization that both are variations of the very same material, part of the same dance of matter and energy.

LATERAL IMAGING

Lateral imaging is a way of seeing the world. It is a philosophy that links our sensation, emotion, and conception. Lateral imaging views the world as a field of coincendental events, each affecting all others, everything connected in an intimate way.

SELF SIMILARITY

Upon close examination it is seen that all things are constructed of patterns-- the air, the water, the earth. Our breath, blood and bones constitute a body that is a microcosm, a replication of the world order. The distinction between inside and outside, however, is totally artificial and leads us away from the acceptance of reality as a totality, let alone a singularity.

UNITY

The bottom line is to show how we are totally integrated with our world, not standing outside looking in. The patterns of nature are the same as the patterns of life in general, and the patterns of our intellect determine our view of the world, i.e. our world creates us so that we can create our world.

B I O G R A P H Y

Steven Berkowitz became involved with computers in the early 1970's when he began writing programs to translate his drawings from the visual to the aural domain. Subsequently the world handed him a camera and a synthesizer. He received an MFA for his Photography / Computer Graphics / Sound installations from Tyler School of Art in the late 70's after doing independent research at Princeton and the Imperial College of Science and Technology, London.

C U R R E N T

He now resides in Greenwich Village where he owns Lateral Imaging Digital Imaging Studios and continues to teach for Tyler in Philadelphia, His most recent piece is the release of Displacement / Reconfiguration on compact disc for Fluid Music, Inc.

C O N T A C T

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The Electronic Word
Techniques and Possibilities for Interactive Multimedia Literature

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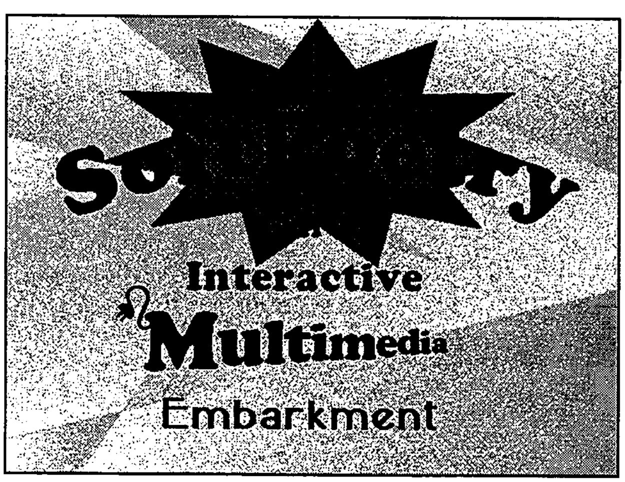
In music, video, and the visual arts, computers are opening new doors, which many artists working in these media have been quick to enter. The role of the computer in literature has been comparatively small, though. Granted, most writers either use a word processor or wish they had one. But in this capacity the computer functions merely as a glorified typewriter and has a very limited effect on the nature of the writing itself. The personal computer has the potential, however, to take literature in some entirely new directions.

For several years, now, I have been using an IBM-compatible PC rather than the printed page as the medium for presenting much of my poetry. This work, which I've dubbed SoftPoetry, presents the text on the screen of the PC with the aid of animation and graphical effects (see illustrations). The graphics are accompanied by a musical sound track, and menus pop up along the way to give the viewer some control over the direction of the poetry.

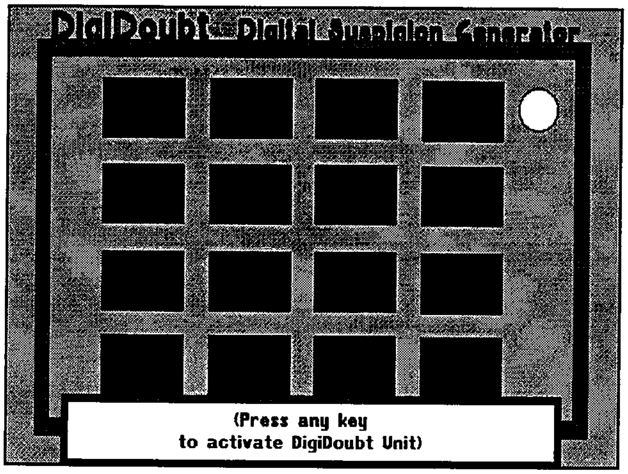


The Birth of SoftPoetry

I was drawn to computer-based poetry in an effort to combine the benefits of the two traditional methods of presenting poetry to the world—publishing it in books and magazines and reading it aloud to an audience. I frequently give poetry readings, and I've always found the direct connection with an audience very stimulating and exciting. When read aloud, a poem comes alive in a way it can't upon the printed page.

There's something lost as well, though. Since the listener can't see the printed words, many textual subtleties just don't come across. Obviously the ear can't pick up unusual spellings and punctuation or interesting layouts, and it can have trouble with coined words, puns, double meanings, and other word play.

Because of this, I found some of my poems not really suitable for reading aloud. I wanted, however, to be able to give these poems the dynamism of live performance. I saw the PC as a means of turning the poem into a performance similar to a poetry reading, injecting it with that added vibrancy. Yet the poem "performed" by the computer



sacrifices none of the subtleties that come through only in the printed word, because the printed word is still there right on the screen.

In fact, the graphical power of the computer can push the visual impact of the word much further than it could ever go on paper. SoftPoetry builds on the 2,000-year-old tradition of concrete poetry, or visual poetry, in which the meaning of the poem is enhanced by its visual appearance through unusual typography and layout. Elaborate color graphics, animation, and transition effects are now added to the visual poet's repertory. SoftPoetry is also a video extension of the tradition of the book as art object—calligraphy, illuminated manuscripts, and illustrated books.

Another strong motivation for my SoftPoetry was the desire to extend the thematic reach of my written poetry, which often explores images and modes of communication unique to the information age. The icons and archetypes of mass media often find their way into my written work. SoftPoetry reverses the process. Instead of putting the cultural icon into the poem, it puts the poem into one of the icons central to our society—the CRT that represents both the computer and television.

Putting poetry on the computer screen lets me explore modes of writing that capture the essence of our techno-centric society in a way that poetry on the page could never hope to do. Rather than merely evoking the symbols of modern life through descriptive imagery, the SoftPoem can actually become a machine with buttons to press; it can become a neon sign; it can become a late-night movie.

Adding music to this work seemed an inevitable step, since it brought the poetry more squarely into the domain of the performing arts. The sound track also clinched the association with TV and movies, the two grand myth-makers of our culture, the two great windows onto the archetypes of our cultural subconscious. Of course, combining music and poetry is an age old tradition that undoubtedly predates written literature. I'm merely taking the tradition in a different direction, since the music accompanies the written rather than the spoken or sung word. It's song without singers; opera without actors.

The Reader as Creator

The interactive element is something entirely new that the computer brings to written literature. The printed page is inherently linear but the computer is by nature nonlinear. Interactivity lets literature more accurately mirror the real world. Life itself is a random-access medium, not a linear one. The human mind is a random-access device, not a linear one. Menu options and hypertext features in a computer-based poem can reflect the myriad choices and possibilities that life presents us with.

The most immediate precursors to interactive literature are found in computer-based entertainment—such as video games and interactive adventure stories—rather than other traditions in the arts. But I think the urge toward audience participation in literature is something quite timeless.

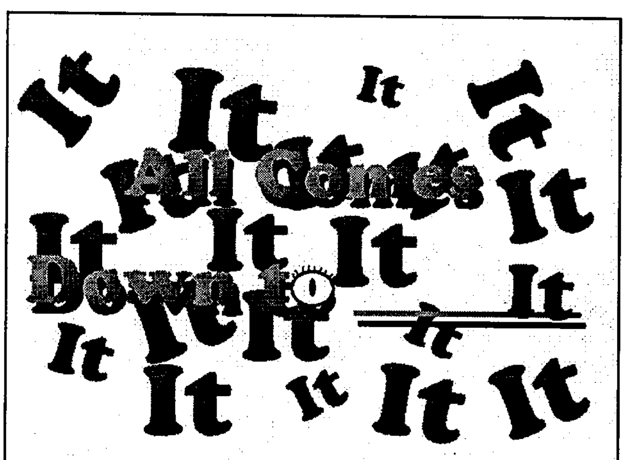
This was brought home to me most pointedly when I became a new parent and of necessity a practitioner of literature in perhaps its purest form—the improvised bed-time story. My 3-year-old daughter continually edits my stories as they unfold. For example, should I introduce characters who aren't to her liking, she's sure to make her teddy bear frighten them away. I'm then forced to replace them with more acceptable protagonists.

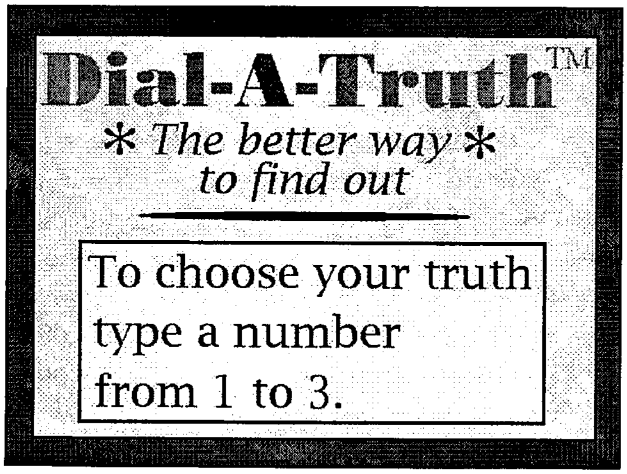
I also began to think about how I tell a story or anecdote to friends. It's far from a matter of merely reciting a fixed text. Not only might I be interrupted by requests for elaboration, but other responses such as laughter, a raised eyebrow, or a yawn might affect the details of my tale. In other words, it's an interactive process.

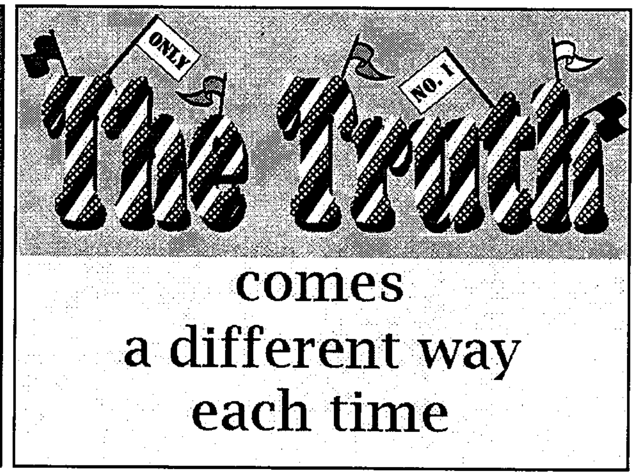
I believe that the instinct for interacting with a story is quite primal, stemming from literature's origins as a purely oral medium. The interactive element was merely thwarted when story-telling bent to the requirements of the written or printed page. Perhaps computer-based interactivity can help recapture something that lies close to the very heart of our innate need for stories and poems.

Interactivity plays a much more important role in my SoftPoetry in progress than in my past work. I've created a technique I call "organic hypertext," which is central to the structure of the poem I'm currently working on. The poem consists of different sections that explore remembered images and scenes, with hypertext links among the sections. The viewer can move among the sections in a nonlinear fashion, but each time he returns to a section already read, he'll find it has changed—sometimes a little, sometimes a lot. Many of the changes reflect what he's read elsewhere in the poem between the first and second readings of a section.

This lets the poem mirror the way thoughts, attitudes, and memories evolve and fluctuate over time and in the light of new experience or ideas. My aim is to create a literature that behaves the way human thought processes do. Since the poem is dif-







ferent every time it's read, it also reflects the dynamic nature of the real world. I hope that the experience of reading the SoftPoem can perhaps even become a little like getting to know a living, breathing person.

Nuts and Bolts

I've created my SoftPoetry with the aid of several development tools, including Visual Basic and the multimedia presentation packages *IBM Storyboard Live* and Gold Disk's *Animation Works Interactive* for *Windows*. Of course, these multimedia programs weren't designed for creating literature or art—they're aimed primarily at business people who want to give a presentation using the computer monitor instead of a slide projector or corporate trainers who need to create computer-based training applications.

I suppose it's fitting that I'm using business software to create my SoftPoetry, since some of my poetry delves into the language and imagery of Corporate America and Madison Avenue—powers that control our lives to a frightening degree, though they are all but ignored by most poetry.

The multimedia packages let me string together graphics images, create transition effects between images, fashion animations, and incorporate menus for the viewer to select from. They can also play my MIDI music compositions while the graphics are being displayed.

Once I had initially created the work, I found myself refining it after observing how people interacted with the poetry. For example, I observed that people might watch the presentation for a while and then walk away before a poem had finished running, leaving a menu on screen with no one to select from it. I then set up the display so that whenever a menu was presented to the viewer, if no selection was made after 60 seconds, the poem would continue on its own. Thus there is always something happening on the screen to attract a new viewer.

The Audience

Bringing SoftPoetry to an audience poses a unique challenge, since it can't be distributed through the traditional channels for literature. Even distributing the work through the usual software channels poses a real problem. Few PCs are equipped with the Roland GS-compatible MIDI hardware necessary to play back the music convincingly. With the poems created in *Storyboard Live,* it's impossible to maintain synchronization between the graphics and the music when the poem is run on a machine faster or slower than the one it was created on.

I've come to think of the SoftPoetry display primarily as an installation—a sort of interactive literary artwork. Some of the venues I've found for it include galleries and museums, colleges, arts and community centers, book stores, book fairs, and literature festivals.

However, this work is published on disk in versions without music by Floppyback Publishing International (PO Box 2084, Hoboken, NJ 07030; 201-963-3012). A third distribution means is videotape. In this form, one of my SoftPoems was aired on cable TV and presented at a video festival. While videotape lets me retain the music, the interactive element is completely lost and some of the quality of the graphics is sacrificed.

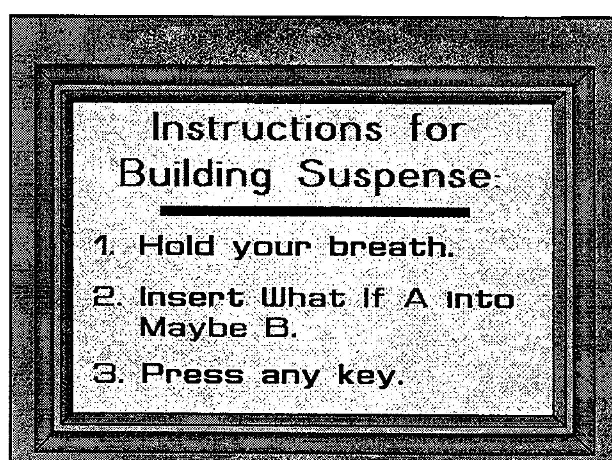
The SoftPoetry installation does have one significant advantage over books, literary magazines, and poetry readings when it comes to disseminating poetry. It lets me reach beyond the normally very small audience attracted to contemporary poetry, which has become the poor relation of the arts in this century. I've found that my work greatly appeals to the general public's fascination with computer technology, as well as its interest in anything that bears a resemblance to television. Young people are particularly drawn to these aspects of the work.

As technology improves, distributing this type of work will become much easier. I hope that eventually disseminating SoftPoetry on a medium such as CD-ROM will become as easy and routine as distributing an audiocassette or a videotape today.

I also take comfort in the interactive multimedia technology for the mass market—such as interactive TV—that is on the horizon. When the general public becomes accustomed to interactive multimedia, I think we'll see a sudden surge of interest among artists in interactive computer-based art forms. In fact, I believe this genre may eventually become so popular that it will characterize the next century in the same way that film and video in this century emerged from new technologies to create a distinctively 20th-century medium.

I feel that I have just scratched the surface of this new medium, and I find its seemingly endless possibilities very exciting. Already I feel it has allowed me to express artistic ideas that would otherwise have remained mute. It has also attracted a surprising amount of new interest to my poetry from many different quarters. Though I continue to write and publish poetry on the page in the conventional manner and continue to give poetry readings, more and more of my energies are going into SoftPoetry, which has now become my primary genre.

I guess one of my dreams is that 50 or 100 years from now, lit students will call their anthologies up on their PC screens and immerse themselves in interactive poetry and fiction. All the technological barriers to this dream will fall away during the next few decades. Whether or not it becomes reality will depend solely on the energies and inspirations of writers.



The Creation of The Mona Lisa

Lillian F. Schwartz

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The identity of Leonardo da Vinci's model for his painting *Mona Lisa* has plagued historians for over 500 years.

In previous investigations (Ref.1), using computer-aided and historical analysis, the author posited that Leonardo first started the *Mona Lisa* with Isabella, Duchess of Aragon as the subject, which he later changed using himself as the model. But while the results reveal the identities of the model for the *Mona Lisa* the creative decision-making steps Leonardo used in transforming the Duchess into the *Mona Lisa* using his own features remained a mystery.

Special picture-processing programs and morphing algorithms were used to reveal the metamorphosing of Leonardo's *Mona Lisa* from the face of Isabella, Duchess of Aragon to the inclusion of Leonardo's own features to the the celebrated image known to the world (Fig.1). In addition, the morphing of the x-ray of the *Mona Lisa* revealed a closer alignment with the features of Isabella, Duchess of Aragon than with those of the *Mona Lisa* (Fig. 2).

This paper describes the author's hypothesis of the steps in the creation of Leonardo's *Mona Lisa.*

Chronology

Leonardo lived in Milan in the Palace of Ludovico Sforza from 1483 to 1499. Besides working as court painter for the Duke including drawing Duchess Isabella and her children, he painted the Last Supper, built models for his flying machines and began work on a new method for shading portraits, a technique called *sfumato*. (Renaissance portraits were mostly painted with clearly defined lines rather than subtle shading.)

Prompted by his increasing debts and lack of payment from the Duke whose position was weakening, Leonardo left Milan before completing the portrait of Isabella. He traveled extensively from Mantua to Venice, and on to Romagna where he joined Caesare Borgia and his army. He carried with him the small wooden panel with the image of the Duchess and worked on developing his *sfumato* technique.

By the early 1500's Leonardo arrived in Florence (Raphael must have seen the famous composition since Raphael's sketch with the same pose is dated 1504). But his stay was aborted since Michaelangelo was receiving the major commissions, such as the Cistine Chapel.

But Leonardo had one difficulty. He was faced with working without a model. Scholars who studied Leonardo's anatomical drawings demonstrate the Master's inability to draw what was not in front of him.

He handled this problem by using himself as the model. One can imagine that he would set up the "canvas" to work on his new technique. He would look in the mirror to check facial proportions. His own features began to merge with the Duchess's. And, except for the top line of the bodice, he maintained the size and shape of the body.

He tilted the head, and changed the direction and size of the eyes to the corner positions his eyes would take when looking into a mirror to create a self-portrait. In order to accommodate the larger pupils Leonardo extended the upper and lower lids on the *Mona Lisa* painting. The lids now appeared more elongated and horizontal. He used his *sfumato* technique to delicately shade and deemphasize the now oversized appearance of the outer edges of the eyes. He left much of the shading over the left eye of the Duchess but changed the shading to match his own brow. He transformed the Duchess's left nostril into the curve of his left nostril and dropped the feature into shadow. If he had used a clearly delineated line for the nostril without shading, the face would have taken on a more masculine appearance.

He next changed the contour of the Duchess's face to the contour of his forehead and cheekbones. He painted his masculine brow across the Duchess's brow and painted over her eyebrows.

But now the nose overpowered the Duchess's mouth on the left side of the face. Leonardo changed the shading of the lower lip to correspond to his lip to give the impression of a larger mouth. He then painted the left half of the Duchess's mouth much like the right half as if it were simply flipped. He extended the mouth and implemented his *sfumato* technique to obscure a clearly defined mouth. He changed the short, straight, hair into long, curly hair.

In Leonardo's commissioned portraits he always provided a clue as to the name of the sitter even though the identity was known. But, concerning the identity of the model for the *Mona Lisa* there were no records. Even her name was given to her by Vasari (Ref. 2), a Renaissance biographer, whose description was based on hearsay evidence alone, Curiously much of the description fits Isabella, Duchess of Aragon, where eyebrows and pink nostrils are noted. This description does not fit the *Mona Lisa.*

Leonardo's delight in puzzles and riddles (Ref. 3) provides obvious clues to the identities of the models for the Mona Lisa.

He painted a landscape with one side real and the other imaginary. We recognize the bridge at Lecco, the La Grigna mountains, and Lake Como, all near Milan, clues to the identity of the first sitter and now hidden face of the Duchess. He painted a design of wickerwork on the bodice, thus providing the the name of the final model - Vinci. (The Italian vinci means wickerwork.)

Leonardo made his final move to France at the invitation of King Francis I who provided living quarters and a studio for the artist. The painting was completed, the enigmatic smile its emblem. He died in 1519 at Cloux with the celebrated painting in his chambers.

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2. Vasari, G. *Lives of the Most Eminent Painters, Sculptors, and Architects* Trans. by Gaston DuC. DeVere, (The Modern Library, NY 1959) pp.203, 204.

3. McMullen, R. *Mona Lisa The Picture And The Myth* (Houghton Mifflin, USA. 1975) pp.86, 182.

4. I thank Gerard Holzmann for the picture-processing software and morphing algorithms, and Tom Killiam in the printing of the images.

ILLUSTRATIONS

Fig.1. **Cartoon** of the head of Isabella, Duchess of Aragon, photographed before restoration morphed into the *Self-Portrait* by Leonardo da Vinci, (Original in Turin,

Biblioteca Reale, No.15741) morphed into the *Mona Lisa* (Louvre Museum, Paris) showing the stages in Leonardo's creative-decisions in creating his masterpiece.

Fig. 2. **X-ray** of the *Mona Lisa* morphed into the **Cartoon** of the head of Isabella, Duchess of Aragon, photographed before restoration; Morphing shows the **X-ray** matches the matches the **Duchess** or **Hidden** Mona Lisa.

Figure 1

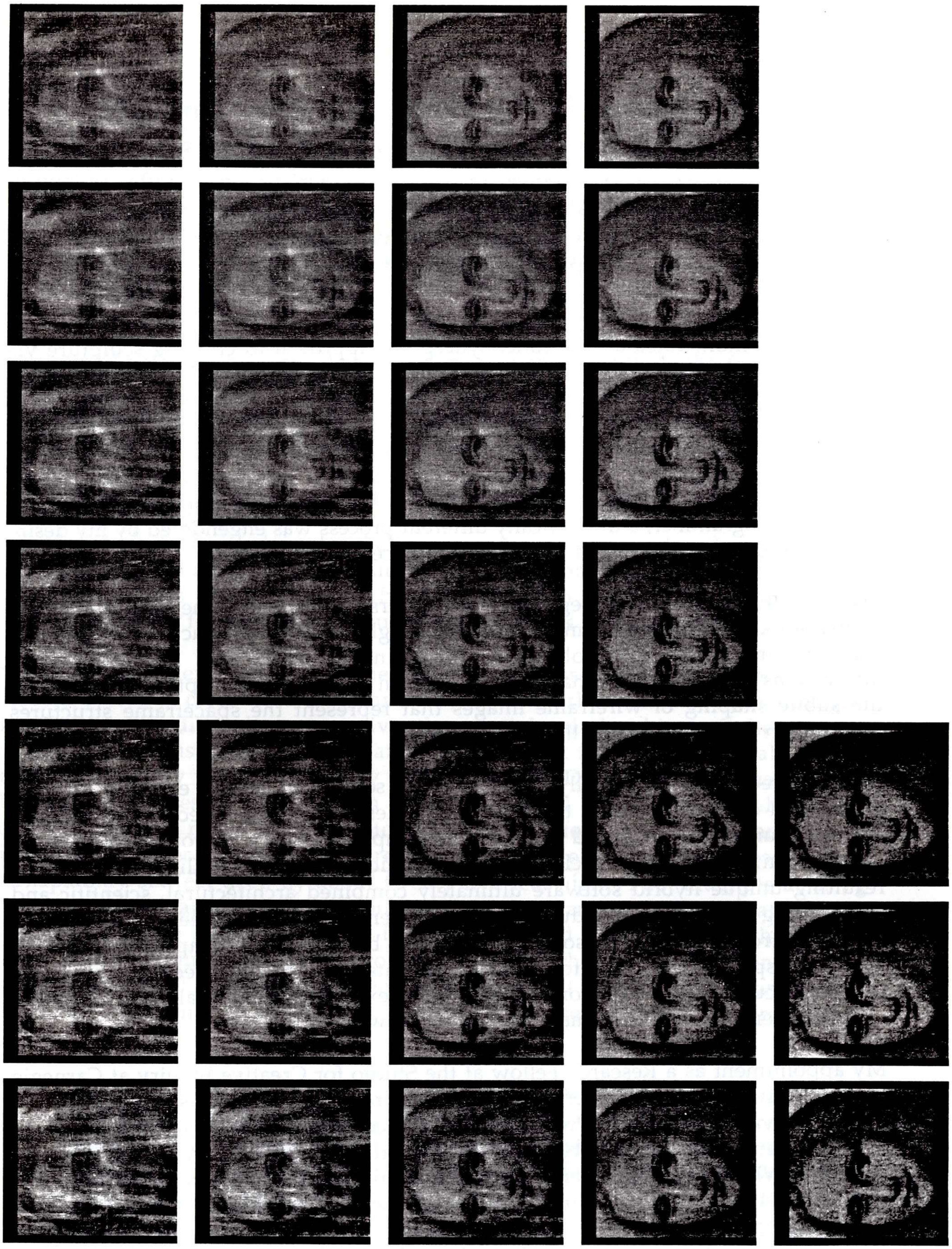

Figure 2

Sculpting in Cyberspace: New Tools and Stereo 3-D Enhancements

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My work demonstrates a symbiotic, synergistic approach to creating sculpture via computer technology, and proves the efficacy of this approach by realizing these projects in realtime and realspace. Several years ago, as a result of a commission to create a huge sculpture for the exterior of the Carnegie Science Center in Pittsburgh, I directed the development of unique hybrid software that combined a full range of computer applications, from scientific visualization to CAD and architectural simulation. Utilizing a Silicon Graphics IRIS Indigo Elan, and working closely with an expert programmer, a dramatically different process was engendered by my desire to create sculpture that would be as much Science as Art.

My current research at Carnegie Mellon University focuses on the development of software tools which enable me to take the roughly shaped products of the original software and refine these objects to the point of production. This has led to innovations in stereo 3-D enhancements, and an array of menu options that permit the subtle shaping of wireframe images that represent the spaceframe structures from which the sculptures will be constructed.

Just as a tree grows organically from the earth, so did this project establish its roots in the field of Science. More than 5000 new lines of code produced a new medium for sculpture creation based on an artistic application of Voronoi Tessellation software intended for the scientific visualization of polycrystalline growth. The resulting unique hybrid software ultimately combined architectural, scientific and engineering programs introducing scale, dimension and engineering properties. The data from this hybrid software can then be output to computers at MERO Structure, spaceframe fabricators. Using this data, they can engineer and build the resulting sculpture. The outcome of this complex procedure is realworld sculpture that has been determined by natural organic growth algorithms.

My appointment as a Research Fellow at the Studio for Creative Inquiry at Carnegie Mellon University led to several collaborative projects with Professor Andy Witkin and his advanced students. Professor Witkin recently won the Prix Ars Electronica for innovative developments in texture modeling. One of Witkin's doctoral students, Will Welch, had been developing software for shaping three-dimensional forms by addressing the underlying polygonal wireframe structures in novel ways. We recognized the potential for his software to allow me to further refine the unique but rough forms produced by the polycrystalline hybrid software. Over a period of several weeks, we added several new tools to his program and simplified many of his tools to permit their intuitive use. We moved the data from one of the "Cybernaut" figures proposed for the Carnegie Science Center into his program with the goal of refining this sculpture to the point of production. An offer by MERO Structure Company to underwrite the costs of the first sculpture and a request by a sculpture park in California to feature the work proved highly motivating. (The developments occurred on Silicon Graphics IRIS computers including a "Reality Engine" recently acquired by Witkin's lab.)

The new tools for shaping the wireframe images, comprised of nodes and connecting lines that represent the spaceframe sculptures, include the following:

1) Nodes can be added or deleted at any point in space.
2) Lines can be added or deleted.
3) Lines can be split into two with a new node appearing in the center.
4) Nodes can be moved in space along with their connecting lines either singly or in any number.
5) Nodes can be merged, i.e. by clicking on any number of nodes, they merge into one node and all of the connecting lines radiate from this new point.
6) Vertical lines can be dropped from any node to a horizontal ground plane which allows for the design of supporting elements for the sculpture.

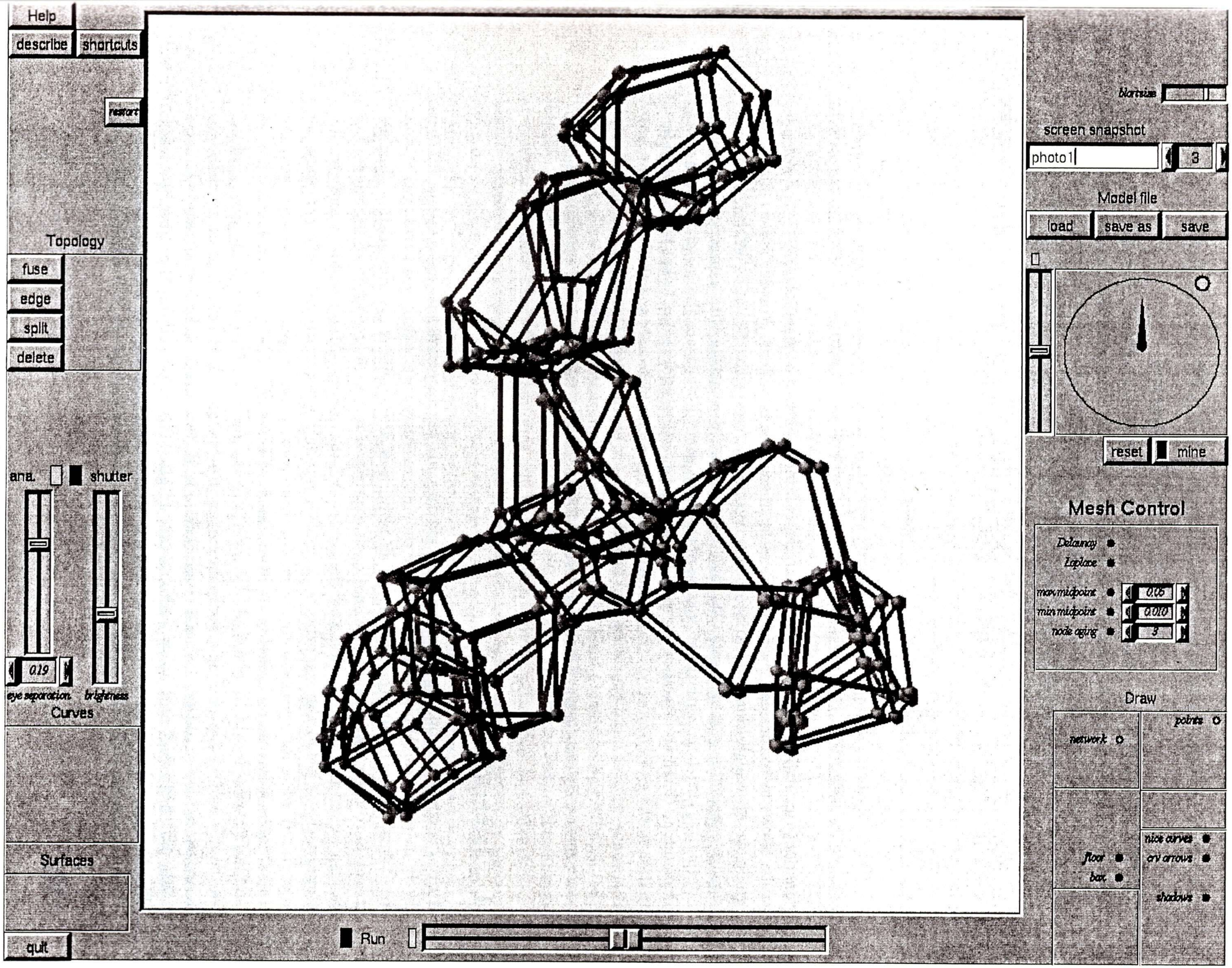
Among the most exciting enhancements to the process was the development of a stereo 3-D tool. I discovered, like anyone who has worked with wireframe images, that it is very difficult to perceive the spatial relationships of the various components because they are transparent and complex forms. The crystallography field has for many years successfully utilized stereo 3-D for molecular analysis and docking procedures. I have also on several occasions used stereo to enhance my ability to see and refine sculptures to considerable effect. In this instance, a new problem arose because the sculpture is proportionately shallow in space. It is perhaps only six feet deep by about twenty five feet high. First attempts at using stereo revealed that the shallow depth and a distant vanishing point created many ambiguities in the perception of the form. We needed a war to "supercharge" the stereo effect to counter the depth problem. After much discussion and input from Andy Witkin, Paul Heckbert and others at the lab, Will Welch came up with a tool which permitted me to affect three aspects of the stereo program using simple sliders.

1) I could move the convergence point (the point at which the eyes converge) forward or backward in the space. This meant that if the sculpture was sitting at a distance which would normally decrease the stereo effect (our ability to perceive stereo greatly diminishes proportional to the distance the object is from us), I could move the convergence point closer to the rear of the object and it would exaggerate the angle of convergence giving the impression of the viewer being much closer to the object.

2) I could change the ocular disparity, or the distance that the eyes are apart from one another. This disparity plays a dominant part in our perception of stereo as it enable us to see an object from several points of view simultaneously which are then reconstructed in our brain. Submarine captains have long utilized a technique for allowing them to get a better sense of the range and shape of a distant object viewed through their periscope by "moving" the eyes much further apart as a function of the distance from the object. This meant that when I was viewing the sculpture from a distance, I could enhance the stereo effect by this method as well. As I moved closer to the object, I could move the eyes closer together, adjusting this effect until the object practically popped off the screen.

3) A third feature was the location point of the observer (me) relative to the object and had the effect of using a combination wide-angle to telephoto lens on a camera.

The combination of these three options, which took some getting used to assess their combined effect, ultimately led to my ability to substantially enhance the presence of the object and to see the often extremely subtle spatial relationships between the nodes and the lines that make up the image. As a result, I could manipulate my point of view and maximize the stereo effect prior to each change I made on the sculpture giving me much more confidence in the reality of the changes I was initiating. The net result was to raise my capabilities at sculpting a complex wireframe form to a higher plateau than I have yet experienced in the many years I have been developing sculptures via computer. It is my feeling that this software enhancement may have positive results in other fields and I am currently sharing the effects and techniques with other labs at CMU and anyone else interested in this research.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Consideration of Facial and Audio Channels for a Facial Animation System

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Abstract

Our overall goal is to produce facial expressions and head movements as automatically as possible from spoken input. Towards this end we have produced a high level programming language for 3D animation of facial expressions. We have elaborated a partition of facial actions into specialized functions (lip shapes, conversational signal, punctuator, regulator or manipulator). This decomposition allows us to consider several independent dimensions of actions. Starting from a functional group we offer algorithms which incorporate synchrony, create coarticulation effects, emotional signals, eye and head movements. We have been concerned primarily with expressions conveying information correlated with the intonation of the voice, some of which are also correlated with affect or emotion. Given an utterance, we consider how the discourse information (what is *new/old* information in the given context) is transmitted through the choice of accents and their placement, how it is conveyed over facial expression and how the two are coordinated. Our system embodies rules that describe and coordinate these relations (*intonation/information*, *intonation/emotions* and *facial expressions/emotions*). The lowest level is **FACS**, making the generation system portable to other facial models.

1 Introduction

During a conversation, a person is always moving, his/her face varies its expressions, his/her body its postures. While talking, lips are moving, eyebrows are raised, head and eyes change positions, blinks occur etc. The face is an important and complex communication channel. Faces have their own language where each expression is not only related to emotions, but is also linked to the intonation and the content of the speech. Many linguists and psycholinguists have noted the importance of spoken intonation for conveying different emotions associated with the speakers' messages [4]. Moreover, psychologists have found some universal facial expressions linked to emotions and attitudes [9]. Many applications in human communication would be enhanced by incorporating facial and vocal information. Indeed, the audio and visual channels complement each other and their combination corresponds more to real-life situations. Visual channel can clarify and make unambiguous what is being said. For disturbed and noisy audio, a face might help in perceiving the missing speech. The listener relies more, in such a case, on the visual channel than on the audio one [2]. As an example, information assistance system or teleconference can be improved by using facial expressions with synthesized speech instead of just speech. Teleconference will enhance long distance communication system. Its goal is to transmit in real-time audio and visual information. Transmitting images is time-consuming and today's techniques cannot supply real-time. Instead researchers are looking toward establishing a schematization of gesture and facial expression and having to send only a few parameters characterizing this schematization.

Animating the face by specifying every action manually is a very tedious task and often does not yield every subtle facial expression. Thus, in order to improve facial animation systems, finding a parameterization technique to cover every type of facial action and understanding such a language and its interaction with intonation is one of the most important steps. In addition, motions of the head and eyes, which accompany speech, correlate with and amplify the communication process. These movements are not arbitrary and are essential to integration of facial expressions with a general simulation of human-like speaker-listener communications.

1.1 Our Approach

Our goal is to derive a parameterization scheme that considers the link between spoken intonation and emotion to drive and automatically generate facial animation from a high level model of the face and the linguistic information.

1.1.1 Notational System

We are using the notational system **FACS** (Facial Action Coding System) to denote any visible facial expression. This system, developed by P. Ekman and W. Friesen [10], is based on anatomical studies. Every facial action is due to muscular activity, relaxation or contraction. **FACS** describes temporary changes in facial appearance, how a feature is affected by specifying its new location, and the intensity of changes. An action unit (**AU**) is the production of the action of one muscle or of group of related muscles. Each **AU** describes the direct effect of a muscle plus eventual secondary motion due to the propagation of movement, and possible apparition of wrinkles or bulges.

We are working at the level of the **AUs** and not at the node level. The computation of facial action is independent of the geometrical model used to display the animation. Contrary to the technique that uses a stored library of expression which computes facial expressions for one model only, our process can be applied to any other facial model using **FACS** to drive their animation [25], [29].

1.1.2 Parameterization

To counterbalance the difficulties involving in manipulating manually the action of each muscle, our system offers to the user a higher level of animation by lip synchronization and automatic computation of the facial expressions related to the patterns of the voice. Facial expressions are partitioned into the ones linked to emotion and the non-expressive ones.

We have elaborated a repertory of such movements [23]. Head and eye gestures are also included as part of the animation. These partitions are independent from each others. This decomposition is not done by facial regions at the image level but at the level of action units (**AUs**, head, and eye motion). Indeed, the same facial region can be involved with different facial functions. Raised eyebrows can be the signal of surprise or can be used to highlight a word in an utterance. We view this partitioning of facial expression as an important tool to analyze, and explore the significance or role of certain facial action with spoken intonation and within the context of other facial movements. Therefore, we used this classification to parameterize the animation. We define a *channel* as a function involving one or more regions of the face. These channels are separated from each other even though they may have some regions in common. They correspond to a specific function relative to the flow of speech. They are not only functionally orthogonal to each other, but also complement each other. The computation over these channels are defined by a set of rules. These rules were derived from physiological, psychological, and linguistic considerations. This scheme allows the user to modify, add, or delete a rule for one channel without modifying the other part of the system. The program runs through the set of rules for each channel computing the existence and type of actions. The final animation is obtained by summing together all the individual sets of actions of each channel. The mere fact that they merge together in producing an unified animation is strong evidence that this parameterization is reasonable. Furthermore, considering different channels for facial movements offers the possibility for researchers to experiment with their individual significance. Switching off one of the component channels is a way to analyze the meaning and information it conveys. For the same reason, the system will allow modular refinement of each channel.

Facial expressions follow the flow of speech but they are also tied to the individuality of the speaker. Speakers differ in their way to delineate utterance, to accentuate a word, etc. Raised eyebrows are mostly used but nose wrinkling or a wink can appear; P. Ekman [9] cites the case of the actor Woody Allen who uses the eyebrows of sadness (inner side of the brows drawn up) to accentuate his speech. Each individual is also differentiated by the number of actions displayed; not every accented segment is punctuated by an action. Therefore two variables define a facial action, its *type* (set of **AUs**) and its *presence* in the spoken utterance. In order to vary the manifestation of speaker's individuality and attitude (what s/he wants to convey such as, for instance, politeness or irritation), we defined a facial action by these two independent parameters. The user can modify one without altering any other variable in the system.

1.2 Organization

In the next section, we present the background of our system. We define emotion in our context and characterize the various channels of facial expressions. We present as well the vocal parameters of emotion and the intonational system we are using. The input representation for our system is also given in this section.

We explain the assumptions of our system and its properties in the following sections.

Then we develop the algorithms we have implemented. Especially, we look at how we solve lip synchronization and coarticulation problems.

2 Background

After defining *emotion* for our present purpose, its properties and parameters are introduced. Six emotions are characterized by their specific facial expressions. We elaborate the various types of facial expressions and their properties one by one.

2.1 Definition of Emotion

An emotion is generated not only by the perception of an action but also by its signification to us. It is a function of our memories, our present and future motivations. One reacts when the action he encounters is unusual for him, when one has difficulties to adapt to it, to evaluate unexpected events. The cognitive aspects of emotion, that is, how a person interprets the emotion through his own memory, images, social experiences, play an important role. Emotion can be completely solicited, the remembrance of the death of a friend can make a person sad. Therefore the context and factors from which an emotion arises, the reaction and the control over this person are important determinants concerning emotion. The description of an emotion is a process [26] with various components such as physiological responses (visceral and muscular states), autonomic nervous system and brain responses, verbal responses (vocalizations), memories, feelings, facial expressions. For example, anger can be characterized by muscle tension, decrease of salivation, lowered brow, tense lips, increase of the heart rate. Each emotion modifies in a particular way the physiology of a being.

2.2 Intensity of Emotions

A person may feel an emotion with different strength. If an emotion is felt very lightly, not every facial movement corresponding to the emotion will be visibly displayed; in other words, changes expressed in the face do not meet minimal levels for notation [10]. Nevertheless, a minimum level of facial movements is required in order to express or recognize an emotion. In the case of small intensity, just the minimum requirement will appear with very little action, while in the case of very high intensity, the facial expressions of the emotion will be extreme. For example, in the case of mild fear like apprehension, only slight expression around the mouth can express it; but in the case of extreme fear both areas, the muscles around the eyes and the mouth, are very tense.

Thus, the intensity of an emotion controls not only the amount of movements (strong or light) but also the appearance of some movements. The intensity of an emotion is a very important parameter.

2.3 Characterizations of the Emotions

Six emotions (anger, disgust, fear, happiness, sadness and surprise) were found to have universal facial expression [10]. We have chosen to study more particularly all six of them (see Figure 1). There are three main areas in the face where changes occur: the upper part of the face with the brows and the forehead, the eyes, and the lower part of the face with the mouth. Each emotion is characterized by specific facial changes. Note that there may be several alternative ways to create similar emotions. These are meant to be representative prototypes derived from the universal patterns found by P. Ekman.

2.4 Display Rules

Emotions (at least some) have universal patterns but their display is modulated by social environment, and cultural dependencies. Display rules [9] refer to this problem of who can show which emotion to whom and when. An employee may be angry and smile in order to be polite to his/her boss for example. In some occasions, a person should not show his/her emotion, but should attempt to modulate it (i.e., decrease the intensity of the felt emotion or even try to neutralize it, i.e., to show nothing of the felt emotion) as much as s/he can. Display rules are an important factor to explain the discrepancies in the facial expressions of emotion among different cultures. The universality of facial expressions of emotions is not questioned, rather it is still maintained but the notion of modulation of the facial expressions within a culture should be added.

2.5 Other Facial Expressions and their Rules

All facial expressions do not correspond necessarily to emotion. The raise of brows can punctuate a discourse and not be a signal of surprise. P. Ekman differentiates between facial expressions as emotional signals, and as conversational signals. The first ones (e.g., surprise expression) are tied to emotion while the later ones (e.g., raised brows) are tied to intonation. Most of the time these last signals are over-learned and stereotyped, the speaker is not aware of them. These signals overlap on the face. P. Ekman [9] characterizes facial expressions into different groups:

- **emblems** are non-verbal actions that may replace or repeat a word (or a small group of words). They can be directly translated into verbal statements. For example, instead of saying 'sure' or 'I agree', one can use eye wink. They may occur when words are blocked, or when there is too much noise to talk. It may also occur when people are too far from each other, or during a speech to accentuate graphically what is said. They are usually produced as consciously as words are. Their main purpose is to communicate. Contrary to emotions, they are socially learned. Their aspects and their meanings are culturally dependent. Their coding is very often arbitrary and therefore decoding is culture specific.

- **emotion emblems** are made to convey signals about emotion. A person uses them to speak about this emotion, even though s/he does not feel it at the moment. S/he just refers to them. It is quite common to wrinkle the nose when talking about a disgusting thing. Such movements are part of the emotional ones (wrinkling the nose is part of the facial expression of disgust).

- **conversational signals** are made to punctuate a speech, to emphasize it. A stressed element is often accompanied not by a particular movement but by an accumulation of rapid movements (such as more pronounced mouth position, blinks or rapid head movements). Conversational signals may occur on an accented item within a word, or, it may stretch out over a syntactic portion of the sentence (corresponding to an emphatic movement). Raising brows often accompanies an accented vowel. They are over-learned and culturally dependent.

- **punctuators** can appear at a pause (due to hesitation) or to signal punctuation marks (such as a comma or exclamation marks) [7]. Certain types of head movements occur during pauses. A boundary point (such as a comma) will be underlined by slow movement and a final pause will coincide with stillness [11]. Eye blinks can occur also during pauses [6].

- **regulators** are movements that help the interaction between the speaker and the listener. They control the flow of speech and correspond to how people take speaking turns in a conversation. Head and Eye movements are coordinated to synchronize speech and organize communication.

- **manipulators** correspond to biological needs of the face, like blinking the eyes in order to keep them wet, wetting the lips, etc.

- **affect displays** are the facial expressions of emotion.

All these movements must be included to obtain a more complete facial animation [23]. A face can make many more movements such as grimacing, contorting, lip-biting, twitching, and so on, but we are not considering them. They are not related, a priori, to emotion or speech (or at least directly so).

2.6 Synchrony

An important property linking intonation and facial expression (in fact, it is extended to body movement) is the existence of synchrony between them [6]. Body and facial actions follow the flow of speech; they are in accordance with it. Synchrony implies that changes occurring in speech and in body movements should appear at the same time. If a change in the direction of a movement occurs, it will occur at the same time as the other movements. If a movement has its direction sustained, its next change point will be in concert with the other ones.

Synchrony occurs at all levels of speech. That is, it occurs at the level of phoneme, syllable (these two are defined by how their patterns are articulated), word, phrase or long utterance. Some body and facial motions are linked to these groups. Some of them are more adapted to the phoneme level (like an eye blink), some others at the word level (like a frown) or even at the phrase level (like an hand gesture). The main point is that there is no part of speech or body motion that is not grouped together in some sort of cluster. In the present study, the smallest unit is the phoneme, and the largest one is the utterance. This synchrony property is the basic rule we are using to compute facial actions in relation to speech. For any occurring facial action, the program should compute its starting and ending points in correspondence with the speech.

2.7 Intonation

Intonation is defined as the melodic feature of an utterance and can be decomposed into three components linked to: the syntax of an utterance (such as interrogative, declarative, etc.), the conversational attitudes of the speaker (what stand the speaker takes towards the listener: for example, politeness or irony which may be directly signaled or conversationally implied) and finally the emotions (involuntary aspects of the speaker's speech) [26]. In our current research, we are not considering the speaker's attitude.

2.7.1 Physiology

The production of a sound is dependent on the muscular activity in the respiratory organs, laryngeal muscles [26]. Thus, we can assume that various components of speech, such as fundamental frequency, intensity, and others, vary according to the action of certain groups of muscles.

Emotional arousal may affect, in particular, the muscles involved in speech production. Those muscular changes can produce, for instance, stuttering, tremulous voice, breathless voice. Furthermore, we can postulate a direct relation between fundamental frequency changes and emotional arousal. Emotions, in the sense this term is used here, can be characterized by specific vocal characteristics.

2.7.2 Parameters

A parallel between the syntax of sentences and suprasegmental features is defined [26]. Suprasegmental features are added by the speaker to the text and their meanings are directly related to the strength of the conveyed affect as a linear function of the degree of arousal. The listeners detect the speaker's emotion from prosodic features. Emotions are differentiated mainly by the pitch (while frequency is a physical property of sound, pitch is a subjective one), loudness (the perceived intensity of a sound), pitch contour (the global envelope of the pitch), tempo (rate of speech) and pause.

2.7.3 Contributions of Those Parameters

We present here an overview of the role of those vocal parameters [26], [31].

Pitch Pitch is an accurate indicator of emotional arousal. Pitch increases with stress. Indeed, a person under stress is characterized by muscle tension which affects directly speech production. A high pitch level corresponds to an excited person (anger, fear, happiness and surprise) while a low pitch level characterizes a sad or disgusted person.

Loudness Muscle tension produces also an increase in intensity. Fear and anger show very abrupt and quick rises in intensity while sadness is defined by moderate and round variations.

Tempo Here also, changes in activation of the muscles produce changes in tempo and rate of articulation. So a decrease of activation of the muscle brings a slow speaking rate in the case of sadness while highly activated emotions show the opposite phenomena.

Pause There are two forms of pauses, the hesitation and the fluent [7], [24]. Pauses of the former type are generally filled with "mhm" or grunt. They are characterized by no discontinuity of the intonational contour. After the pause, the contour continues as it stopped before the pause. They occur principally before words of high lexical content or after the first word of a phrase (corresponding to false start for eg.). Fluent pauses are mainly silent. Contrary of hesitation pauses, they show a discontinuity in the intonational contour. These pauses are marked by a low or rise of the contour, and a break is seen between this contour and the next contour corresponding to the next utterance. They appear specially at major boundary points. A sad person punctuates his/her speech with long pauses while happiness, fear and surprise show few pauses of short duration.

2.7.4 Generative Intonation

To define the syntactic structure of intonation, we are using an extension of Janet Pierrehumbert's notation [24]. Under this definition, intonation consists of a linear sequence of accents made from two tones (**H** and **L** for high and low tones respectively). Utterances are decomposed into *intonational* and *intermediate* phrases; intonational phrases are terminated by a *boundary tone*. Different intonational "tunes" composed of these elements are used to convey various discourse-related distinctions of "focus": old/new information, contrast and propositional attitude. Thus they serve to indicate the status of the current phrase related to the next one, for example, the continuation of the same topic or the introduction of a new one.

We can represent the decomposition of an utterance into intonational (or intermediate) phrases by brackets (see below). The appropriate use of intonational bracketing is determined by the context in which the utterance is produced and on the meaning of the utterance (i.e., what the speaker wants to focus on, what he considers as new information versus old). This bracketing is (partially) reflected in intonation.

Consider the sentence "Julia prefers popcorn" (the example is related to one discussed in [27]) The possible intonational bracketings reflect the distinction between an utterance which is about *What Julia prefers* or about *Who prefers popcorn*:

- (Julia prefers)(popcorn)
- (Julia)(prefers popcorn)

These bracketings can be imposed by intonational tones.

For example, in the following context, we will have the following tune:

```
Question: Well, what about JUlia? What does SHE prefer?
Answer: (JUlia prefers) (pOpcorn).
Accent: (L+H*      LH%) (H*  LL%)
```

(**H** and **L** denote high and low tones which combine in the various pitch accents and boundary tones. **L+H*** and **H*** are different kinds of pitch accent, and **LH%**, **LL%** and **L** below are boundaries.)

By contrast, in the following context, we will have a different bracketing, imposed by a different set of intonational tunes:

```
Question: Well, what about the pOpcorn? Who prefers IT?
Answer: (JUlia) (prefers pOpcorn).
Accent: (H*  L) (        L+H* LH%)
```

These two examples show different intonational patterns. They emphasize different information (in the first context, the new message is 'popcorn', versus 'Julia' in the second one). The bracketing of the sentence, the placement of pauses and the type of accents also vary. Consequently the facial conversational signals and punctuators related to the first utterance will differ from those of the second one.

2.8 Assumption for the Input

We assume that the input is an utterance already decomposed and written in its phonological representation with its accents marked in its bracketed elements. For the moment, we are using recorded natural speech to guide our animation. After recording a sentence, we extract from its spectrogram the timing of each phoneme and pause. We plan to use analysis-and-re-synthesis methods to automate the determination of paralanguage parameters and phoneme timing [12] driven by a representation like the above.

At the beginning of the file, the user should specify the emotion s/he wants. S/he can choose them from the pre-defined set: neutral, anger, disgust, fear, happiness, sadness or surprise or s/he can define it interactively. S/he should also indicate the intensity of emotion (a number between 0, for minimum intensity, and 1, for maximum intensity). Furthermore, we assume that the input (an utterance) contains the decomposition of the utterance into its bracketed elements, the placement and type of accents. The sentence is written as a list of strings corresponding to the phonetic representation of the utterance and whose notation is compatible with Dectalk's ascii-keyboard notation [1].

3 Steps for Computing Facial Expressions

Emotion does not modify the shape of the contour of an utterance, i.e., it does not affect either the type or the placement of the accents (which are defined by the context of the utterance, what is new/old information to the speaker). This property allows us to compute every facial action corresponding to the given intonational pattern. Nevertheless, their final occurrence and their type is emotion dependent. The emotion will affect in an overall manner the first computation [28]. Now, we explain how to derive this set of rules.

3.1 Organization of the Rules

The computation of facial expressions corresponding to each item listed above (conversational signals, punctuators, and so on) is done by a set of rules [22]. Two parameters are used to define an action: its type and its presence. Our rationale is to allow the user to modify one of the parameters for one action without touching any other variable in the system. As mentioned in the introduction this decomposition is a useful scheme since people differs by the types of facial actions they performed as well as by the relative time in the utterance these actions occur; the type of actions performed by a person while talking is still not very well-known by researchers. Most of the people show eyebrow movements to accentuate a word but other facial action may be chosen such as nose wrinkling or eye flashes [9]. The user just needs to modify the rule which describes the action and need not alter the rules of occurrence. Another unknown parameter is the occurrence of an action. A paralanguage feature is not always accompanied by a facial movement. The function of the last one is established (focus one word, etc.) but their presence is uncertain. Thus we need to have access to the time of occurrence of an action. Having access to the parameters (type and presence) of each action allows to specify various personalities. Authoritarian, anxious, extroverted, or depressive persons, for example, show different body movements in their number of postural shift, degree of postural relaxation, in the type and number of hand-to-head movements, in the percentage of gaze aversion and so on. These variables correlate with personality dimensions [19].

3.2 Choice of the Rules

From the definitions of emotions presented in previous sections, and information stated in [2] [5] [9], we established the corresponding facial expression of emotions in term of a set of **AUs**, eyes openness, pupil size and types of movements.

Happiness is an active emotion. A happy person moves a lot in a fast, expansive and emphatic manner. His/her head motion shows also the same characteristics. S/he punctuates his/her speech with smiles (occurring at pauses) while a disgust person wrinkles his/her nose. A sad person shows few movements; They are slow, non-emphatic, hesitating. Eyebrow movements occur only on few pitch accents with low intensity. Sadness is the least active emotion.

Choosing interactively an emotion not belonging to the basic set (of the six defined emotions) allows the user to enlarge the set of the pre-defined emotions. It is obtained by adding to the main set of rules, the rules defining the occurrence of facial actions and the list of **AUs** for the chosen emotion; that is to specify for example if blinks should occur on pauses and accents.

Amount and type of movements vary with the level of arousal [5]. For example, fear does not have the same types of action depending if the intensity of emotion is low or high. Fear is expressed only with the eyes for low intensity while for intense emotion, all the face express fear. We compute the intensity of a facial action of emotion proportionally to the intensity of the emotion.

Each other facial action such as conversational signals, punctuators and so on, has its intensity proportional to the speech rate, since its appearance follows the voice pattern.

4 Details for each Channel

Each facial expression is expressed as a set of **AUs**. The sentence is scanned at various levels. The lip shapes and blinks are computed at the phoneme level while the conversational and punctuator signals are obtained by the intonational pattern at the word level. First, we compute the list of **AUs** for the given emotion. We add to this list the **AUs** needed for the mouth shape synchronized with each phoneme. Finally, using a set of rules, we compute the conversational signals, punctuators, regulators and manipulators. Emblems and display rules are then added.

We present now the outline of each function one by one.

4.1 Emotion

Each emotion generates a facial expression which serves as the basis for the other facial actions.

The rules corresponding to emotion are evaluated ahead of other rules. They determine the presence of a facial movement; for example, a sad person shows less movement than a frightened person.

Some types of facial action are emotion dependent and are therefore computed at this level. For instance, an angry person has a tendency to punctuate silences frowning, while a happy person smiles.

4.2 Lip Shapes

The first step for the animation is lip synchronization. Some earlier systems rely on cartoon techniques in that only few mouth positions are used [3], [21]. A correspondence between a phoneme and a mouth position is established. Defining a set of parameters to describe at the phoneme level lip shapes have been proposed by a number of animation systems [13], [16], [17], [20]. Looking at how people use visual cues in noisy context to understand speech [18], and at the limit, how deaf persons are able "to read from the lips" [14] give information about lip movements. Speechreading techniques were developed to help the hearer to interpret speaker's lip movements.

4.2.1 Speechreading Technique

Speechreading technique is concerned with visible lip movements. The main problem is that there is not a characteristic lip shape for every phoneme. Rather, languages like English contain a lot of "homophonous words" [14]: words that look alike on the face, even if they differ in spelling and meaning. For example, 'f', 'b', and 'm' involve the same lip movements. Phonemes are grouped together depending on their corresponding lip shapes. This division into clusters varies also with the speech-rate. A person speaking fast will move much less her/his lips in comparison with a person speaking slowly which carefully articulates each word. For fast speech-rate, many segments loose their characteristic shapes

Intonation of an utterance is the enunciation of a sequence of accented and non-accented segments. An accented vowel is differentiated acoustically from the remaining part of the utterance by its longer duration and increased loudness; visually, the jaw dropping motion is a characteristic of accented or emphasized segments.

We shall draw on these observations in specifying our articulatory **AUs**.

4.2.2 Coarticulation

This phonemic notation, however, does not tell us how to deal with the difficult problem of coarticulation. For input, speech is decomposed into a sequence of discrete segments such as syllables and phonemes. Coarticulation occurs due to the overlap of segments during their production. The boundaries among phonemic items are blurred. Sometimes, lips move in anticipation of the following vowel; in other cases, lips keep the same shape over a succession of segments.

A simple solution to the problem of coarticulation is to look at the previous, the present, and the next segments to determine the mouth positions [30]. But in some cases this is not enough, since the correct position can depend on a segment up to five positions before or after the current one [15].

Some rules look at the context of phoneme production to compute adequate lip positions [15]. Nevertheless, a complete set of rules solving every coarticulation problem does not exist. We have implemented the forward and backward coarticulation rules [22] which consider articulatory adjustment on a sequence of consonants followed or preceded by a vowel [15]. To solve particular problems (certain visual transitions between segments) which cannot be solved by these two rules, we consider a three-step algorithm. On the first step, these coarticulation rules are applied to all clusters which have been defined as context-dependent. The next step is to consider relaxation and contraction time of a muscle (i.e. we check that the current speech posture has time to contract after the previous speech posture, respectively to relax before the next one) and finally to look at the way two consecutive actions are performed (the intensity of an action is rescaled depending on its surrounding context and on the cluster it belongs to). Therefore, the speech and physical context is considered and a more physically-based model is built (see [22] for detailed example).

At the end of these steps, we obtain a list of **AUs** for each speech posture (see Figure 2). These constraints between adjacent **AUs** are defined by a constant and are easily changed as is relaxation/contraction simulation. Moreover, lip shapes associated with each speech posture are determined by rules and are also easily modified. This is also a first approach to solve the problem of the corresponding timing of the visual appearance of a phoneme from its audio timing, since we consider through relaxation and contraction of a muscle, the notion of appearance and disappearance of lip actions. This approach may therefore eventually provide a tool for phoneticians to study coarticulation problems.

4.3 Conversational Signals

Most of the time, conversational signals invoke the action of eyebrows. P. Ekman [9] found that raising eyebrows or frowning are the more common signals. Accents can be marked also by rapid head movements.

When an action appears on stressed items, the program computes the onset and offset of the actions depending on the speech-rate. Indeed, if the speech-rate is slow, the movement will start at the beginning of the syllable, otherwise at the beginning of the word. In the case where emphasis (due to sustained loudness) is spread over more than a word, the program follows the same algorithm. The onset and offset of the action coincide with the beginning and ending of the emphasis.

4.4 Punctuators

When an action occurs on a pause, its onset and offset coincide with the beginning and ending of the pause. The type of movement varies with the emotion (for comma, frown will be chosen in the case of anger) or with the type of pause (period will be marked by a frown, while a question mark with a raise of the eyebrows, especially when the question is not stated linguistically). Some head movements co-occur with pauses. A comma between two syntactic elements is underlined by a slow head movement; while an hesitation pause coincides with rapid head movements.

4.5 Regulators

The communication between two agents is expressed by the body, the face, the voice and the gaze. Body movements and spatial relationship are out of scope of this study. The use of the voice has been presented above. Visual behavior plays an important part in the coordination of conversation; Gaze can be used to collect feedback from the listener, regulate the flow of speech, show the emotion and attitude, comment on what is being said and so on. Depending on the context, eye contact or its avoidance can be interpreted in different ways [2]. The length of mutual gaze increases as the intimacy between both agents increases. Eye contact is broken just before the end of a speaking turn but it is re-established at a change of speaking turn. The eye movement is defined by its direction, the percentage of eye contact and the length of mutual gaze.

Regulators correspond to the signs present during turn taking in a conversation. S. Duncan [8] enumerate them as part of a Turn Taking System:

- Speaker-Turn signal: The speaker gives his/her turn to the listener. It is composed of different signs in the intonation, syntax, body movement and so on. The speaker turns his/her head toward the listener, his/her body shows a more relaxed position, all hand gesticulations end.

- Speaker-State signal: it is displayed at the beginning of a speaking turn. The speaker turns his/her head away from the listener and start to gesticulate.

- Speaker-Within-Turn: it is used when the speaker wants to keep the floor and assures him/herself that the listener is following. It appears at the end of a grammatical clause; the speaker turns his/her head toward the listener; the listener often answers by nodding the head and/or with a vocalization.

- Speaker-Continuation signal: it follows most of the time the speaker-within-turn signal; the speaker turns his/her head away from the listener.

The eyes, when looking at some object or person, will investigate it. They scan it from the most salient features to the least. When looking at the picture of a person, viewers are found to look mainly at the eyes of this person (58% of the time), then at the mouth (13%); the remaining regions of the face are scanned just 1% of time each [2].

We first scanned the utterance and compute all the existing head and eyes movements. If no movement is specified for some phonemic items, the head is forced to go back to its neutral position and the eyes scan the listener's face.

4.6 Manipulators

Eye blinks occur quite frequently. They serve not only to accentuate speech but also for eye need (to keep them wet). There is at least one eye blink by utterance. We consider only eye blink as manipulators. A blink is added when there is too much time elapsed between two consecutive voluntary blinks (occurring as conversational signals or punctuators). We find the segment (phoneme or pause) whose time from the last blink is the closest to the period of occurrence of blinks. The remaining parts of the blinks are synchronized with the following segments. The period of occurrence is emotion-dependent. This time will be shorter for fear, anger, and happiness, and longer for sadness [5].

4.7 Emblems

In the present state of the study, we do not compute automatically the channels of emblems and emotional emblems since they imply the voluntary participation of the speaker. Both types of emblems are given by the semantics of the utterance and not (at least directly) by the intonation of the voice. The user decides manually their eventual presence related to the speech by marking it in the input file and their type by choosing from a library of emblems described as a set of **AUs**.

4.8 Display Rules

Given a context, an emotion is associated with a particular facial expression. But there may be some cultural variability (some cultures forbid direct gaze while other find gaze aversion an offense; mourning in some cultures are over-acted while, in others, it should be masked by a smile). We have not taken Display Rules into consideration for automatic procedures since they are very difficult to handle and very little information is available. But we define 3 modulation modes that characterize some display rules acts [9]:

1. they can amplify, de-amplify, or neutralize an expression;
2. they may blend with other expressions;
3. they may be masked by other facial expressions.

For each of these effects, a function is written. Amplify, de-amplify and neutralize affect the intensity of the facial changes. Decreasing the intensity of an emotion can be done by eliminating the expression of the emotion in some part of the face, by shortening the duration of the expression, by contracting the muscles involved in the expression less. Neutralizing is the extreme case of des-intensifying, thus the face should be relaxed, showing no tensed muscle. The blend is done by blending emotions together. Masking an expression A by another one B affects the timing of the parameters of B; besides, some features of A still remain.

5 Conclusion

A tool to compute separately each of the channels of facial expressions offers a better grasp on the problem and better control over the final animation. We are particularly interested in the facial actions which punctuate a speech, their type and presence. We have proposed a method of characterizing any facial movement by separating it into different channels. These channels correspond to a specific function relative to the flow of speech and not to a regional decomposition of the face at the level of the image. Such decomposition allows us to take account of several independent dimensions of an action. The coordination of these various facial motions with the intonation is done by a set of rules. Our model can be expected to help further research of human communicative faculties via animation. In particular, it offers to linguists and cognitive scientists a tool to analyze, manipulate and integrate several different channels of communication including face, eyes and voice. Since our program offers the possibility to switch each channel on and off, the function and the information that each of them bring can be analyzed.

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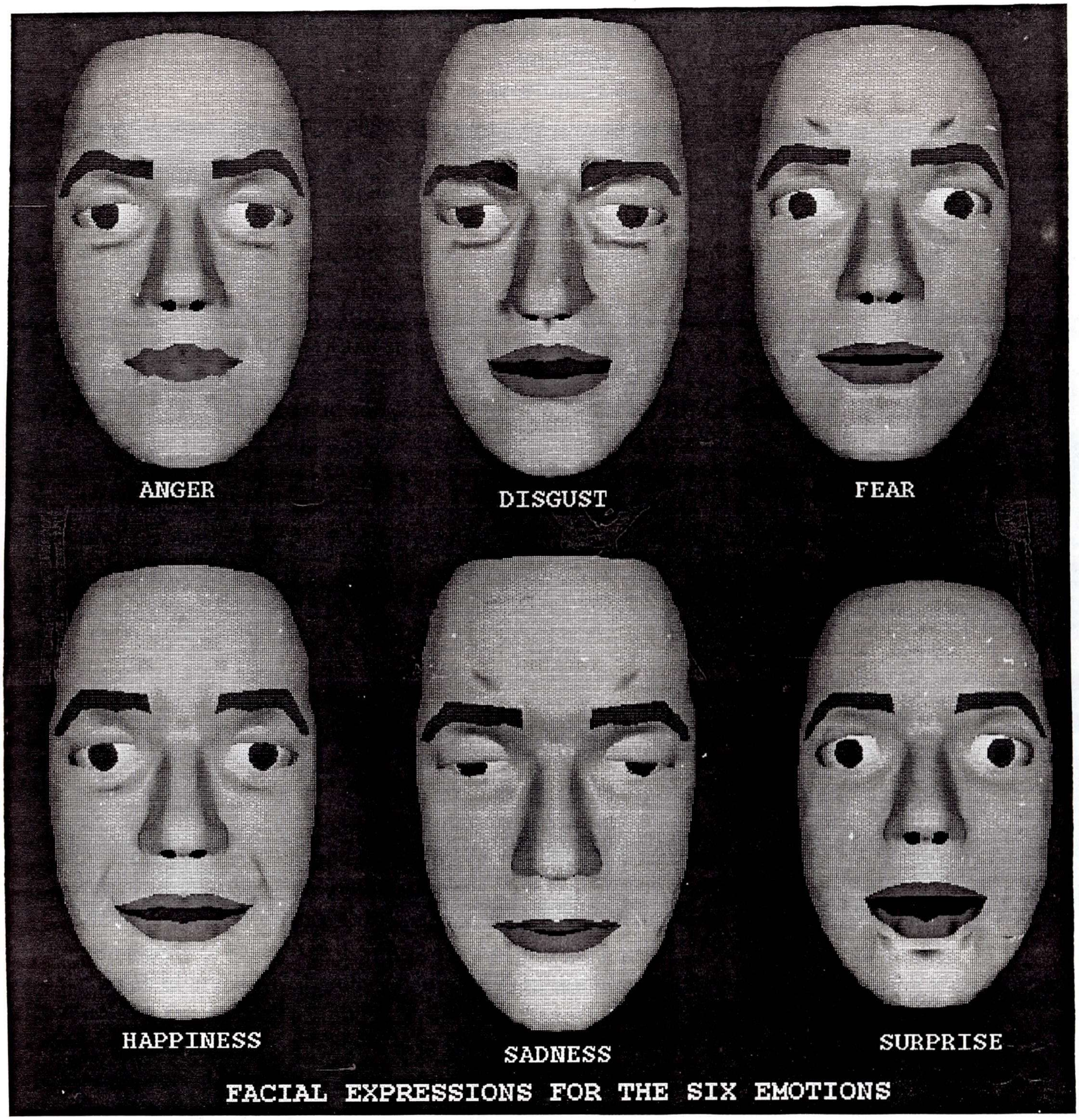
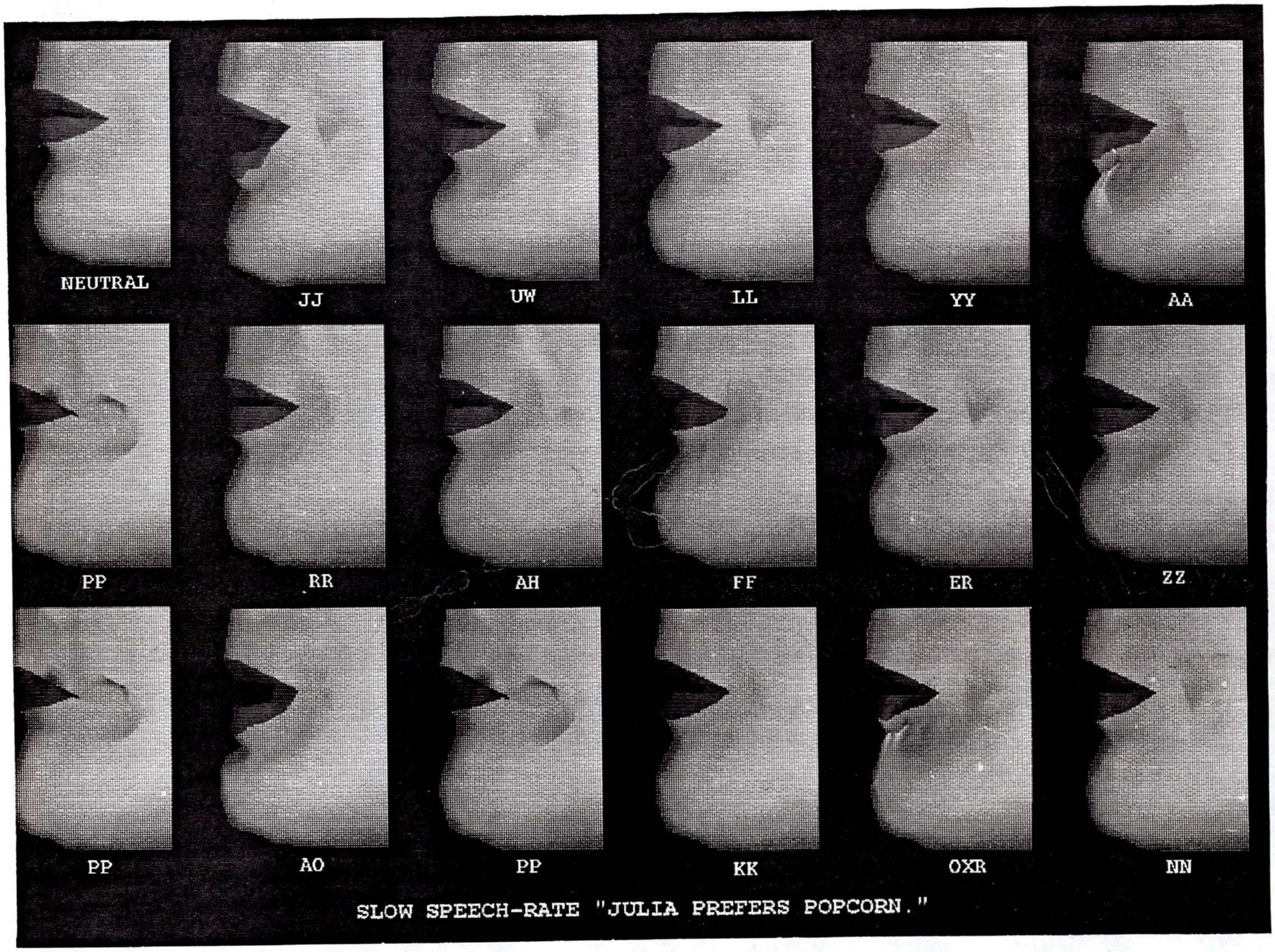
6.1 List of Figures



Comparison of the Lip Shapes for 'popcorn' with Fast and Slow Speech-rate



Lip Shapes for 'Julia prefers popcorn' with Slow Speech-rate

Creating the Virtual Gallery

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Abstract

This paper explores the process of creating the virtual gallery and the issues surrounding it. Creating the virtual gallery using a 3D modeling and animation program is described. The process includes a site visit, creating architectural sketches, building a three dimensional model of the gallery, giving it surfaces and lights, and rendering various views of the gallery. The placing of art in the gallery is done by scanning slides of the art and texture mapping them onto polygons placed on the walls. The curatorial process is now assisted by giving the curator access to this gallery from a virtual perspective. This enables one to move the art around the gallery and to change lighting conditions interactively. The larger issues of the virtual gallery as a forum for digital art is discussed. Ideas for virtual art and the challenge of computer art in a virtual world are addressed.

Introduction

With the development of virtual reality and the creation of virtual worlds, the emergence of real world applications of this process is beginning. One application of importance to curators and artists is the creation of the virtual gallery. By having access to a gallery recreated within a computer, a curator can now plan art shows more effectively. In addition, the promise of telecommunications will enable digital artists to exhibit their work internationally and on-line. There are several issues that arise immediately when thinking about this process. The first is the issue of the medium itself. Is digital art most appropriately shown in digital form? Another issue that is raised is the fundamental gallery experience. The recent show, "Virtual Reality: An Emerging Medium" at the Guggenheim Museum SoHo, New York City is an indicator that the art community is beginning to recognize this new art form. This paper will explore the process of creating a virtual gallery and then discuss and raise issues concerning it's place in the art world.

Building the Virtual Gallery

Given the task of curating the first Digitial Salon art show to be held at the Art Director's Club in New York from December 6-17, it only seemed natural that a computer should be used to assist in the process. The idea was that a replica of the gallery would be created using a 3D modeling system and then the art would be scanned, texture mapped and placed in the gallery for the process of curating the show.

The first step was to gather together all the data needed to build an accurate scale model. This involved several trips to the gallery. The first trip was a scouting mission to determine the appropriateness of the space and to record various details about the gallery. Several photographs were taken as well as a camcorder video. From these images a plan was made to take measurements of all the critical dimensions, i.e. the length and height of the walls of the gallery, the architectural details, lighting placement and any other physical objects that would be important in recreating the gallery. The process was begun from the entrance and then moved around the space.

From this data a series of architectural sketches were drawn of the gallery. These included a top, side and front view of the gallery. Incorporated into these sketches were the actual dimensions of the space. At this point, the data was ready to be put into the computer.

The hardware and software for this project is an IBM PC compatible computer and Autodesk 3D Studio. The computer was a 66mHz machine with 16 MB of RAM, a 340 MB hard disk and SVGA graphics. It also has a Targa 32 + graphics card and a RGB monitor. This combination was chosen due to the software features of using dimensioning, ease of texture mapping and speed of the computer for the rendering of images.

The first step in building the computer model was to set up a grid and to set the dimensions in architectural units. Once this was done, the model was entered using the top view first. By building the model from the top, it could be extruded to the correct height of the walls. In addition, there were other details that were planned to be added later. The top view of the model was then extruded to give the gallery dimension.

At this point a camera was created so that one could see and move around the gallery. Lights were added to match the actual lighting conditions of the gallery. Omni lights were added to mimic the overhead lighting and spot lights were used to light the walls where the art would be placed. The ambient light level was also adjusted to match the time of day and the light coming in from the windows. Additional architectural details were also added at this point. Several test renders were made from different points in the gallery for the purpose of refining the model. Once this process was completed, the virtual gallery had been created. It should be mentioned that render time was also an issue. The model was made as accurately as possible to match the actual space, but intricate details such as scrollwork around columns, interior moldings and grills were not included. These details were not considered essential for the curation of the show and enabled render time to be kept at about 2-3 minutes per image.

The next step in the process was to scan in the art for the show. Once the show had been judged, the 35mm slides were scanned in using a Leaf slide scanner. They were brought in at 72 dpi in 16 bit color which gave a file size of about 350-600K per image. Given that there would be many works of art, memory management of the database was an issue. The works could have been brought in at a higher resolution, but the hard disk memory needed would become very large and the render time would increase significantly. The file size chosen allowed a relatively accurate representation of what each piece of art looked like.

Once the virtual gallery had been built and the worked scanned in, the process of curating the show was begun. Another trip was made to the gallery to confirm what the actual space looked like. A list of the pieces, their descriptions and dimensions was also brought along to help come to some early decisions as to where each piece would be placed. From this point, the computer was used to view the work and place it in the gallery.

Being a work in progress, this is where this project stands at the present time. The next step is to actually hang the show and make the final decisions as to placement of the art and final lighting decisions.

Curatorial Issues

The advantage of this process is that it gives the curator access to the virtual gallery at any time. Most galleries are in constant use, and it is impossible to curate a show in a gallery ahead of time. In the past, scale models of galleries have been built and scaled prints of the art made. Although this process did allow some interactivity on the part of the curator, there were limitations. A major problem with models is that the curator could not place a scale model of ones self into the galley and view it as a gallery visitor would. The computer camera allows one to look around a gallery in a way very similar to being there. Walkthroughs can also be done based on the most likely path one would take when viewing the show. This process also allows the curator to work with and try different lighting scenarios. If a scale model is used, it is generally being looked at under room light. Computer lighting can be adjusted by location, color and intensity as well as type (omni, spot, ambient).

In the process described above, the most time consuming part was the building of the gallery model itself. In a commercial gallery operation, this model needs to be built only once. From then on, the process would involve scanning in the artists work and then texture mapping it to polygons and placing it on the walls.

Future Concerns

This paper has focused on making a virtual gallery of one that already exists. It has also dealt with an art show that consists of two dimensional work that was to be hung on the walls. There is no doubt that this process can be used as an aid in the curation of traditional art shows in galleries. In addition, it could allow for the creation of interactive gallery exhibits operated from kiosks within the gallery. These could contain additional information about the work and the artist.

The larger issue of completly virtual galleries and virtual art then becomes obvious. Is the virtual gallery a legitimate forum for art in and of itself? This also raises questions about the fundamental art experience. With the development of virtual reality tools, telecommunications, and networks, how does the art experience change from the traditional gallery and museum experience? There are no definitive answers to these questions and the authors would like to stimulate this kind of thought and discussion among artists.

In order to form a basis for discussion, the authors would like to put forward some of their ideas about this subject. First, the traditional art experience of galleries and museums will certainly continue to exist. Most traditional artists create their work in a studio with the intent of it being exhibited. For the digital artist, the issue of the virtual gallery takes two basic directions. The first is the choice of venue for their art. Digital art is best exhibited in its original form. Most computer artists have been through their trials and tribulations of output to photographs, prints and silk screens. The colors almost never match and the issue of archival permanence is often raised. The virtual gallery offers a medium that is of digital archival quality. The RGB color of computer monitors is, for the most part, consistent, and certainly so when compared to print output or NTSC video. The virtual gallery is also something that can exist on a network. By doing so, the digital artist can allow people from wide geographic distances access to their art. This is not possible with the current art gallery situation. The issues of resolution and hardware independence must also be addressed in this context.

The second issue to be looked at is the actual nature of digital art. Computer art is in its infancy. It has yet to define itself. Being such a new medium, much of the early computer art has been an attempt to extend the traditional artmaking process into the digital realm. The virtual gallery offers a challenge to artists to create new art. What could this be? Some clues are the nature of the virtual gallery itself. Being a product of 3D modeling and animation software, certain parameters become clear. Artists have access to three dimensional space, they are in total control of what the viewer sees, what objects exist in this space, how they move and react, and the lighting, etc. In addition, adding sound is possible. Virtual reality can also allow interaction on the part of the participant. Virtual galleries could now contain animated sculptures that the viewer could interact with audio sculptures that change along with music, kinetic sculptures that could take the viewer on a virtual tour of the gallery or to some virtual space created by the artist. From the other point of view, there are unlimited possibilities for the artist in the virtual studio. Building on 3D modeling and animation, the virtual artist must now be in control of the software. They must know how to move and create in three dimensional space. Working with currently available tools, they must have ingenuity and a firm grasp of the limitations of technology. To make art in this environment is currently limited by technical advances in the field.

However, the excitement resides in the knowledge that the creative use of technology to make art is a never ending process. Technologies such as air brush, oil paint, film-based photography, and videotape have become mature and have reached most of their physical limits. These media place the responsibility for content and aesthetics on the artist within their own physical restrictions. Computer art and the virtual world have just begun to be explored and offer the somewhat serendipitous promise of advancing technology and ever changing software. It is this challenge that we as artists must accept, to move creativity forward into the future.

Like Telling Dreams

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Personal Material

Having a personal computer can be like telling someone your dreams: at first you don't understand the imagery, but as soon as you speak the words which describe the pictures, you realize the dream was about something very personal. It's obvious to both of you what the dream means, and you know you never meant to reveal yourself that deeply. But there you are. You might as well hang out there, because you can't go back. Whether you're working alone, or working in collaboration, a personal computer affords a personal approach to your work. Examples from works-in-progress illustrate here the possibilities and pitfalls of getting personal.

The works are video songs, created in segments on AutoDesk Animator Pro. None is finished yet, nor do they have music. They are songs by virtue of the rhythms created by the Animator files. They contain images and words. They are pieces which have little to do with beginnings, middles, and ends, as the nature of the computer encourages timelessness. You bring up fragments of your life, and you run them, like screen savers or electronic wall-paper while you do the laundry and load up the dishwasher. You put a piece up for a friend who will come to celebrate his birthday. You leave a moving greeting on the screen for parents, who will arrive from out of town while you are at work. These pieces suggest an audience beyond their original intended viewers. You must decide how appropriate it would be to share these dreams with a wider audience.

Things Change began as a video birthday card for a friend. It contains text and digitized images which become at once an epitaph and a valentine. During its creation the relationship changed, the video piece became more than a birthday wish, and I lost my audience of one. At the same time, I decided the piece could be presented to a wider audience.

Working alone on the computer encourages a dialogue much as one has with a journal. You work with images of friends, you talk to them in your imagination, you create the relationship you want, all by yourself. It's a beautiful relationship you think, then when you tell your dream to the other person, you find out they weren't dreaming the same dream. What do you do? Turn your dream into art.

text from the video song
Things Change

He was the dog John bought to keep Hannah company.
His death means, John said, the passing of an era.
Things change, he said.

Things change.

No matter how much you want them to stay the same,
they change.

But I never thought it would change like this.

The Shirt Off My Back uses images from a certain garment, along with text. The piece began as a search for the point at which I diverged from one path of creativity into another; the search retraces that path to find the point of divergence. That seemed a safe path to explore, but when I finished *The Shirt Off My Back* , it was clear that it tapped an old hostile pattern. By the time the piece was completed, I no longer wanted to make such a hostile statement about a relationship. Do you put what you used to be out there, and go on? Or do you wait for who you will become to be finished and reveal that self? Sometimes change occurs so rapidly that to keep up with change can cause paralysis.

In *The Shirt Off My Back*, I wasn't clear about exactly what I wanted to say. An edge crept in which is evident when watching the looping time of each segment of the piece. The piece was created with the idea of allowing the loops to cycle several times at each break point before continuing. What I had not counted on was that the repetition of phrases changes the meaning in some interesting ways.

text from the video song
The Shirt Off My Back

I gave him the shirt off my back.
I didn't want to but he demanded it.
It never smelled the same again.
I never liked the smell.

We stayed together twelve years.
We had a child.
I had no more shirt.
I wanted it back.

I did get it back.
When I looked in the attic yesterday, there it was.

It doesn't fit me anymore.

I should know better than to surrender
a piece of my soul
to someone else.

I know better now.

Communal Material

Sarah's Novel requires the reluctant collaboration of my 8-year-old daughter. She spent three days furiously writing a novel. She swept her marker across the pages, making word-like marks. She paused, looked off into space and chewed the end of the marker while she considered her next phrase. She created chapter headings and numbered the pages. The marks she made were beautiful. She wrote at least 110 pages in this novel, and not one word was a recognizable word; she had to read it to me so I would understand it. She was reluctant to allow me to use it in a video song, but it became a profound teaching to me of the nature of communication: You must set it down in a form in which others can pick it up, or they will make their own messages from it.

And Now I Am Pencil results from a writing group which meets regularly. In the sessions, we cycle and recycle seed phrases, writing together from a seed phrase and then reading our work, using phrases from each writing to seed new writings. While this activity takes place in the presence of one another, using handwriting, the structure could be followed online in a cyberspace. *Pencil* is an example of taking something created individually from within group energy, and working with it as an individual piece. It is the least personal of the examples here, although the writing group at other times has elicited much more personal writings. Though written within an intensely personal context, it was clear *Pencil* was intended for a general audience.

text from the video song
And Now I Am Pencil

And now I am pencil,
tall strong straight yellow careful edges for holding,
sharpened beyond columns to roundness to point.

I wear down easily.
I am lead, I am soft, I use my greyness to see,
I keep my edges moving fresh as they wear down.

Will someone please sharpen me?

I want to be free.
I want to use my red rubber head to rub myself out,
to give up my ghost,
my soft silver edges and crumbs
and what about those shavings in the sharpener?

It depends - the electric one chews me up too soon,
takes too much of me
and I am sorrow;

I bleed shavings,
bleed lead,
bleed the soft smells of graphite burning the tiny wood shavings.

The child's sharpener
sitting in a Mickey Mouse holder
hiding from reality his sharp cutting edge -
hiding behind the little mouse
who has the stupid voice
and has taken over the world.

My friend who was iridescent purple
and blue on the wood was sharpened there.
Afterwards her shavings were glued to paper
they were so beautiful,
and then the child wore her down in shaving;
she never knew the joys of writing marks on paper.

And the green one was chooed by the cat
chewed and chooed
and sent all poked and sore

and lost his rubber
and said OUCH
life hurts so much!
So he hid behind the couch.

He was found and he escaped again.
He fell between the wood and the water bed
and was split in two when lovers lumped
the pencil rubbing the wood until he broke and the lovers laughed.

He wanted to poke the covers
poke the what was that called that squishy thing?
the mattress!
and let the water out.

Quilt Material

I have always been interested in group creativity, and the people with whom I meet have provided many opportunities to explore a variety of creative structures. One such structure is as a highly personal cell within the body of a more impersonal work; in this case the intensely personal statements by each cell member become less personal when one steps back to view the whole. *Kid Quilt* and *Digital Quilt* are examples of this.

Another structure uses a group to create something quickly; in this structure, individual cells are created simultaneously, then joined together into a single work. *Kid Quilt* is an example of this type. In both examples, a quilt provides rich metaphors for structuring group activity.

Kid Quilt is a piece made at a kid's camp over a two day period. The kids ranged in age from 3 to 14. The first day, they painted individual pieces of cloth; the next day they stitched them into patterns while at the same time converting the digitized image of each square into flic files. They had the opportunity to observe their works as painted pigment and as moving light. They had the chance to arrange their pieces into sequences and to tell stories with their pieces; and they had the chance to contribute on an original and personal level to a group whole. They had the opportunity to experience an enormous amount of creative work being finished in a short amount of time, as a result of each person's contribution.

Digital Quilt is not a video song, but a collection of images faxed and mailed by individual contributors. The black and white images are arranged into patterns on a wall. The concept of a digital quilt fits the collaborative potential of computer art: Binary information is the stitching which turns patterns of dark and light into words and images; individual patterns make their unique contribution to the whole. Individual pieces are created and pieced together into one overall pattern. The piece involves a community of creators building according to a theme.

The Digital Quilt was originally a multi-site fax-art event presented during Women's History Month in March of 1993, curated by Byron Grush and myself. A call for entries involved more than 60 participants from as far away as Australia, who submitted images created on the computer or with electronic media of some sort, based on the theme, "Women and Spirituality." We received works by fax, USmail and email. Images were hand-drawn and photocopied, collages pasted or electronically composed, or created entirely on computers. Some images were down-loaded as image files, some were text. The technology generally transcended the wide variety of hardware and software used. The quilt was hung in several sites: Northern Illinois University, De Kalb; Columbia College, Chicago; College of New Rochelle, New York; Grand Valley State College, Grand Rapids, Michigan; Cleveland Institute of Art, Ohio. Each site had curatorial freedom in hanging the images. Since then the quilt was installed in Chicago SIGGRAPH's Brave New Pixels show. This installation appeared this summer at the Northern Illinois University Art Museum Gallery in Chicago, and at the NIU Art Museum Gallery in De Kalb Altgeld Hall this autumn.

This method of collecting group work based on a theme was so satisfying that I am currently preparing to begin another based on the theme, *Time Dreams*. I would appreciate hearing from anyone who wishes to participate.

Whether one uses a computer for creating art on the solitary path, or as a tool within group creation, a personal computer can lead to work as personal as any other medium. Like telling dreams, or talking to a journal, using one's computer is a pathway into revelation. One hopes that in revealing oneself, others will follow that path or connect their own paths with this one. Personal computers provide the means to connect in the most personal ways.

SONG OF THE HELIX

Computer Aided Composition of Genetic Information Derived from the HIV Virus and the Human T-4 Immune Cell

Bryan T. Shuler

I began to assemble the concept for my composition in 1991 with the idea of creating a composition based on the sequence of the DNA chain as it related to some critical aspect of the twentieth century American society. My initial intention was to compose a trilogy based on the DNA "gene-printing" or information used by police authorities in positively identifying criminals, specifically three serial killers in the state of Florida. It was my hope that the pieces, under the same arbitrary interpretation may enlighten the listener as to either the dark side of the sampler or to the similarities in the melodies between all three.

My first contact was Stewart Sheres of the Hillsborough County Public Defenders Office who directed me to Craig Aldridge also of the Public Defenders Office. Aldridge was in charge of cases that involved DNA related evidence for that office. He, however was unable to offer any information other than to recommend that I speak with Christine Fogel of the State Attorney's Office. Ms. Fogel was the in-house expert on DNA identification procedures. Unable to give me any details, she referred me to David Kaufman of the Florida Department of Law Enforcement in Tallahassee. Mr. Kaufman explained that other than the basic DNA-typing of the criminals in specific cases, no other information has been assembled. Most criminals do not go through the typing procedure due to the cost, time, and lack of necessity in their particular case. Above all, he stated, the American Civil Liberties Union has fought to keep all DNA material of criminals restricted. Unlike the fingerprinting process, DNA-typing is still being battled in court as to both accuracy and infringement of privacy. Mr. Kaufman informed me that the concept was very interesting but unfortunately ten years ahead of the information necessary to complete the task. He told me that some states such as Virginia, Kansas, California, Washington, and Minnesota are now in the process of DNA-typing every one of their criminals and assembling a data base using FBI software. Florida now only has one hundred and ninety-two samples.

Unable to obtain any information, I turned to the academic environment to attempt information gathering. Dr. William Blackshear, Vascular Surgeon and Professor for the University of South Florida Medical School recommended that I speak with Boris Kousef, also of the University Medical School. By this time, I decided to use myself, my father, and my daughter as the samples for the DNA and compose a trilogy based on that data. Dr. Kousef informed me that, although I was using this information as a graduate project, the three samples in question were both very time consuming and expensive, approximately eight hundred dollars per sample. I was directed to Johns Hopkins Hospital for further possibilities. I had hoped that I would not have to leave the state for information making this composition regionally exclusive in its nature and composition.

In the fall of 1991, I was engaged in preparing a proposal to the Museum of Science and Industry located in Tampa for organizing and documenting their collection of early acoustic and electronic instruments. My contacts, Wit Ostrenko, Museum Director, and Warren Zager, Director of Collections both informed me that a Dr. Charles Edwards, formerly of the University of South Florida Medical School had discussed with them the possibility of setting DNA information to music. In consideration of the project I had planned, they felt that Edwards and I might turn out to be a perfect research team. Edwards instead referred me to Dr. George Blank of the U.S.F. Bio-Chem Department. Blank explained that his computer could indeed print out the letter equivalents of the specific DNA helix that was available in the computer banks, however, not all gene material had been explored or typed. I suggested that he print out information on each of the five senses and my composition would become a suite based on that information. Much to my disappointment, some of this information had not been researched to date. Dr. Blank explained that his particular interest and research was the HIV and T4 cells in the immune system of the human body and perhaps I could use that information readily available on his computer. I then realized that this information was not only important to the state's future, but the world's as well.

My next step was to interpolate the DNA information into a twelve tone musical expression. I decided to use the procedure that was derived from nature. Each part of the DNA, represented in letters A, C, G, or T, match up only to one other letter. Therefore the pattern is as such; A-T, T-A, C-G, G-C. Since there is never a change in this pairing, the DNA computer bank printout only issues one side of the DNA helix. The other side is assumed.

Another aspect of pairing is the concept of the HIV using another cell as a host for development. The HIV virus invades the host cell and alters the host cell's DNA, causing the host cell to produce replicates of viral RNA. In the case of HIV these replicates bud from the host cell as mature HIV virus, in the process destroying the host cell. (U.S.F. Center for HIV Education and Research) Within two to twelve weeks, antibodies form but it may take from seven to ten years for the victim to be diagnosed with Aids.

Using the pairing concept, I paired up every two letters of the one side of the given helix. For example the first line of the T4-cell would result in this pairing:

CA, AG, CC, CA, GA, GC, CC, TG, CC, AT, TT, CT, GT, GG, GC, TC, AG, GT, CC, CT, AC, TG, CT, CA, GC.

I then had to create a conversion system that would translate these pairings into musical equivalents. I therefore wrote down all of the possible pairings and found the number totalling sixteen. Since there are only twelve tones in the Western scale and I did not want to create a sixteen tone scale for this composition, I had to eliminate four of the possible pairings from the list. This was done by giving those letters that matched up to themselves a separate function. The function entailed retrograde where all pairs that followed a double-letter pair would be read from the second letter to the first. For example, AT or CG would be read TA and GC respectively. This pattern of retrograde would continue until another double-letter pair would appear in the pairings and the pairs would then go back to the prime order; first letter, then second. Of course, if two double-letter pairs (signified by X in the transposition examples) appeared side by side, the retrograde function would cancel itself, or in the case of more than two double-letter the cancellation process would continue to the last double-letter pair and then all subsequent pairs would follow the last double-letter pairs direction. As for the other twelve, the translation was created as follows;

T-A = C; T-C = C#; T-G = D; A-C = D#; A-G = E; A-T= F; C-G= F#; C-T = G; C-A = G#; G-T = A; G-A = Bb; G-C = B.

Again, T-T, A-A, C-C, and G-G are all double-letter pairs signified as X and decide the direction that the other pairs are to be read.

Therefore the above line of pairings would be interpreted as follows;

G#, E, X, D#, E, F#, X, D, X, C, X, G, A, X, F#, G, Bb, D, X, G, D#, D, G, G#, B.

This process continues through out the entire seventeen hundred letters of the DNA helix of the T4-cell creating the melody. The same process was used in the creation of the HIV melody.

After all of the information was translated, I then entered it into the computer using the Professional Performer software program by Mark of the Unicorn for Apple systems by means of an Ensoniq EPS digital sampler midi'd by a Mark of the Unicorn Midi Time Piece. Each voice is then laid down on an eight track tape machine by the SMPTE method and the final product is mastered on a Digital Audio Tape.

The composition begins with the HIV melody performed using a sample called "Celestial Voices" accompanied by a sample of lower strings. There have been no changes in either the HIV melody or the T4-cell melody later to come. Based upon the terrain of the melody, I arbitrarily chose the durations of the individual notes attempting to enhance the melody line. The lower strings are merely functional or non-functional harmonizations.

The T4-cells, voiced by a sample referred to as "Moonlight", enter at a quarter note value, speeding up to eighth notes and finally accelerating to sixteenth notes. This along with the sample known as "Chase Loop" create a spiraling effect much like the shape of the double helix of the DNA. I have repeated both the HIV and the T4-cell melodies once, but have allowed the composition to end itself by not altering the order in which the voices stop.

This piece follows my typical compositional style of expressing numerology based on information from extra-musical sources. In "Tele Funk 'n Fugue", 1990, I used one hundred and twenty three phone numbers chosen by chance to be the source for the composition. In "13 Monkey", 1991, I used the cyclical patterns of the ancient Mesoamerican calendar as the basis for a thirteen, an eighteen, and two twenty tone rows. This forty-seven minute composition also used retrograde, inversion, retrograde-inversion, and chromatic treatment of the tone rows. In 1992, my composition, "Akwasadai", written for the Ghana Dance Ensemble was based on the numerology of the Ghanaian Festival Calendar.

These experiments in composition not only exemplify the success of interdisciplinary work, but also indicate the ability to express concepts through alternative mediums, in this case music, with the aid of the personal computer. This piece specifically has demonstrated the impact that computer-aided creations can have on the international community through its performances and world-wide media coverage.

This composition is dedicated to Danny Hernandez, Henry Parrish, and Randy Warren whose artistry awed me, whose dedication inspired me, whose friendship supported me, and whose passing angers me.

Real-Time Methodology for 2-D Rendering of 3-D objects of Vastly Different Scale

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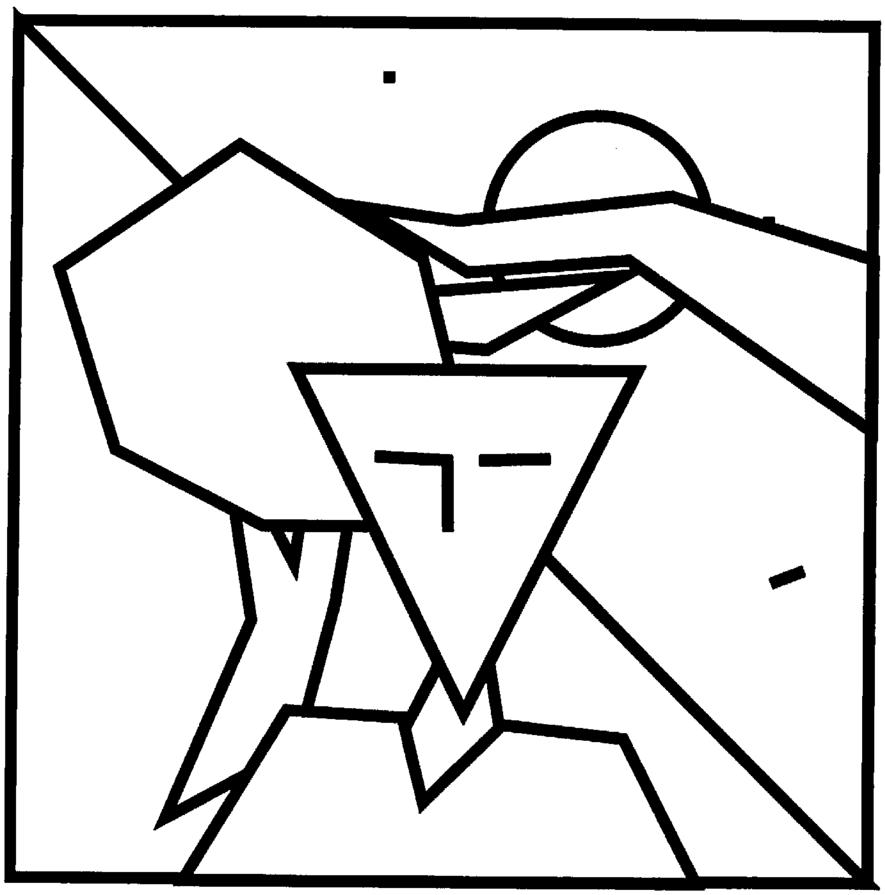


abstract:

This paper introduces proceedures and information structures appropriate for digital computers equipped with real-time two dimensional graphic displays. The goal of this methodology is to provide a real-time 2-D display of 3-D objects that is capable of representing objects of vastly different scale simultaneously. This methodology is oriented toward 3-D simulation and animation, although it should be suitable for object composition (sculpture) and interactive abstract data representation. It is assumed that the reader is familiar with basic euclidean geometry and digital computer programming.

Visualization: a "Perspective"

The relatively recent advances in technology have enabled us to reveal aspects of the universe around us that would be impossible for an individual to see without mechanical assistance. The visualization of subatomic particles along with the distribution of galaxies within the same universe is a testament to our ability to visualize the relationships of objects of vastly different scales.

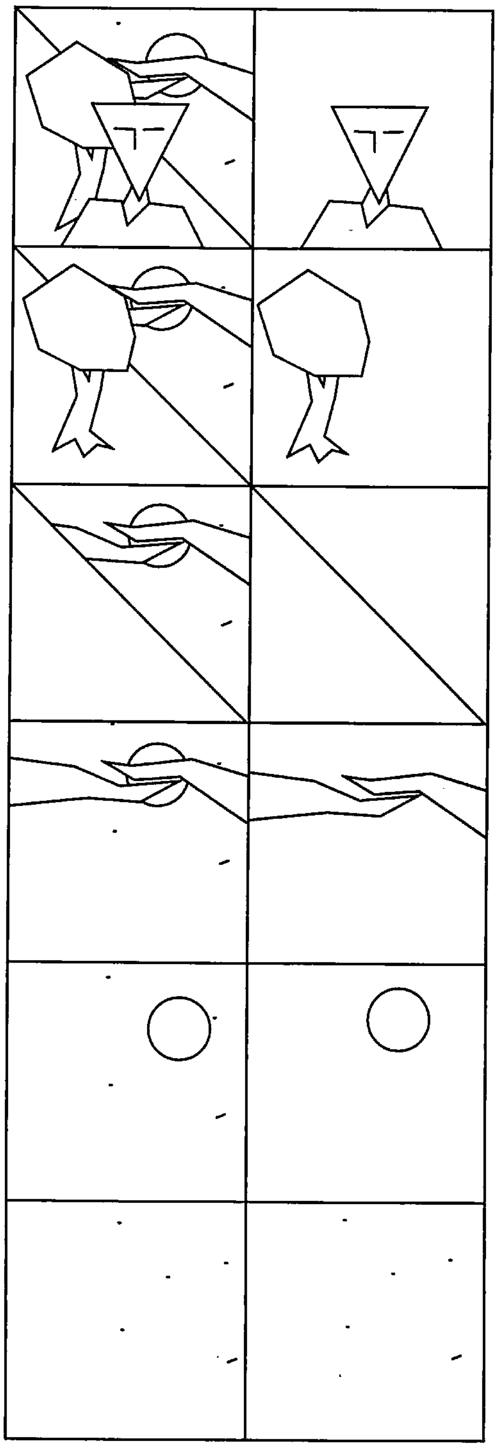


Figure 1

Photography and more recently videography have made it possible for us to easily capture images of the universe in it's multitude manifestations of scale. An extreme example of this would be a close-up photograph of a person's face behind which trees, mountains, clouds, the moon, and stars are visible in successively more distant areas of the background. Another good example would be a NASA video showing a astronaut looking out the window of a space shuttle through which another more distant astronaut is space walking with the shuttle hull and the immensity of a planetary atmosphere stretching out in the background.

The mathmatics of scale, namely geometry and specifically perspective, have been studied steadily now for almost a millennia. Although even older art with perspective has appeared several times in human history, it was not until the instictive exploration of illusionist painting by Giotto (1267-1337), as shown by his fresco *Herods's Feast* (1320), that perspective started to grow into the feild that it is today. The formalization of perspective as a pictorial system occurred in the early 15th century with the "peep show" experiments of Brunelleschi (1377-1446) and the treatise *On Painting* by Alberti (1404-1472). Some works that illustrate the development of perspective as a pictorial system include: the fresco *Trinity* (1429) by Masaccio (1401-1428), the painting *The Flagellation* (1460) by Piero della Francesco (1415/20-1492) and the painting *Lamentation Over the Dead Christ* (1480) by Andrea Mantegna (1431-1506).

Perspective as a pictorial system in painting was transformed into a quasi-genre by the advent of photogrphy in the19th century. With artists freed somewhat from the duties of portraiture and landscaping, perspective lost its importance in art as is indicated by the character of painting with expressionism, and slowly maturing modernism. However, geometry and perspective since photography have remained important in contemporary feilds such as engineering, science, and cartography.

The development of the digital computer has opened another chapter in the role perspective and geometry can play for the visual arts and sciences. Its ability to speed through mathematical operations which originally required tedious manual labor allows the geometry of perspective to be applied to the generation of visual imagery in ways that were hopelessly impractical until now. In part out ability to fathom the vast and the microscopic has been aided by this rapidity of calculation.

Scale in the Universe

The 2-D rendering of 3-D object methodology to follow is designed primarily to accommodate objects of vastly different scale and preserve object detail appropriate at different scales. Additionally, a metaphor for representing object data for use by a digital computer is introduced that allows expansion of scale by relying on modest integer numbers and recursion instead of resorting to massive floating point numbers which often require special hardware/software.

The scale of 3-D objects depicted in a 2-D picture can be organized into a finite set of layers of successively greater scale. Each layer has a coordinate system appropriate to its scale.

Computer programs employing 2-D z-buffering and the painter's algorithm techniques can apply the layers of scale discussed above. This method of rendering is conceptually not unlike painting with opaque pigments such as oil or acrylic. A computer program in this case would render the layer of the greatest scale into a 2-D graphic area. Then each each additional layer in decreasing magnitude of scale is rendered into the same graphic area. Successive renders are made in such a manner that if a layer rendering leaves a portion of the graphic area untouched, the area not rendered to will retain the preceding layer's rendering.

To illustrate this, lets consider the case of Figure 1 depicting a close-up of a face behind which are trees, mountains, clouds, a moon, and stars. The panels in Figure 1 depict the objects of different scale that when overlaid (layer of least scale in the foreground; face, layer of greatest scale in the background; the stars) form the image in the top left panel of Figure 1.

For ray-tracing programs the layer rendering order would be reversed. As a ray is fired from view point, collisions with surfaces belonging to the layer of least significant scale are checked for first. If the least significant layer offers no collisions the next significant layer is checked. This continues until the ray fired collides or all layers have been traversed and the ray is assigned background color. It is interesting to note that since ray collisions often cause another ray to fire from the collision site in a new direction, the layer checking must begin from the least significant layer again, but using a new view point. Additionally, the results of a layer of greater scale reflecting a layer of lesser scale are negligible. Since ray-tracing is computationally expensive (especially if a scene has many reflections, light sources, and radiosity calculated) subsequent references in this paper to rendering will be concerned with the prior rendering technique employing z-buffering and the painter's algorthym.

Using the method of successive rendering and overlaying above it is possible to accommodate images containing objects of vastly different scales. Theoretically one could arrange a universe to render that contained layers of scale arranged from the scale of galaxies down to the scale of sub-atomic particles and be able to represent both object galaxies and sub-atomic particles simultaneously.

Object Manifestions of Scale

It is important to have a representation for object data that takes into account the dynamic nature of objects and view points and allows objects of vastly different scale. Objects in a universe can move and have their attributes modified. In a system in which 3-D objects are viewed from a particular view point, the view point can change.

$$\text{Apparent Object Size} = \frac{\text{Object Size X focal length}}{\text{Distance}}$$

The basic rule of perspective is that the apparent size of an object from a given view point is inversely proportional to the distance between the object and the point of view and proportional to the focal length (telephoto, fish eye, ...) of the viewing model. As an object gets closer to the point of view, the object appears larger and the composition of the object becomes more apparent. The further away an objects gets from the point of view, the smaller an object appears and its composition approaches that of a dot, and if sufficiently far away it becomes invisible.

With the above in mind, it should be possible to design a representation of object data that can make available different amounts of data depending on the apparent size of an object. When an object's apparent size is slightly more than a dot in a field of view, only a reduced form of object data is necessary to render the object accurately. An object with an apparent size that occupies the entire field of view may require an expanded form of object data. An object with an apparent size so large that it exceeds the field of view may be scaled too large to be rendered, in which case an addition level of smaller scale detail would supply necessary detail to accurately portray the object. Therefore it is necessary to design an representation of object data that allows multiple levels of of scale.

Object Data Structures

Object Structure
- size
- XYZ position
- XYZ attitude
- Apparent Shape Data->Apparent Shape Structure (linked list)
- Prime Child->Object Structure
- Additional Children->Child Object structure (linked list)
- optional fields

Apparent Shape Structure
- % field of view
- Shape Data->Shape Primitives (dots, lines , polygons, ...)

Child Object Structure
- XYZ position offset
- Child Object->Object Structure

At the greatest scale in a modeled universe an Object Structure exists for each object. The object structure contains the general size of the object, position, attitude (rotation), pointer to linked list of apparent shape data (empty/invisible or grouped from most reduced to most expanded), pointer to a prime child object, pointer to linked list of additional children objects, and optionally additional fields for custom applications. The amount of detail to render can be scaled by choosing an apparent shape structure according to the calculated apparent size of an object. In this manner an object that has the apparent size of a dot can be rendered with the most reduced shape data while an object that fills the entire field of view can be rendered with the most exhaustive shape data in the shape data table.
The Prime Child object is used to extended the precision of the position and attitude values and to supply additional lesser scale shape data if appropriate. A Prime Child object can point to another Prime Child Object down to the least significant layer of scale in a universe. This allows precise position

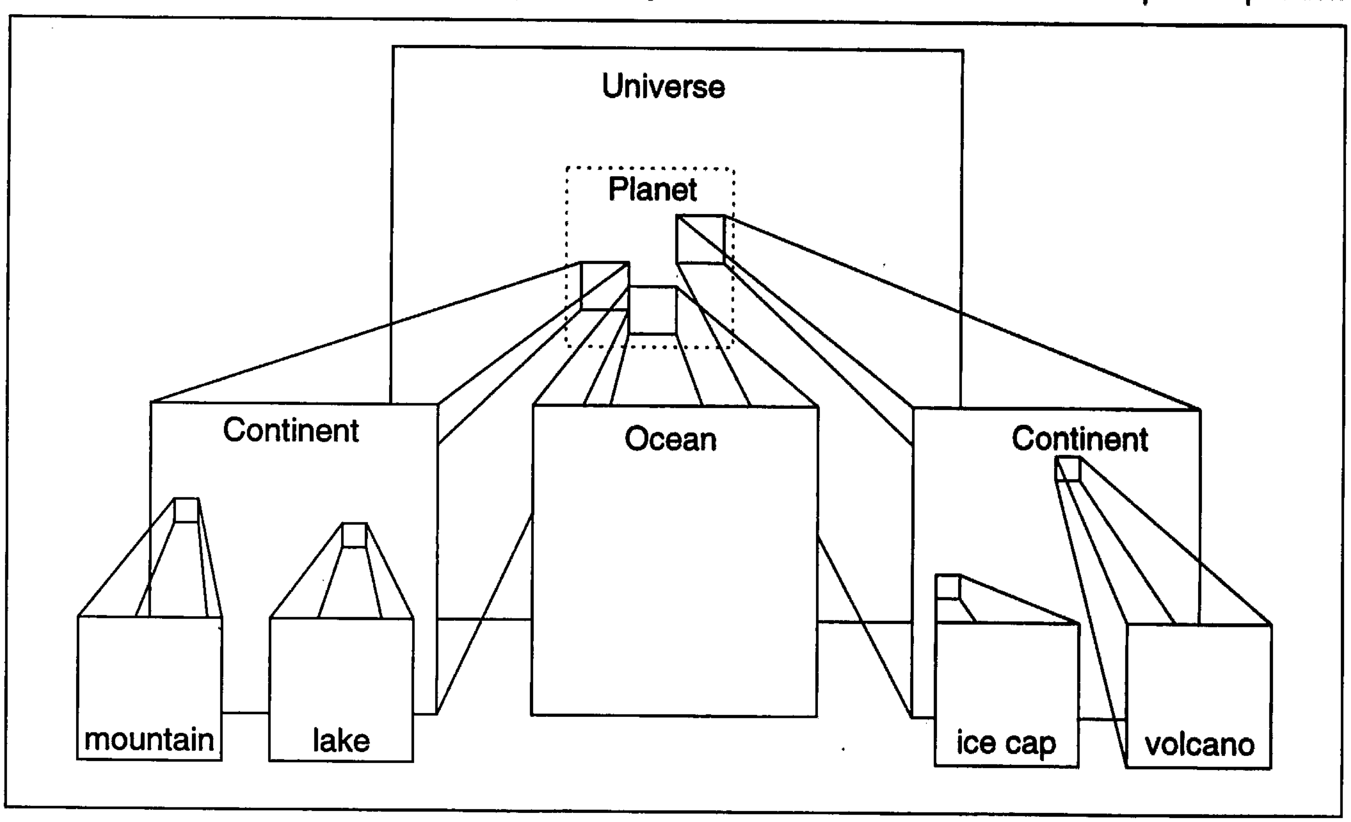


Figure 2

and attitude of the original parent object down to the resolution of the least significant layer of scale in the modeled universe. Precise positioning is useful for smooth motion of children of vast objects. Precise attitude can be very important for vast objects because a slight attitude change can potentially cover a great deal of distance at the least significant scale of the universe.

Vast Objects Rendering Algorithm
(for use with painter's algorithm)

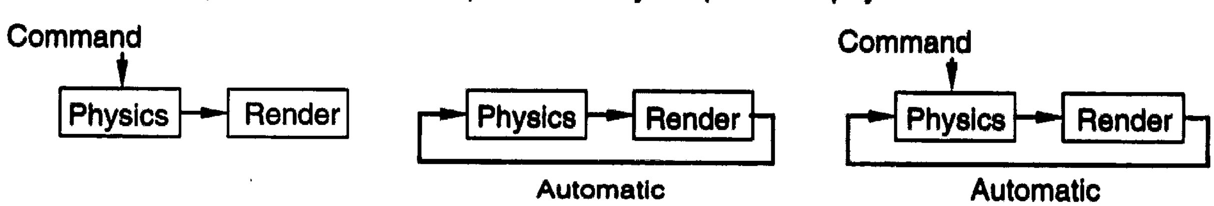
- Enter Most Significant Scale
- Initialize canvas to background color
- Initialize Current Scale Object Queue to contain all parent objects
- LOOP
  - Initialize, Next Scale Object Queue = empty
  - LOOP
    - initialize z-buffer
    - Translate object by view matrix
    - Object within scale coordinate space? (NO, exit LOOP)
    - Object to fore? (Object to back, exit LOOP)
    - Apply perspective to object origin, size
    - Object visible? (NO exit LOOP)
    - Render object to canvas
    - Object has Children? (NO exit LOOP)
    - Queue object Children into Next Scale Object Queue
  - UNTIL last object
  - Current Scale Object Queue = Next Scale Object Queue
  - Enter Next Lower Scale
- UNTIL Current Scale Object Queue = empty

Additional Children objects allow specific areas of a vast object to be resolved in detail at the next lower scale in the universe. A position offset (using the units of the parent's coordinate system) is supplied to specify the region of the parent object to clarify. Additional Children can reference Additional Children down to the least significant layer of scale in the universe. This referencing of objects of greater scale to objects of of a lesser scale can form object hierarchies of scale as many levels deep as there are scale levels modeled in a given universe. Figure 2 shows an example hierarchy of scale for a planet object in a universe with 3 levels of scale.

The Vast Objects Rendering Algorithm can be used with the vast object structures just discussed to determe which objects to render when employing z-buffering and the painter's algorithm. Using this algorithm, a scene like that shown in Figure 1 earlier in this paper can be generated.

Physics of Scale

To model a universe dynamically, the objects contained in it must be allowed to interact with each other over time. The manner in which objects are manipulated (position, attitude, color, shape, ...) and their state of existence (creation, elimination) is defined by the particular physics of the universe.



Physics can be applied in two ways to a universe. For static abstract data displays or 3-D object editors, a user issues a command which causes the physics of the command to be applied to one or more objects in the universe followed by a render. This application of physics could be called 'command' physics. An example of command physics would be a 3-D object editor receiving a command from a mouse activated menu command to rotate the currently viewed object. A user in this case could be looking at an object using a 3-D object editor which has a particular 2-D rendering displayed, the user could command the editor to rotate the object by some amount and and it would perform the physics of the rotation on to the object then render the display to show the object in a rotated state. At this point no more rendering or physics are applied until the user issues another command.

For applications such as real-time 3-D simulators, a continuous cycle is set up that applies physics to the universe. This cycle performs predefined physical rules on every object in the universe, then renders the universe, and repeats. Physics applied in this way could be called 'automatic' physics. A good example of automatic physics is a star-field simulator. In this case a viewer sees stars appear and whisk off the screen without issuing a single command.

An interactive 3-D simulator would combine automatic physics with command physics. A flight simulator is the classic example of this combined physics. Without any commands, the view of landscape outside the airplane passes by. However, the user can tell the plane to turn, or dive and the view outside the plane will change according to the command given and continue to show the landscape passing by.

For physics to be applied to objects in a universe, the data representation of the objects often requires special fields to accommodate such physics. For example, each object may be required to have a mass value for the physics of gravity to work. The rules of physics do not have to adhere to classical physics either. Artificial physics in which objects are given additional value like good or evil, sexy or ugly, friendly or hostile can also be used.

Prototypes and Epilogue

A preliminary implementation of the methodology discussed in this paper is being written for the Amiga family of computers, with the Macintosh family being considered as an additional platform in the future.

The original reason that I started to embark on this 3-D methodology occurred when I was studying Electronic and Computer Music at Indiana University. The lack of any meaningful visual feedback during electronic musical performances, especially those using the MIDI protocol, led me to study ways to make the computer respond visually to the MIDI messages that were otherwise invisible during performance. Methods of representing virtual electronic instruments as abstract 3-D objects eventually caught my fancy and ever since I've honing my 3-D rendering skills and understanding.

Glossary

Z-Buffer - An array of depth values corresponding to every pixel in 2-D graphic display.

Painter's Algorithm - Method of rendering a 2-D scene in which the depths of already drawn objects are checked to insure that only the visible portions of subsequent objects are drawn.

Ray-Tracing - Method of rendering a 2-D scene in which the light of every pixel that makes up a graphic display is determined by firing a ray from the view point through pixel and detecting what object collisions occur.

Suggested Reading

Interactive Computer Graphics - Electrical Engineering - Lecture Notes, D.C. Anderson, 1986 Purdue University

Art, a History of Painting, Sculpture, Architecture - Frederick Hartt - 1976 Prentice-Hall

Eyewitness Art, Perspective - Alison Cole - 1992 Dorling Kindersley

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UBIQUITIOUS COMPUTING AND THE NEW RENAISSANCE

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Art and the Zeitgeist
Art is intimately linked to the Zeitgeist, which today is increasingly defined by digital technologies. Art cannot be isolated from this technology but must embrace it and offer perspective to, as well as expression of, this digital milieu.

Ubiquity:
Today we know that the typical computer looks essentially like a box with a monitor resting on top, a keyboard and perhaps a mouse or tablet attached. This characteristic architecture is only the beginning of what will eventually become a varied panoply of inventive manifestations. The trend may lead in the direction of the devices becoming more function oriented. One such example would be a digital drawing table with interactive display and controls that emulate traditional media. It would have the large flat surface of a typical drawing table yet engage all the control and power of page layout, drawing, text entry and photographic image processing that are now abstractly controlled by conventional computers.

Ubiquity will mean that our day to day environment will be filled with inexpensive devices that although actually computers, will not be thought of as some special device. Similar to the way electronic calculators or telephones are nothing special to us, cameras, drawing tablets, communication devices and reading surfaces will be digital in nature. We will accept them as any other "natural" material that surrounds us. As perhaps the polar opposite of virtual reality, a system that must utilize complex and expensive hardware, "ubiquitous computing," as Dr. Mark Weiser, Director of Xerox PARC has termed it, will pervade our working and living environments with what will seem very ordinary but highly functional devices. The highly imperfect but ground breaking Newton technology from Apple Computer is one such example that will become as commonplace as the daytimer notebook.

Communication / Arts / Future
The future will harbor potential new realms for creative expression that will engage the emerging "data superhighways," permitting artists to

structure pieces that are dynamic in character, that alter over time and will range from text, to sound, motion and three dimensional display. This meta-medium will have interactive structures that will give the viewer/participant choice over what they desire to experience, and whether or not the piece will involve personal interaction. It will be possible to create an interest profile of oneself and have a database do routine searches for pieces that relate to the profile. In this manner, an individual interested in ancient musical instruments could be informed about individuals who restore or build such instruments, and who has or will be performing appropriate works. It will also be possible to gather samples of a performance to preview a work, and then either purchase a ticket, order a disc or perhaps even download the complete digital work.

New Renaissance:
What this portends for the arts is nothing less than a renaissance of relevance and participation. Since the medium is visual and aural in its most basic form, experience vendors will of necessity be sophisticated in the basics of visual communications. This certainly does not guarantee that what is provided will be good, but it should influence greater awareness of how important intelligent design and art can be when coupled with the presentation of information. Commercial television has certainly recognized this importance as evidenced by the enormous concentration of talent that has been devoted to production of sophisticated commercials. When set against the vision of this super network of the future, it is clear that there is more than enough work for generations of artists and designers.

It is clear that what is coming is a process of evolution in art that has been underway since western art lost its secure linkage with religion. Art has reflected upon and informed the shifting values of culture in ways that have brought it closer to the mainstream of life though at times it has seemed desperately alienated. Each vibration of change in art has signaled redefinition of its role, its outward appearance and the manner by which it addresses meaning. We can grasp, cherish and delight in past forms, but each developed form eludes recapitulation. An idea once formed and fully realized is no longer able to be more than a foundation for what follows. It cannot be revived but it must be understood as forming the basis for all that follows.

In the immediate future there is an unprecedented role for the arts that signals a renaissance that should by any measure be as important as the Renaissance. Through the nature of the new media that are emerging is a

future in which the artist will be intimately woven into the fabric of their time rather than being alienated from it. This may signal for some an uncomfortable shift from the detached and ennobled position traditionally relegated to the arts, into a mainstream role in our culture. Indeed, what may emerge as new art forms may not resemble our current conceptions of the art object. Experiential forms have been under development for a number of years that utilize computer networks through which groups of individual audience/artists collaborate and build a work. Increasingly we must relize that this is a time that requires fresh expressive solutions and invention. Comfortable paradigms of the past will not suffice as we confront
a New Renaissance of the arts.

Art for Technology's Sake

Tim Anderson
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Cambridge, MA

One of the characters pictured in the photo is Van Gogo, Robot Artist. It paints with a brush suspended by Kevlar threads. It dips the brush into a row of paint containers. It is controlled by a program in the MAX graphical language visible on the Macintosh screen. The program has controls (knobs) that control parameters of the probabilistic "Fake Creativity" painting process.

It is 12 feet high and wide. It can paint scenes presented to its video camera or abstract painting generated from scratch (with enough scratch you can do anything). The program simultaneously composes music with probability characters "stolen" from a Midi sequence. The other freak is Tim Anderson, Cambridge, Mass. He can be reached by email at robot@mit.edu.