PROCEEDINGS

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THE SCAN STORY

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

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

Today SCAN is an organization which provides information for those interested in using computers and related technology in the arts. This includes music composition, music synthesis, music performance, graphics design, animation, video, textile design, sculpture, dance, writing, and other aspects of the arts. SCAN performs its services partly by means of a 100-page resource guide to the field published twice a year entitled Small Computers in the Arts News. Current subscribers are located across the country, in Canada, and in several European countries. In addition, the annual Symposium on Small Computers in the Arts is organized by SCAN and provides a forum for those working in the field to present new works, developments, and techniques. Courses and workshops are offered at both beginning and advanced levels. Demonstrations, film and video shows, a computer art gallery, and the computer music concert are also part of the Symposium.

An important service which SCAN performs is to provide information for educators who have been charged with setting up computer-based music or graphics programs in their respective schools and institutions. Approximately half of our Symposium attendees and newsletter subscribers are connected with educational institutions. A speakers and consultants bureau has recently been established by SCAN to connect those who have experience in the field to those who need it.

SCAN has operated for the past nine years as a volunteer organization with a minimal budget and has been entirely self-supporting. We have recently obtained some support from the Pennsylvania Council on the Arts for a much needed part time staffer. We currently have a mailing list and data base of over 1800 people across the country and internationally interested in this field.

INTRODUCTION

In past years we've gone through all the papers, and organized them according to their **"look and feel"**. This year we had so many papers I gave up this approach. What you will find is a straight alphabetical split into three major divisions: **Music, Graphics,** and **Multi-media.** As usually, even these boundaries are grey.

Are we all feeling the ripples of the mass market success of the **Apple Macintosh**? Suddenly people in every office, lab and art shop are telling themselves: "There is something to this 'computer graphics', 'computer software', 'computer environment' mentality after all... "

Until now, the sense was: "It's fascinating on TV or in the arcade, **but what can I do with it?**" Now almost anyone has the chance to find out with low-cost 68000-based and PC platforms available starting at around $1000.

Mass market and custom software packages are being created out there on this new plateau. Many of us are software engineers, "soft" scientists investigating, cataloguing, and building within **ready-made hardware environments**...

Eventually, as software becomes standardized and customizable enough (so that we are not **forced to rebuild our tools** from scratch) we can start to focus on output, the results of the electronic process.

And if the product happens to be clip-art, a 3-d architectural database, or brain scan cross-sections (several examples), it is not a static art object at all but indeed **a third level of tool**...

With hardware and software advances integrating innovative digital artists into the **real world** in this way, what roles will we choose to play? What roles do we want to play? Don't be unimaginative now!

The current situation in graphics has been already encountered by the electronic musician, who over the past ten years has seen the entire music industry standardize on "avantgarde" electronic conventions.

Does our new technology provide new solutions for video, photo-retouching, sculpture, live musical performance, print-making, etc? Read on, throughout this **Proceedings** you can find both answers and questions.

This **Electronic Media** will continue to grow year to year with the work of increasing numbers of interested souls.

Mark W. Scott

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MULTI-MEDIA

Research Report: Aesthetic Issues in Electronic Media

Dr. Bill Kolomyjec

Northern Illinois University

Abstract

A questionnaire was sent to individuals active in Electronic Media education and related production fields. The returned questionnaires provide a summary statement of prevailing attitudes as well as a means from which to begin to identify aesthetic issues in Electronic Media.

Introduction

To preface this report, as was done with the survey materials, two operational definitions of "electronic media" are given. These definitions serve provide a basis for common understanding (this is what I want to talk about) and, to externalize my personal comprehension of electronic media (this is what I mean.)

1) Electronic Media is a generic term for the use of high technology tools in the creation and synthesis of computer graphics, video and audio in both design and fine art.

2) Electronic Media is characteristically multidimensional embodying two, three and four dimensions and, multisensory; often accompanied by sound or music.

In essence, electronic media involves processing imagery and sound as data in either analog or digital form. The tools often used are said to be "highly technological" in nature, specifically, hardware and software related to computer graphics, video and digital image processing and electronically generated audio. To help understand or generalize this, you could use the following as a "qualifier:" If at some point in the creative process a work existed as encoded electrical impulses on magnetic tape or diskette, then that work could be classified as electronic media.

I consider myself to be an electronic media artist as well as an art educator at the post secondary level. I use electronic media for individual expression and I teach it to others. I considered the research project I am about to report to you as an opportunity to take both a global view of the subject and to formalize my thinking in this area.

The Research Project

Last year (Spring 1987) I proposed a research project to the Northern Illinois University Graduate School that would have enabled me to gather information from a group of experts that were to have assembled at Northern Illinois University as conference speakers and workshop leaders for the Second Annual Symposium on Small Computers in the Arts and Media. The conference was scheduled to be held at the NIU campus in DeKalb in July, 1987. However, after much preparatory work (and a mailing of 1500 brochures) the conference had to be cancelled due to a lack of preenrollment.

Cancelling the conference significantly affected my original research proposal. To retain the grant I was allowed to submit an amended proposal. In the amended proposal I suggested two major changes: 1) to expand the pool of respondents to not only scheduled participants but other experts as well. And 2) to modify my interview outline into a formal questionnaire or survey instrument. The latter change would enable me to gather data through the mail rather than by way of interview directly from the subjects. The amended proposal was approved.

I prepared a questionnaire and sent it to 25 prospective respondents. This mailing consisted of the 15 of the originally scheduled speakers and workshop leaders plus 10 other experts. I would like to note that this sample may seem rather small but in terms of electronic media experts I feel it would have represented a significant sample.

The Questionnaire

The major intent of this research effort was to identify relevant issues. The strategy to accomplish this task was to formulate appropriate questions and present these questions to experts whose responses might illuminate those issues. As the investigator I decided there were several areas of inquiry in which I would direct questions to those people whom I regarded as expert. These were: 1) Background and Qualifications of the Expert. 2) The opinions of the expert concerning Electronic Media Procedures and Processes. 3) The expert's opinions concerning Aesthetic Issues. And, 4) The experts' ability to identify researchable issues.

My questionnaire consisted of twelve "open-ended" items. The outline below shows the specific context area I formulated my questions to address.

Respondents Background and Qualifications

1. State your professional qualifications and your relevant background in electronic media.
2. Identify factors relating to your initial involvement in electronic media.
3. Identify roles the technology plays for you and vice versa.
4. State your level of involvement (user or maker of tools.)

Opinions about Procedures and Processes

5a. As an artist, what is your state of mind going into a project? Identify the unique aspects of your work.
5b. As an educator, do you have formal educational goals & objectives? Identify the major one(s.)
6. What aspects of electronic media do you work with and do you seek to combine aspects?
7. What's in store for you (and/or the medium) in the future?

Opinions about Aesthetic Issues

8. By what aesthetic criteria should electronic media works be judged?
9. How has electronic media challenged "well-defined" meanings in aesthetics (Example, the notion of art as artifact.)
10. What is the significance process to product and why?
11. Identify the 3 most important aesthetic opinions.

Opinions about Researchable issues

12. Identify areas in electronic media that would justify funding or formal investigation?

Comments on the questionnaire

Feedback I received was that these twelve open-ended questions did tax the respondents' patience. The questions I asked were originally designed as an outline for a face-to-face interview and, I did not modify them enough for a mailed survey instrument. If I had it to do over again I would develop a different instrument that would not take so long to complete. I feel that length attributed to only a moderate number of returned questionnaires, namely, 10 of 25 or 40%. Furthermore, that number was probably high because over the years I have met most of the respondents and they tolerated the survey instrument as a favor to me. Yet, as incentive I promised to share my summary information with each respondent. Perhaps this appeal to curiosity was a motivating factor for completing the questionnaire. As promised, each respondent was sent a copy of the final report as submitted to the NIU graduate school.

Findings

The respondents are geographically diverse: Two from the East, six from the Midwest, one from the South, and one from the West. Eight males and two females responded. The List of Respondents is given at the end of this report with their permission.

Summary of questions regarding respondents background and qualifications.

All respondents are involved in electronic media education at the postsecondary level; seven of the ten individuals who returned the questionnaire are to some degree practicing electronic media artists. All became involved in electronic media as the result of a fascination for technological gadgetry and its output be it either imagery, sound or both. All respondents qualified themselves as users; three of the ten possessed a level of expertise that classifies them as makers of electronic media tools. There was a consensus among the respondents that the role of electronic media devices, small computers in particular, was to serve as intelligent tools. One respondent implied that his role was to command those who knew how to use the tools, a managerial attitude. He implied that there is more to electronic media education and electronic media aesthetics than simply teaching or learning technique.

Summary of questions regarding opinions about procedures and processes.

All but one respondent stated they had well-defined educational goals and objectives in mind prior to instructing their students. When asked to respond as artists, seven of the ten replied. For most traditional artists the process of creating the work is often more interesting than the product; electronic media artists are no exception. Electronic media processes, such as writing algorithms or working with tools that have a scientific and technological nature frequently leads to works with new looks or to new aesthetic experiences. Most respondents stated that they began their artistry with either a specific task in mind or a general intent but almost always the interaction with the medium itself played a significant role in the process. An individual can always use electronic media as a more traditional tool to solve specific design problems, but it was implied from the respondents that, in practice, working with electronic media tends to provided more avenues for exploration which in turn may lead to more creative solutions.

Nine out of ten respondents were interested in more than one aspect of electronic media and they often seek to combine these aspects in a variety of ways to achieve media synthesis. This implies the recognition of electronic media by its practitioners as a multisensory experience. One respondent felt that it was most interesting not to necessarily achieve a greater end (synthesis) but rather a different end; something never achieved before with any other medium or combination of media. Many respondents felt that the integration of electronic media was inevitable, since both imagery and sound are capable of being digitized and, many advances are being made in the processing and transmission of these kind of data. One respondent stated: advances in electronic media have happened for all the wrong reasons, such as MTV... but other technologies and standards such as MIDI (Music Instrument Device Interface) and SMPTE (time code) are practical and facilitate linking various media forms together.

Summary of questions regarding opinions about aesthetic issues.

Many respondents felt that aesthetic criteria should be general enough to include electronic media, but to judge imagery and sound produced by electronic media in the same way as more traditional forms is an error. In addition to intent, one must consider whether the artist developed the tool. One respondent pointed out that electronic media has obstacles to overcome because it has been exploited by commercial endeavor and abused by "The Media." A consensus was that electronic media is still in its formative stage and important issues (and works) will be sorted out in time.

All respondents had some opinion concerning electronic media with regard to perceived traditional notions in aesthetics. Typical comments include: it makes art more public (through broadcast), more interactive (in exhibition spaces) and puts less emphasis on the artifact. One respondent observed electronic media to be just another manifestation of the post-modernist spirit and that it is erasing existing boundaries within and between aesthetic disciplines. Another respondent stated that the honeymoon for electronic media is at an end: we are past the stage where getting computers to do anything at all significant is over. The implication for the producers of electronic media is that novelty is waning and the imagery and sound works that electronic media makers generate must stand on their own artistic merit.

The respondents identified the following areas that, in their opinion, they consider to be important aesthetic issues in electronic media:

1. To investigate what qualities of electronic media suggest new ideas and formal structures independent of pre-existing forms.
2. To explore the concepts that seem directly related to electronic media: especially, interactivity, time art and "narrative media."
3. To examine the issues of talent, integrity and depth as they relate to electronic media.
4. To determine the differences between glitz and aesthetics.
5. To deepen understanding of artistic control over intelligent devices.
6. To examine the relationship between algorithms and aesthetics.
7. To explore the hyperrealism issue; how close can electronic media get to realism.
8. To investigate creativity using EM; how to get through the technology of the medium to evoke or facilitate creativity.
9. To identify how electronic media affects the quality of life.
10. To investigate ways of using electronic media to redirect the focus from making products to the aesthetic experience.
11. To investigate ways of using electronic media to deepen human understanding and self-expression.
12. To explore new applications and new directions, such as metaprogramming and artificial intelligence.

Summary regarding the question about researchable issues.

The respondents identified the following areas that would, in their opinion, justify formal investigation involving electronic media. As another list these are:

1. Electronic media in scientific visualization.
2. Electronic media in visualization aspects of artificial intelligence.
3. Research in electronic sequential imagery for visual communication.
4. Storage and retrieval of visual data and image preservation.
5. Local, national and global communication networks

(electronic forums or bulletin boards) for presentation of ideas, works and the exchange of information between electronic media artists

6. Artist-in-resident programs in existing electronic media studios and research facilities
7. Relationships between new technologies in the arts such as videodisc and CD ROM
8. Artistic interfaces and interactive installations
9. Electronic media as it relates to quality of life issues.
10. International compendium for new tools for artists.
11. Catch-up programs for established artists.
12. The creation of databases and forums to gather and exchange information regarding:
    a) case studies of the most effective computer laboratories and studios.
    b) sources for the identification of foundation support and funding agency activity in this area.
    c) something similar to a consumer's report group that would produce unbiased evaluation of hardware and software.
    d) catalogs of reliable equipment vendors.
    e) electronic media clearing-houses (for slide, video, floppy disk, audio tape) which would pay royalties to artists.
    f) support in the way of funding for artists working in the area.
13. Lastly, to work creatively with the medium is in itself research. To investigate and engage in electronic media production efforts significantly broaden the knowledge base.

Conclusion

I can give no statistical measure of the significance of my research and I agree it lacks quasi- experimental fortitude. In fact, this was not my aim. I feel that the real significance of this research is that it provides some information as to what questions we ought to be asking and in which directions we ought to investigate further.

I am grateful to the NIU graduate school for supporting my "formal" investigation into aesthetic issues in electronic media. I am grateful to the responding experts. They and others like them are at the forefront of an emerging discipline and with their help we are beginning to understand the nature of electronic media.

List of Respondents

Donna Cox/ Assistant Professor/ School of Art and Design/ University of Illinois at Urbana-Champaign/ Champaign, IL 61820.

Bryon Grush/ Assistant Professor/ School of Art/ Northern Illinois University/ DeKalb, IL 60115.

Issac Kerlow/ Director of Computer Programs/ School of Art and Design/ Pratt Institute/ Brooklyn, NY 11205.

Joseph Kuszai/ Professor of Design/ Kresge Art Center/ Michigan State University/ East Lansing, MI 48824.

Don Lloyd/ Box 159/ Pt. Reyes, CA 94956 (San Francisco Art Institute)

Robert Mendell, MA in Electronic Media (NIU graduate)/ Bally Inc., Bensonville, IL

Susan Metros/ Associate Professor/ Department of Art/ University of Tennessee - Knoxville/ Knoxville, TN.

Barry Moore, PhD/ Director of Computer Operations/ College of Fine Arts/ Illinois State University/ Normal, IL 61761.

Jim Pallas/ Detroit Artworks/ 1311 Bishop/ Grosse Pointe Park, MI 48230 (Macomb County Community College).

Walter Wright/ Associate Professor/ School of the Arts/ Virginia Commonwealth University/ Richmond, VA 23284.

MUSIC

Optical Music Recognition: A Progress Report

Bo Alphonce, Bruce Pennycook, Ichiro Fujinaga, Natalie Boisvert

McGill University

Despite the tremendous potential of an optical recognition system for music notation, very little research has been done in the area. The project at hand proposes to develop a system for automated score recognition. Preliminary work involving the use of projections as the sole recognition technique has achieved 73% correct recognition with various samples of monophonic music. Combining projections with other established pattern-recognition techniques should allow the system to achieve near-100% correct recognition, with a minimum of operator intervention, of complex polyphonic music including orchestral scores.

Introduction

Vigorous developments in many areas of computer-music have proved, beyond doubt, the applicability of computers to music. The development of computer-assisted score processing, however, has been severely hampered by the absence of a fast and reliable method to convert musical information into machine-readable data. Early experiments with optical scanners were successful in principle, but never reached a stage where implementation would be practical.

A reliable and inexpensive optical music recognition (OMR) system would allow for a revitalization of computer-assisted research in musicology, while simplifying many tasks in the preparation of performance materials. Potential areas of application include the establishment of large music databases, convenient electronic score transmission, score-based analysis, score editing, and re-coding for Braille printing.

The basic task of an OMR system is to convert the score to a machine-readable format through an optical scanner; the digitized image is then analyzed to locate and identify the musical symbols. The objective of the prototype system, described in detail in Ichiro Fujinaga's M.A. thesis, *Optical Music Recognition Using Projections*, was to ascertain the feasibility of implementing an OMR system in a microcomputer environment. In particular, the use of projections as a suitable recognition technique was investigated.

The objective of our current project is to go beyond Fujinaga's accomplishments and achieve the complete symbol recognition of complex polyphonic music including orchestral scores. While the use of projections has proved promising so far, other recognition techniques are under investigation and may be applied to solve particular problems.

Criteria

To be practical, the system needs to be relatively fast and should achieve a high recognition rate without excessive operator intervention. Since most musicologists receive limited funds and few have access to sophisticated hardware, the system must function in an inexpensive, microcomputer-based environment.

The system's usefulness depends on its ability to recognize a wide variety of scores. A quick look at samples of printed music will confirm the difficulty of attaining this goal. The use of many different printing methods and the absence of definite notational rules have resulted in large variations in the size and shape of the musical symbols and have made notational syntax unreliable (see fig. 1). With most methods, the appearance of the printed music depends on the quality and state of the printing tools, as well as on the individual printer's skill. Because tools wear out and individual skill varies, no printing method guarantees uniformly shaped, well-aligned symbols. Computer music typesetting promises to correct many of these problems, but to this date, only a small number of publishers use this technology.

Obviously, a system capable of dealing with such a wealth of different symbols and printing styles must be extremely flexible. To accommodate the numerous font and style variants, a method of training the optical recognizer, using certain key features of a given set of notational symbols, will probably be essential to the system's long-term viability.

Finally, because of the hardware considerations mentioned above, various strategies must be devised to reduce the amount of data to be processed. Image processing is computationally intensive and generates large data files. In this context, projection-based recognition algorithms are extremely attractive, in that they generate much less intermediate data than spectral domain recognition algorithms.

Figure 1

a) An example of high-quality music printing by a major music publisher. Note the uniformly shaped and evenly spaced symbols.
b) An example of music print that causes difficulties for OMR. Note the strange clef, square note-heads, short flags, irregular length of stems, and the uneven placement of notes on the staff.

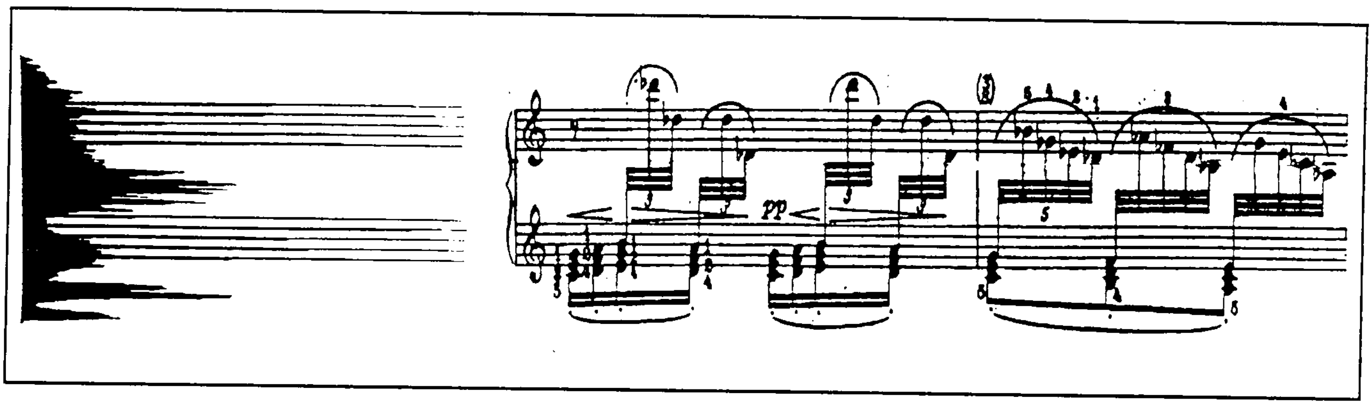

Figure 2a

One system of piano music and the plot of the y projection. The two groups of 5 peaks correspond to the lines of both staves.

Software design

A pattern-recognition process usually consists of four stages: preprocessing, segmentation, feature extraction, and classification.

Preprocessing involves standard image-enhancement utilities, such as noise filters and image-restoration devices. The system does not use them at present because projections are fairly insensitive to image details and to uniformly distributed random noise. The target system, however, will certainly resort to additional recognition techniques, which may or may not be noise-sensitive. Moreover, the abundance of low-quality print means that broken, warped, incomplete, or smudged symbols are commonplace. With any technique, the recognition process will be facilitated if these flaws are eliminated beforehand.

The recognition process itself consists of the three remaining stages: segmentation, feature extraction, and classification. Because the size and location of the staves is unpredictable, the printed page must be divided into individual systems (a system is defined here as the total collection of symbols that belong to one staff). This is done with a projection of the entire page onto the vertical axis, where each system will produce distinct peaks (fig. 2a). Once the exact location of the staff is known, a projection onto the horizontal axis is scanned from left to right for variations in slope; a sudden increase in the projection value indicates the presence of a symbol (fig. 2b). Its exact location and distinctive features are extracted through a series of local projections (fig. 2c). (Segmentation is facilitated by the rule that states that no symbol is to touch another.)

Since musical symbols can often be differentiated by size alone, their height and width suffice for a useful if somewhat crude classification (fig. 3). Additional features are extracted as needed for positive identification, after which the process is repeated until all the symbols have been identified (fig. 4 illustrates the entire process).

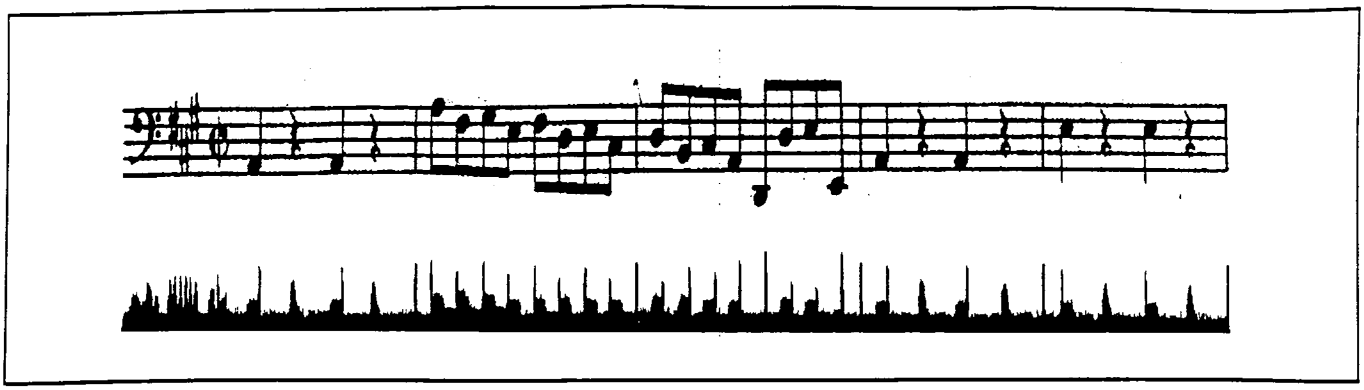

Figure 2b

The x-projection of one staff. Each musical symbol produces a clear peak on the projection profile, which is used for initial segmentation.

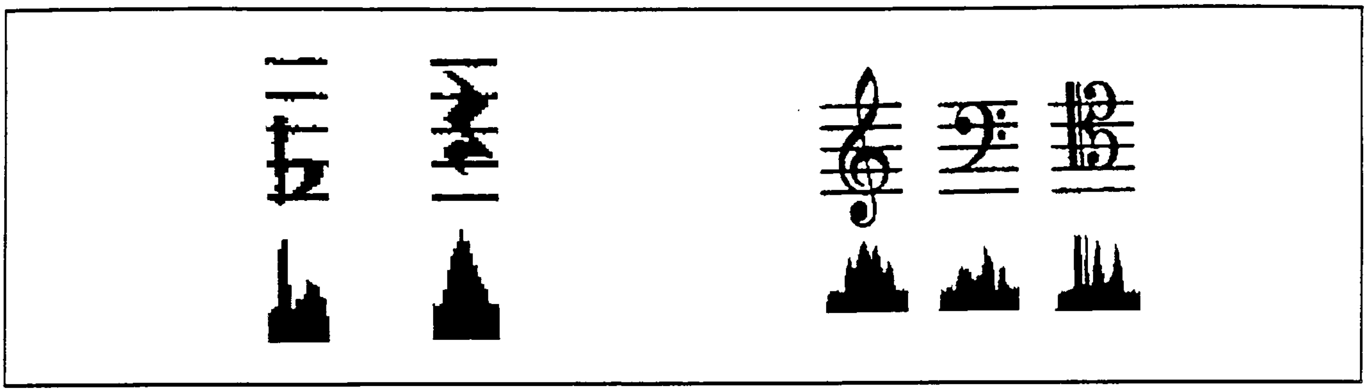

Figure 2c

An x-projection taken in a small window helps to differentiate the symbols that fall within the same size class. The flat and quarter-rest signs differ by the location of the maximum projection value (to the left for the flat, near the centre for the quarter-rest). Observe also the different profiles generated by the three clefs.

Projections essentially transform the two-dimensional scanned image into one-dimensional data, resulting in 100:1 data-reduction. Because of the distinct features of each musical symbol, the reduced data-representations usually contain enough information to locate and identify the symbols. Interference from the stafflines is minimized since the lines appear as random noise in the projection profile. The projections' inability to detect details becomes an asset when analyzing a musical image; indeed, the technique is insensitive to slightly mis-shaped or crooked symbols, or to non-parallel or skewed staff lines. Since the size of musical symbols tends to increase linearly with the size of the staff, threshold projection values are easy to calculate once the staff has been located and measured.

On the other hand, projections fail where symbols are very similar. For example, the prototype will correctly identify a flagged note, but cannot find the "number" of flags (eg., it cannot yet differentiate an eighth- from a sixteenth-note). Other recognition techniques will be required to analyze such details, in particular, template matching. Nevertheless, computation time can be kept down if intensive techniques are used only to solve areas of uncertainty.

Current status and assessment

The prototype system was geared to the recognition of a small number of target symbols, including clefs, half-notes, quarter-notes, flagged or beamed notes, several rests, accidentals, and dots of prolongation. The test samples were restricted to music for a single, monophonic instrument. Projections were the only recognition method used, with one small exception: the ratio of white to black pixels at the centre of the note-head was used to differentiate between half- and quarter-notes. A near-100% recognition rate was achieved with some training samples. When the system was tested with four new samples, the recognition rate ranged from 64% with a sample containing oddly-shaped symbols to 82% with a high-quality sample printed by a top publisher. A surprisingly high rate of 66% was achieved with a sample of well-formed hand-written music. The average recognition rate for these four samples was 73%, and all were tested without operator intervention or assistance (fig. 5). Processing took an average of 15 seconds per printed system on an IBM-AT-compatible microcomputer.

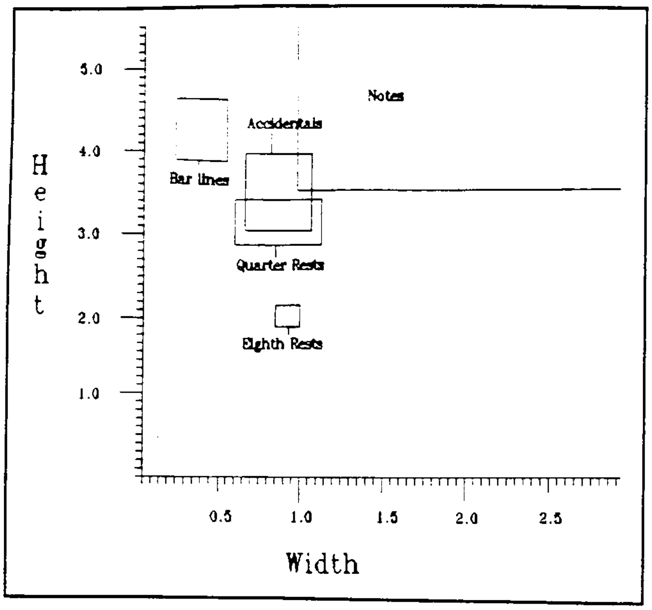

Figure 3

This chart shows how the height and width of the symbols permit a preliminary classification. A symbol is immediately identifiable if its corresponding rectangle does not intersect another. Otherwise, more projections must be taken before the symbol can be classified.

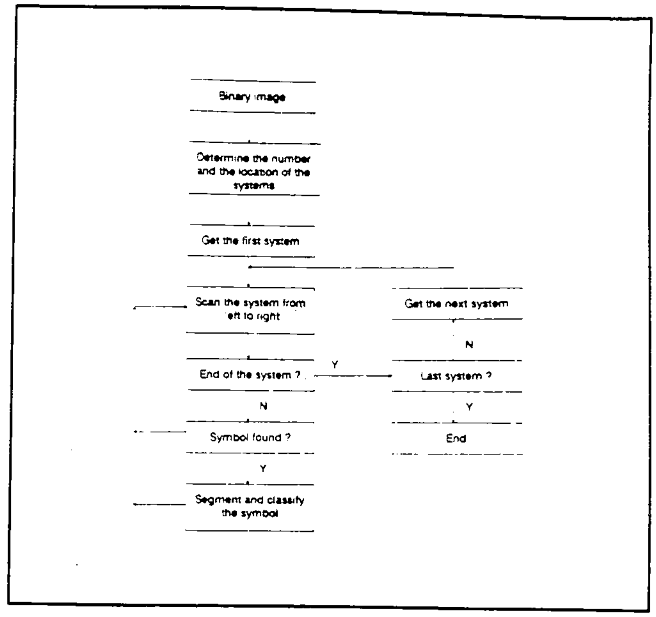

Figure 4

The overall process. Once the location of the staves has been determined by the initial y-projection, each system is scanned from left to right until all of its symbols have been classified.

While the program is still in its infancy, it represents a tremendous step over previous research on OMR. Indeed, despite the tremendous potential of OMR, research in the area has been limited to two MIT dissertations, by Prusslin (1966), and Prerau (1970). Because both were committed to the use of a contour-tracing technique to segment the symbols, the staff lines became an enormous obstacle. The bulk of both theses is devoted to this problem.

Prusslin's program achieved the recognition of quarter-notes and beamed note groups in one measure of piano music. Prerau's program recognized a total of 137 symbols in a 20-measure sample of a duet for wind instruments by Mozart. Both programs used the same samples for the development and for the test runs. Prerau's program processed the equivalent of four to six measures of solo music in about four minutes, on an IBM mainframe (versus our program: 15 seconds on a PC-AT for one complete system!).

The respectable recognition rate and speed that our prototype has achieved using simple, linear recognition techniques demonstrate that OMR can indeed be implemented on microcomputer-based systems. Moreover, the system has demonstrated its ability to deal with scores other than those used for its development. Of course, many improvements and refinements must be brought to the program before it is fully operative. It is imperative that the system acquire a larger vocabulary of symbols, and a flexible knowledge-base must be added to allow the program to learn new symbols with the help of a human operator. Major improvements can probably be attained by the addition of musical heuristics to the program. That is, grammar-driven rules of notational syntax can be implemented to assist the classifier. Vague or ambivalent decisions can be re-considered during a second pass.

For the users' and the developers' benefit, provisions must be made for the system to interface with other applications, such as music editors, music-printing software, and MIDI (Musical Instrument Digital Interface).

Discussion

Immediate goals concern preliminary work on the recognition of polyphonic music. The segmentation process becomes considerably more complex here, since some symbols are shared by multiple staves. More important, the presence of several voices on one staff means that multiple symbols can occur at a given vertical location. In many cases, the number of superimposed symbols is unpredictable, which suggests that some degree of user-intervention may be essential for a fully functional product.

Assuming that a suitable learning system can be devised, it should be possible to implement a very reliable system that will recognize most types of music. A few theoretical problems remain to be solved, however. In dense scores, some symbols overlap between systems. Free-standing, overlapping symbols will be difficult to assign to a particular system. There are a few musical symbols whose size is not fixed, including crescendo and diminuendo wedges, ties, and slurs. These may be difficult to segment and to describe in the classifier's

	Number of symbols correctly identified	Total number of symbols	Percentage of correct symbols
Sample I	79	111	71%
Sample II	138	211	64%
Sample III	92	140	66%
Sample IV	281	344	82%
Total	590	806	73%

Figure 5

The performance of the system on its final test.

vocabulary. Moreover, it is a rare page of music that doesn't contain some text, from isolated tempo and dynamic indications to extensive settings in vocal music. Many different fonts can be found on a single page of music; in addition, most engravers do not use standard typefaces. Finally, it is not known to which extent the system will be able to recognize hand-written music, unless it is very neat and consistent.

Conclusion

We are confident that many of the primary problems in optical recognition of musical symbols have been successfully addressed. We are hopeful that our methods will continue to prove fruitful as we tackle the remaining issues.

THE TEACHING OF LIVE PERFORMANCE SYNTHESIS: A LOOK AT THE STATE OF THE ART AND A VIEW TOWARDS THE FUTURE

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As the use of high technology in live music becomes more and more widespread, the education of those using this technology plays an extremely important role in ensuring the continuance of musical ideals and musicality. The Music Synthesis department at the Berklee College of Music provides such musicians with the key to attaining a sophisticated level of understanding in the creation of musical and emotional expression with electric instruments.

Observing the state of the "art"

Last night, a friend of mine called me to ask if I wanted to see a major group in concert. Seeing how this was a free third row ticket, and a chance to see an all electronic group of that caliber, I couldn't pass up the opportunity. The result of attending the concert has solidified recent insights and ideas about the state of this art which we call by various names - mine will be electric music.

What I heard was nearly two hours of continuous sound - no breaks lasting more than around five seconds. "Dynamics" hovered around *ff*, occasionally climaxed to *fff*, and, during the most sensitive moments, quieted to a mere *forte* . Six onstage Atari computers provided ample power to deliver sequenced material of a punishing nature. Back to back 7 minute pieces consisting of juvenille, mechanical drum patterns, unvarying harmonic progressions, treatment of timbral considerations with an "all or nothing" attitude (all), and no attention paid to phrasing of any type.

There **were** three people on stage, all playing mulitple keyboards. Their primary function became a reminder to the audience that they were there to see and hear a performance of music **by** musicians. Their musical contribution, however, was reduced to adding monophonic lines and whole note chords to the sequenced material. They were motionless, emotionless (they were out and out **bored** on stage), and neglected any attempt to interact with each other. Given the present musical potential of electric instruments and MIDI, is this the best they can do? Why do a majority of performers of electric music neglect their instruments' abilities to capture the same subtle nuances as acoustic instruments? Is this the best anyone can do in the electric genre? If so, I will retire from electric music, accept the title 'ex-buttonpusher', and pick up the oboe I once played.

I refuse to acknowledge that what I heard is natural for electric instruments. This cannot remain the state of the art.

Evolution

What shocks me is that the group I heard has been regarded as pioneers in electric music since the 1960's. They've had plenty of time to evolve their art and surely ignored such an opportunity. Evolution in this context calls for, ironically, a few large steps backwards, followed by the normal path in a forward direction. The electric musician must abandon the racks for a few hours and take a good look back at musical traditions that have worked since the beginning of time. These traditions bring me back to the classical and jazz instruction I've received during my life. Those genres do well to reveal the result of phrasing, density, rhythm, articulation, dynamics, and sometimes silence: a unity between musician and listener, the shared emotions. Due to the novelty and sensory appeal of the recent revolution of electric instruments (due to its youth), far too many performers and composers have relied on audience response through "sensory blitzing".

As this new art of electric music matures, more accurately as the audience matures, the novelty will wear off, and the current music will appear as emotionless. Maybe this process can be accellerated through an improved fusion of classic ideals and modern technology. This is one of my missions as an educator of performance synthesis at the Berklee College of Music in Boston, Mass.

Berklee: a center for evolution

Located within an extremely varied 15 course curriculum in music synthesis are two courses devoted to live performance synthesis, of which I teach both. Since our department is completely open to instrumentalists of all types, students of the performance courses are not necessarily keyboard players. Teaching performance techniques on keyboard instruments does not present a large problem, as one might think, due to the universal nature of the musical ideas presented. For example, I do not look for right hand dexterity in non - keyboard players, but I will grade heavily on their left hand and foot techniques. The synthesist uses these limbs plus breath for most controller and pedal work, which I regard as common to any expressive instrument. Equate, if you will:

1) a breath controller with the mouthpiece of any wind instrument

2) foot switches with the pedals found on a harp or piano

3) key velocity with the articulation of a plucked string instrument

4) a pitch bender with the tremolo bar on an electric guitar

5) after touch and continuous foot controllers providing unique forms of control,

and so on. With non - keyboard players, I often notice a musical hastiness associated with controller usage. Due to primary concentration on notes in the right hand, the integration of controllers falls to the back burner, and, in a small fit of panic, will either rush the use of that controller, or add the controller nearly at random, for the 'sake' of adding some type of expression. Obviously, this is not the prefered course of action. True, these problems generally exist for non - keyboardists, but, given the student's **awareness** of the ideal phrasing of notes and controllers, a universal concept if you think about it, plus a lot of practice (also a universal concept), music can be made.

In a general sense, the amount of time to make music electrically can easily be doubled compared to an equivalent acoustic realization, based on the requirement that the synthesist invent the orchestra as well as the music. Therefore, beyond the teaching of musical "ideals", there is the enormous task of mastering the technology involved, so as to permit unrestricted freedom of musical movement with a performance setup. As an instructor, I frequently notice this element of electric music trying to dominate and steal time away from musical considerations. Through intelligent instrument design and proper education, this does not have to be the case.

Paving the road through education

The incorporation of microprocessors in instruments and the ensuing realization of MIDI has certainly made musical expression and freedom more possible than ever before. Electric instruments are increasingly becoming more expressive. A variety of controller types (wind, guitar, etc.) are now appearing and are at least beginnings of a future of technology which can be brought to a level of understanding most will accept and choose to investigate. This will increase the acceptance of electric music in the music community, alleviate the fear and mystique of electric instruments, thus permitting a greater community, looking to bring their musicality to the electric genre.

A problem I have with many performers of electric music is their failure to **maximize** the capabilities of any one instrument. Instruments are currently being designed to offer the musician a healthy variety of control over sound in real time, only to be largely ignored by the user. Manufacturers, in their quest for market supremacy, boast a plethora of performance features with the introduction of any new product. The presence of these features serves as a marketing move for the manufacturer, but also serves as enhanced musical potential for the musician. Unfortunately, the latter is the underdeveloped of the two. In class, I stress the concept of taking one instrument and using every available feature in order to maximize control over the pitch, loudness, and timbre of any given single sound. This is done most effectively by dealing with one controller at a time, developing skills and a vocabulary of usage for the controller. Once completed, more controllers can be added, in a similiar fashion. Accompanying sequences provide supportive parts (bass, drums, etc.) for the student to work out ideas and solidify skills.

The Literature

One needs to listen to Isao Tomita's interpretation of Ravel's "Daphnis and Chloe:Suite #2", "Pavane for a Dead Princess", and "Mother Goose Suite" (RCA/Victor ARL 1 - 3412) to fully understand the meaning of maximizing an electric system. A similiar concept in a different musical genre suggests attention to George Duke's solo on "Corine", found on his "Follow the Rainbow" album (Epic Records). Both are wonderful examples adding life to sound through changes in pitch, along with timbral and dynamic variations in articulations and sustained portions of sound. The musical heights achieved through their techniques are immediate.

Looking ahead

Some of my goals as an educator are to:

1) demystify the technical aspect of creating electric music

2) master the use of technical techniques to gain a desired effect,

3) organize those effects in order to create a moving statement. This, of course, is a colossal task for the musician, but can and will put an end to the notion that electric instruments cannot function as musical instruments.

The future should see an increased breakdown in the wall between the acoustic and electric domains, with workable alternative controllers, reduced cost for effective synthesizers and processing (with real time control over processing possessing mind boggling applications), and the increased use of the synthesis "workstation", providing an easier time of working with many components of electric music (sounds, storage, sequencing, performance,etc.). This will also lead to more musicians becoming involved with the electric medium.

Hopefully, the future will also air increased awareness and attention to making these instruments breathe and sing the way acoustic and other electric instruments can with such natural ease. Educational institutions such as Berklee are an important step in increasing that awareness, as the knowledge passed along to others will heighten the quality of the music we all make.

MUSIC TECHNOLOGY IN THE EDUCATION OF THE PROFESSIONAL MUSICIAN

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Music technology is changing the ways in which music is made, taught, and learned; its impact is being felt by performing musicians and by music teachers at all levels. Colleges must recognize and respond to these developments in order to prepare music students for the realities of the evolving musical world. The School of Music at Duquesne University, cognizant of these needs, has integrated music technology across the curriculum. Two lines of development have been followed: an instructional/ training line and an artistic/creative line. Instructional applications are designed to strengthen basic musicianship skills as well as to provide strategies for use in classroom and private studio settings. Creative applications are intended to expand composition and performance options; these applications may also be used in instructional settings. A cross-disciplinary program and a music technology group for educators within the community have also been developed. Implementation of the program has taken place in several phases over a period of four years. Each phase is described with reference to equipment, curriculum, and procedures. A Program Model has been developed and is proposed for consideration by other institutions.

Current music technology is changing the ways in which music is made, taught, and learned. Recent publications highlight the impact of technology on the ability of professional musicians to earn a living, challenging traditional modes as well as providing new options. In television, radio, and the motion picture industry, for example, a composer using a digital music system can do the work formerly assigned to an arranger, copyist, conductor, and recording studio personnel. One or two musicians using a microcomputer, synthesizers, and MIDI equipment of various types can achieve the sound of a small ensemble or orchestra. School music teachers at all levels are affected by developments in music technology. Studio piano teachers find more students interested in studying "keyboards" than they had in the past. Colleges must recognize and respond to these changes in order to prepare students for the realities of the musical world as it is evolving in the late twentieth century.

Music Technology at Duquesne

Cognizant of these developments and their effects on the future of students enrolled in music degree programs, Duquesne University's School of Music has integrated music technology across the curriculum. Duquesne University is a private coeducational university, located on a self-contained campus within the city of Pittsburgh. Approximately seven thousand students are enrolled in the university with about three hundred in the School of Music. Music degree programs offered include the Bachelor of Music degree, the Bachelor of Science in Music Education, the Bachelor of Science in Music Therapy; the Master of Music in Performance, Music Theory, Composition, Sacred Music, and the Master of Music Education.

The School espouses a broad philosophy of performance and of music technology. The Bachelor of Music degree is perceived not exclusively as preparation for a traditional concert career, but as broad education for various music careers. It is expected that students in all degree programs will develop their performance skills to the level appropriate to their specific concentration. Duquesne's goal is to parallel that performance development with suitable skills in the applications of music technology, since nearly all musicians are touched by the technology which currently pervades the music profession, particularly in the areas of performance, instruction, and recording.

The original goal of music technology applications in the School of Music was to improve instruction by integrating computer assisted instruction into several areas of the curriculum. Developments to date have surpassed and expanded upon that original aim. Two lines of development have been followed in the music technology program: an instructional or training line and an artistic or creative line. The instructional applications are designed to strengthen basic musicianship skills as well as to provide strategies for future use in classroom or private studio settings. The creative applications are designed to expand composition and performance skills; they also provide new sound options for orchestration and arranging. These creative applications may, of course, also be used in instructional settings. In addition to these, a cross-disciplinary program offered by the School of Music in cooperation with the Communications Department has been developed. Students working with these applications are introduced to alternative careers built upon and supported by new music technology.

At Duquesne University, all students are encouraged to become familiar with the new music technology. Many institutions with high technology studios limit use of these resources to students in computer and electronic music programs. Duquesne's program is one which is available to all students regardless of major.

Implementation of the program in music technology has proceeded in several phases over a period of four years. Following is a brief description of each of the phases with reference to equipment, curriculum, and procedures.

Phase One

The instructional component was introduced first, in the Fall of 1984. With equipment consisting of one Apple IIe microcomputer located in a School of Music office and a small courseware collection appropriate for use in elementary and secondary school settings, a workshop-style course for Music Education majors was offered. A pre-existing structure was used for this instruction: a monthly Music Education Seminar which had been loosely organized. The four seminars of that semester were designated **Music Education Seminar/CAI** and were employed on a pilot basis for orientation to music applications of computer assisted instruction. Attending this seminar series were Music Education majors scheduled for student teaching during the following semester. The sessions included an introduction to basic computer concepts and a review of music courseware designed for elementary through secondary school levels. Benefits of microcomputer use for students and for teachers were discussed; techniques for integrating computer assisted instruction into classroom music lessons were incorporated into courseware reviews. Students learned to use the computer and music software as tools to clarify and to reinforce concepts learned in the General Music class. Since many of the programs employ a game format, procedures for classroom use included group activities such as two "players" at one computer, relay races, and team competitions. Strategies for integrating computer assisted instruction into the high school music theory curriculum were examined. Also included were procedures for private studio use, since many school music teachers also teach private and group lessons. All students completed an individual project designed to provide them with some practical applications they might use as public school music teachers. While the short duration of the course and the limited access to the computer were not ideal, an overview and basic awareness were achieved.

In Spring of 1985 a temporary Computer Lab was established in a former practice room. The Lab was used by Music Education majors for individual courseware review and by Music Theory students referred by their instructors for aural skills practice. By the end of that semester a Faculty Development Grant supporting the purchase of additional courseware was received. This facilitated expansion of the music education seminars and the initiation of Music Theory applications.

The following Fall, two more microcomputers were secured and additional courseware was purchased, financed in part by grant monies. The Music Education course continued in an expanded format and more Music Theory students gained access to computer assisted instruction. On an experimental basis, students in Theory and Solfege classes who needed extra aural skills practice were given computer assignments tailored to their specific needs. They were directed to work on selected interval, chord, and melodic dictation programs for a minimum of two half-hour sessions per week and to chart their achievement as recorded by the programs. The progress of these students was monitored and Computer Lab procedures were designed for future applications on a larger scale.

Phase Two

The second phase, an expansion of the instructional component, was implemented in Fall of 1986. This phase consisted of integrating computer assisted instruction into the full two-year Music Theory curriculum. Equipment was increased to a total of ten microcomputers. In addition, a rhythm reading system and a synthesizer with music tutor software were purchased. A commercially available courseware library of sufficient scope to support the first two years of the Music Theory curriculum had already been purchased; at this time a few supplementary programs were added to that library. Software included melodic dictation programs, interval, chord, and rhythm dictation programs, and harmonic dictation programs. Music Theory instructors reviewed the software and coordinated the programs with the course content of the two-year Music Theory curriculum. Providing students with convenient access to these resources required a reallocation of space within the School of Music building: a Piano Class Lab was moved to another classroom and its former location became the Computer Lab.

An orientation session for all students was provided as an introduction to computers and to music courseware. Students then attended three Music Theory lecture classes and three Solfege classes each week. In addition, they completed weekly CAI assignments correlated with their class work. The minimum required computer practice time was two half-hour sessions per week. Students were encouraged to spend additional lab time using the rhythm reading system and the synthesizer/music tutor system. Since only one of each type of unit was purchased, use of this technology by all students as an integral part of the program was not feasible. A year-end evaluation of the Theory/CAI program revealed: (a.) general student and instructor satisfaction with supplementary CAI, (b.) some dissatisfaction with regard to Computer Lab hours, which were limited due to staffing difficulties, and (c.) achievement comparable to achievement under the traditional system. Both students and instructors requested additional melodic dictation courseware.

Phase Three

The third phase was implemented in Fall of 1987. This phase consisted of the addition of creative applications of music technology as well as the incorporation of new offerings in the instructional component. It involved more equipment purchases, space reallocations, and curricular innovations than either previous phase. A **Center for Music Technology** was established, consisting of three separate but related areas, all located on a single floor of the Music building. The original Computer Lab was expanded to become a **Music Learning Resource Center** consisting of Computer Lab, Record Library, and video viewing area. A **Synthesizer and Recording Studio** houses synthesizers and other current music technology; this studio displaced a classroom. An **Electronic Piano Lab** equipped with MIDI capable digital pianos has replaced the former Piano Class Lab.

Equipment additions to the Music Learning Resource Center included a Macintosh computer and music courseware designed for the Macintosh. As requested by faculty and students, additional melodic dictation software for Music Theory users was secured. High quality stereo and compact disc equipment replaced outdated Record Library equipment; a compact disc collection and a videocassette library are planned. Merging the Computer Lab with the Record Library doubled the number of monitors available for either of these centers, and greatly increased the accessibility of both Computer Lab and Record Library.

Equipment secured for the Synthesizer and Recording Studio represented an investment in high technology instruments. A Macintosh Plus computer was purchased to control various MIDI equipment, including digital and analog synthesizers, guitar, voice, and drum controllers, and a variety of peripheral MIDI equipment. In addition to this new equipment, a sampler purchased for Symphony Band use in the previous spring was added to the Studio resources. Software purchases included commercially available composer/sequencer programs. The Studio staff maintains open hours for all students and encourages them to become familiar with the synthesizer and recording resources.

The Electronic Piano Lab was equipped with twelve digital pianos and a Teaching Lab System. Since the pianos can be played using headsets, the Lab was made available to students for individual practice as well as for piano class. When interfaced with a Macintosh computer, each MIDI-capable piano will also become an individual workstation for instructional or creative applications.

Curricular innovations marked this phase of the music technology program. The Music Theory curriculum was restructured on the basis of an overall program evaluation: beginning in Fall of 1987, Music Theory students attend two lecture classes, two Solfege classes, and two tutor sessions per week. Supplementing these scheduled classes is individual aural skills practice using computer assisted instruction, with a minimum required time of two half-hour sessions per week. Students work with beginning to advanced melodic dictation programs, interval, chord, and mode drills, harmonic dictation drills, and rhythm drills; some students also use the rhythm reading system. Through the Music Theory program all students become familiar with current music instructional technology and strengthen the basic musicianship skills vital to any musician.

High technology applications were integrated into the traditional Composition curriculum. In these applications the computer controls new sound options for realizing creative work and simplifies the manuscript preparation process. Composition students create at the Macintosh computer using composer/sequencer software: they arrange their work at the computer, experimenting with the sound possibilities of the various synthesizers. The compositions, whether intended for traditional or high technology instruments, can be performed immediately by the synthesized ensemble of their choice, providing users with the opportunity to evaluate the result and make any desired changes and adjustments. All editing is done at the computer, providing neat manuscript from the start. The high technology instruments also expand the composer's resources by allowing the creation of sounds not possible with traditional instruments.

In the area of Performance, the Guitar Department introduced computers, synthesizers, and samplers into the traditional curriculum. While all students in this program strive to develop a unique style, the technology allows each student to develop an individual sound signature as well. This program is among those that incorporate MIDI directly into the curriculum; the equipment supporting it includes the type that students might expect to use as professional performing musicians. Since these instruments are widely used by professional musicians, it is important that students become familiar with them and gain experience with applications. Without such training they may be underequipped for the careers available to them and therefore less marketable than would be desired.

A new course entitled **Music and Technology**, designed to provide systematic instruction in the use of synthesizers and other MIDI equipment, was introduced into the Performance area offerings. This course is structured in the form of applied lessons; it includes instruction in basic physics, creating synthesized sounds, and techniques for incorporating MIDI in performance and instruction. In order to accommodate the demand for this course the structure was expanded to a class format in Spring of 1988.

During 1987-1988 a new **Music Education Methods** course employing both instructional and creative applications of music technology was introduced into the Music Education curriculum. This two-semester course consists of seven-week modules in four areas of instruction. Included is one module directed toward music technology; this module deals with computer assisted instruction in music as well as with synthesizer and MIDI applications for school music teachers. A module on guitar, intended to develop both performing and teaching competencies, includes an introduction to computer software designed for guitar instruction. Field experiences are included to provide practice with the competencies developed during the seven-week periods. This course represents a broader integration of technology into the Music Education curriculum: a wide range of music technology supports instruction within the school music setting. The students in these classes will soon obtain school music positions; they will include music of diverse styles and cultures in their instruction of students who are growing up with high technology. Through programming and performance they will convey attitudes toward contemporary forms of music to students, colleagues, and the public. Experience with contemporary music technology and its applications is, therefore, as vital for these students as it is for their colleagues who will perform and teach outside of the school setting.

A cross-disciplinary course was introduced by the School of Music in cooperation with the Communications Department. Entitled **Audio I**, this course consists of an introduction to techniques of audio design as utilized by recording studios and the communications industry. All aspects of the recording chain and basic recording studio procedures are included. This course is required for Media Arts students and may be elected by Music School students. **Audio II**, an intensive study of the commercial multi-track recording process, was also developed and offered in Spring of 1988. Music students in these courses can achieve a basic preparation for several alternative music careers. At the least, familiarity with this technology will help students to communicate effectively with recording studio personnel, a capability that will become increasingly important for performing musicians.

Overregistration in technology-oriented courses and the many inquiries regarding the availability of degrees or minors in Music Technology revealed a widespread interest in this field among current and potential students. For that reason, planning began in late Fall of 1987 for development of a secondary concentration in Music Technology. This concentration will be implemented in Fall of 1988 as an option within the traditional Guitar Performance degree program.

Summary

The introduction of music technology into the curriculum at Duquesne's School of Music began as many such programs do: a supportive role was assigned, with the computer taking over some drill previously provided by a teacher. The computer was simply integrated into an existing course structure: no changes were required. The Music Theory and Music Education programs were supported and enhanced by the integration of computer assisted instruction into existing curricula.

Later applications assigned a central role to music technology as MIDI became part of the Guitar Performance curriculum, as the computer and synthesizers assumed an active role in the Composition program, and as courses were developed specifically for instruction in the use of music technology. These applications expanded the resources of performers and composers and opened new creative avenues for both. The cross-disciplinary applications extended benefits of music technology beyond the School of Music and provided music students with some skills needed to communicate with recording technicians. The concentration in music technology will provide students in the Guitar Performance program with the skills they need to be marketable as professional musicians.

Program Model

A similar Music Technology program could be developed by nearly any institution that wishes to offer such instruction. As is the case with many moderate-sized institutions, Duquesne University did not utilize computer-based instruction on a mainframe system and software development was not feasible. Further, sufficient well designed and field tested software was available to support the desired Music Education and Music Theory applications. For those reasons, microcomputers and commercially available software were purchased. In general, affordable synthesizers and MIDI equipment were selected since these represented resources that would be used by professionals in the field. Funding was obtained through a variety of sources including the Music School budget, a State of Pennsylvania equipment grant, a University Faculty Development grant, and gift monies.

Programs were introduced at first on a pilot basis, requiring relatively modest investments, small scale instructional applications, evaluations, and program revisions. Expansion of programs was based on input from all concerned in the music technology applications: faculty in content areas, faculty and consultants with expertise in music technology, and student users. Extension of the program from the original instructional applications to both instructional and creative applications was the next step, based on the need for realistic career preparation. The latest stage, degree concentrations, formalizes the commitment to music technology and provides a more intensive focus on the technology itself.

These types of procedures are within reason for almost any institution similar to Duquesne's School of Music. They are not only practical and realistic, they are vital if schools are to prepare musicians for an ever evolving musical world.

References

1. Allvin, Raynold L. (1970). Do Colleges and Universities Need an Automated Music Learning Center? Council for Research in Music Education, 21, 32-46.

2. Allvin, Raynold L. (1971). Computer-Assisted Music Instruction: A Look at the Potential. Journal of Research in Music Education, 19(2), 131-143.

3. Allvin, Raynold L. (1984, March). Microcomputers in Music Instruction: A Plan for the Future. Paper presented at the Sixth Annual Meeting of the Northeast Chapter of The College Music Society, New York, NY.

4. Appleton, Jon. (1987, June 10). Universities' Music Departments Must Adapt to the Revolution Brought About by Technology. The Chronicle of Higher Education, 33(39).

5. Bales, W. Kenton. (1986). Computer-Based Instruction and Music Technology in Education. Journal of Computer-Based Instruction, 13(1), 2-5.

6. Bowman, Judith. (1986, November). Contemporary Techniques for Contemporary Students. Paper presented at the 28th International ADCIS Conference, Washington, DC.

7. Bowman, Judith. (1987). Bridging the Gap: Preparing Students for College Music Theory. Music Educators Journal, 73(8), 49-53.

8. Bowman, Judith. (1988). Music Technology Comes to the Ivory Tower. PMEA News, 52(3), 13.

9. Bowman, Judith and Woods, Barbara. (in press). The Computer Assisted Studio Teacher. Clavier.

10. Carr, Robert. (1986). A Roland Special Report: Synthesizers, Computers, and Education. Roland Users Group, 4(1), 25-32.

11. Chambers, Jack A. and Sprecher, Jerry W. (1983). Computer-Assisted Instruction: Its Use in the Classroom. Englewood Cliffs, NJ: Prentice-Hall, Inc.

12. Coppola, August. (1987). Through the Computer Darkly. Academic Computing, 2(1), 6-9, 42-43.

13. Crawford, Barry. (1987). MIDI--Boon, Bane, or Both? Musletter, 1(1), 7-12.

14. Deans, Karen (Ed.). (1986). Computers and Music Education [Special Issue]. Music Educators Journal, 73(4).

15. DeLoughery, Thomas J. (1987, October 21). Computers Are Giving Music Educators New Sounds and New Ways to Teach. The Chronicle of Higher Education, 34(8), pp. A14-A16.

16. The Education of the Performing Musician. (1973, April). In Monographs on Music in Higher Education (No. 1) (pp. 31-56). Washington, DC: National Association of Schools of Music.

17. Foltz, Roger and Gross, Dorothy. (1980). Integration of CAI into a Music Program. Journal of Computer-Based Instruction, 6(3), 72-76.

18. Gross, Dorothy and Foltz, Roger E. (1981). Ideas on Implementation and Evaluation of a Music CAI Project. College Music Symposium, 21(2), 22-26.

19. Hofstetter, Fred T. (1985). Perspectives on a Decade of Computer-Based Instruction, 1974-84. Journal of Computer-Based Instruction, 12(1), 1-7.

20. Klotman, Robert. (1976). The Musician in Education: 2025 A.D. In Arthur Motycka (Ed.), Music Education for Tomorrow's Society (pp. 12-20). Rhode Island: GAMT Press.

21. Moorhead, Jan Paul. (1986). Assembling An Education. Electronic Musician, 2(10), 22-24, 69.

22. Pembrook, Randall G. (1986). Some Implications of Students' Attitudes Toward a Computer-Based Melodic Dictation Program. Journal of Research in Music Education, 34(2), 121-123.

23. Peters, G. David. (1982). The Fourth Revolution in Education and Music. In Richard Colwell (Ed.), Symposium in Music Education. In Celebration of the Thirtieth Anniversary of the Doctoral Program in Music Education (pp. 299-316). Champaign, ILL: Crouse Printing.

24. Peters, G. David. (1987). Perspectives: Computer-Based Music Instruction. Musletter, 1(1), pp. 2-7.

25. Placek, Robert W. (1980). A Model for Integrating Computer Assisted Instruction into the Music Curriculum. Journal of Computer-Based Music Instruction, 6(3), 99-105.

26. Shetler, Donald J. (1976). This Trip Was Really Necessary. In Arthur Motycka (Ed.), Music Education for Tomorrow's Society (pp. 30-39). Rhode Island: GAMT Press.

27. Stapleton, Peter. (1986). 300,000 Jobs Available--Experience Helpful But Not Required. Electronic Musician, 2(10), 25-26.

28. Thomas, Tony. (1986). Alan Howarth: Secrets of Successful Cinematic Synthesis. Electronic Musician, 2(8), 69-70.

29. Voorhees, Jerry L. (1986). Music in a New Age: The Challenge of Electronics. Music Educators Journal, 73(2), 32-36.

30. Waltzer, Neil. (1986). Educating the New Musician. Electronic Musician, 2(10), 28-29.

THE COMPOSER'S ROLE IN THE BLACK BOX PARADIGM

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Abstract

There is a growing interest in the creation of coherent music/graphic works. Many different approaches are being explored. This report will discuss use of the black box paradigm as one solution to the problem of integration of differing media. The black box model offers possibilities for correlation of aural/visual elements by deriving both from the same algorithm. Not only does this help ensure integration of materials, but the black box algorithm can function as a point of communication between collaborators coming to the work from varying fields.

For the composer the aim is to create sonic maps from data output from the generating algorithm. Simple mapping procedures can produce a variety of aesthetically effective results. The piece *Sonic Map Studies* is used to illustrate some of the possibilities employing a simple fractal process as the common algorithm.

By mapping data into varying pitch domains different music languages are suggested. Time domains are then planned in order to build a syntactically correct musical score. Combining these scores with a computer animation generated from the same algorithmic black box produces varied yet aesthetically satisfactory results.

Introduction

In representing natural phenomena or expressing abstract ideas computer technology has given scientists and artists new ways of realizing their work. For the scientist volumes of data can be understood simply through the medium of computer graphics. Computer animation is opening new areas of time oriented expression to the visual artist. Composers interacting with computers are creating exciting new sounds and formal structures.

Unfortunately, with the differences in training and vocabulary, it is rare that the scientist, visual artist and composer combine their skills in the solving of practical or aesthetic problems. For example the musical score for an animation, artistic or scientific, is too often an afterthought. It is considered a post production problem quickly solved with a convenient pop tune or threadbare classic. Conversely composers uncomfortable in the scientist's or the visual artist's world often avoid them altogether.

Today however there are a growing number of individuals interested in all these areas. In response to this academic institutions are beginning to add or change curricula accordingly. Crossover training is becoming more accepted and new collaborative techniques are being developed.

In work combining music and graphics there is a growing interest in integration. There has been collaborative work done in translating musical works into visual art.[7] Other artists using temporal graphics are exploring ways of combining the visual and the musical into a coherent whole.[1,11] There are still other collaborations using a single algorithm to develop a relationship between picture and music.[5]

Along this track John Whitney with his "differential dynamics" has created austere yet effective computer animations. The adherence to Pythagorean ratios as a basis for his pieces brings the foundations of western musical thought into a strictly visual language.[10] Whitney is also applying these algorithms to the generation of his musical scores, achieving truly integrated music/graphic works.

The idea of one principle as the generative device for both music and graphic materials is also the basis of my work. With a set of data as input to an algorithmic black box it is possible to create graphics and music from the output. All work is derived from a black box algorithm with different media requiring different aesthetic decisions in mapping the output data.

For the composer there are various musics that can be created from the black box output, many of which will work as an integrated partner with the generated graphics. *Sonic Map Studies* shows what can be done using a simple mapping procedure for the musical score. By varying only pitch domain and rhythmic space different aesthetic qualities result. The different mappings reflect simple quantization differences in the output data from the black box algorithm. These differences reflect the compositional controls available after the input data set has been chosen.

The Black Box Paradigm

The black box idea is useful in creating integrated music/graphic works, whether the outcome is meant to be scientific or aesthetic. It functions as the process through which materials are generated. The algorithmic black box is set up to have some type of input which returns numerical output. The artists involved in the paradigm will take the output and translate it into their respective media. The main assumption is that one dimension of the output data is time since we are concerned in this report with temporal art.

As all work generated from the black box is derived from the same source some level of integration is guaranteed. The aesthetic effectiveness of the whole will still be dependent on the skills of those involved. If the work is a collaboration it is naturally important to maintain open channels of communication throughout the works realization.

For a music/graphic piece there are three roles in the paradigm. First there is the creator of the input data. Second and third are the individuals involved in mapping the output into visual and sonic materials. The black box algorithm functions as a platform of communication between these three roles and for three collaborators with divergent backgrounds a place where a common language can be established. For this to occur it helps if everyone understands at least some aspects of the central algorithm. Computer languages can often provide a point of departure for everyone involved in a project. If one individual is performing all three roles in the model communication is hopefully not a problem.

One rule should be followed to maintain a quality of integration in the mappings, the output data should not be altered. If the output data suggests no aesthetically acceptable mapping then the best solution is to change the input (in scientific research this unfortunately is rarely possible). The reason for this is simple - if the visual and sonic materials are not based on the same data at the same time then the cohesiveness of the whole is questionable. If the result of the mappings is purely aesthetic this rule, as is any rule in art, is breakable and dependent on the tastes and talents of the artists involved.

In my experience with this approach different mappings can express extremes of musical language. In creating a sonic score simple changes in pitch domains and variety in sampling increments on the time axis can yield highly contrasted scores. The four different scores in *Sonic Map Studies* serve as an example.

The Algorithm for *Sonic Map Studies*

Sonic Map Studies is comprised of four studies exploring different sonic maps in combination with the same animation. The aural/visual elements are derived from the same algorithm I used in two earlier pieces *Marie Sets* and *Marie Duet*.[2,3] It is a fractal based algorithm similar to the Julia set process and returns an array of numbers with the index values of the array indicating time.[6,9] The input is a time indexed array of parameters. The parameters control the function

$$z_n = z_{n-1}^r + \lambda$$

where z defines a point under investigation in the complex plane. λ is a complex constant, r is a real number exponent and n is a counter measuring time in the dynamic system defined by the current set of input parameters. This function is placed in an iterative process using the following algorithm:

```
let n = zero time in the process
let MAX = maximum iterations allowed in loop

begin loop
    z_{n+1} = z_n^r + λ
continue until n > MAX or |z| >= 2.
```

$$z_{n+1} = z_n^r + \lambda$$

If the loop is exited before the maximum iteration (MAX) the value of n is stored in the output array. If not then zero is stored. For the studies the parameter values interpolate linearly between the start and end values defined in Table 1.

TABLE 1: Start and end input parameters.

parameter	start value	end value
Real(mid point)	+0.516	+0.516
Imag(mid point)	-0.064252	-0.054252
r	+1.9715	+2.0
Real(λ)	-0.74435	-0.74435
Imag(λ)	+0.132929	+0.13292
window size	+0.10	+0.11

z values are points within the window defined by the window size and mid point values of Table 1. In the algorithm the window values are scaled to normalized coordinates where

$$0 <= x < 1.33 \quad \text{and} \quad 0 <= y < 1$$

The z values are defined in this normalized space for the four primary voices of each sonic map as seen in Table 2.

If 480 maximum events are to be calculated each of the 480 input parameter lists is calculated as interpolated values between the start and end values. These values are found using the linear interpolation function

parameter(t) =
start + ((end - start) / maximum events) * t

where

$$0 <= t < \text{maximum events}$$

TABLE 2: z values in normalized coordinates.

Voice #	Real(z)	Imag(z)
Voice 1	.25	.75
Voice 2	.75	.75
Voice 3	.75	.25
Voice 4	.25	.25
Voice 5 (score A)	.25	.5
Voice 6 (score A)	.5	.75
Voice 7 (score A)	.75	.5
Voice 8 (score A)	.5	.25

The t value is the array index of the output array. For 480 maximum events the input would be a multidimensional array with 480 elements where each indexed set would be input into the fractal process. The final output would consist of 480 n values which are then mapped into a predefined pitch domain. The array index defines when the pitch will be played.

In the sonic mappings for the studies musical dimensions of dynamics and timbre are not considered. All dynamics are forte and the synthesis instrument used was subjectively chosen. The same instrument was used for all maps.

Pitch Domains

The fractal algorithm black box for *Sonic Map Studies* returns an array of numbers which is then mapped into a pitch domain in a one to one correspondence. The maximum number of iterations n allowed in the loop is 255. This means that for any given index in the output array

$$0 <= n <= 255$$

For an example lets look at the pitch assignments for score B from the studies. The score B pitch domain is a four octave chromatic scale or 48 total notes. Before we can map the output array values into the pitch domain it is necessary to somehow transform the possible values of zero to 255 into possible values of zero to 47. In all the scores in *Sonic Map Studies* this is done with the modulo function. With zero as the lowest pitch a modulo 48 is

Voices		Pitch Domains	Rhythm Domains	Events per voice	Mod
Score A	(1,5)	quarter tone	32nd notes	480	96
	(2,6)		septuplet 16ths	420	
	(3,7)		triplet 16ths	360	
	(4,8)		quintuplet 16ths	300	
Score B	(1)	12 tone equal temp.	quint. eigths	150	48
	(2)		triplet eigths	180	
	(3)		16th notes	240	
	(4)		eigth notes	120	
Score C	(1,3)	diatonic (C) just tuning	eigth notes	120	28
	(2,4)		triplet eigths	180	
Score D	All	hexatonic (C) just tuning	16th notes	240	24

TABLE 3: Pitch and time domains for Sonic Map Studies.

immediate repetition of a pitch then it is tied to the previous pitch.

Maximum possible events for the voices of each score were also chosen to create a consistent musical syntax. Scores with a more detailed pitch space were given a more detailed rhythmic space.

Technical Miscellany

Each score in Sonic Map Studies is combined with the same animation, illustrating four different musical possibilities from the same mapping procedure. The black box algorithm was written in FORTRAN.

To calculate the graphic output the program was run on a CRAY XMP/48 at the National Center for Supercomputing Applications. The same program was run on an IBM PC-AT to generate the music material as there were significantly fewer points investigated to create the score.

A program written in the "C" language took the output data, performed the specified modulo operations and converted the data into MIDI file format. Different pitch domains were set up by changing the note-on, note-off assignments for each score.

The output from the "C" program was then loaded into the Opcode Sequencer 2.5 on a Macintosh computer. The sequencer played the score on a Yamaha TX81Z synthesizer. Each score was recorded in a single pass.

Conclusion and Further Study

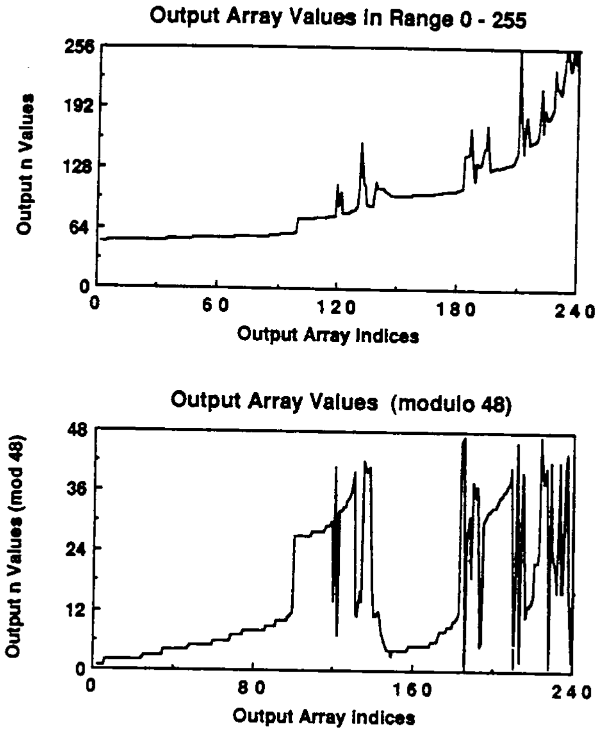
The black box paradigm is a viable model to use in integrating music and visual media in a single work. With one algorithm as generator of all elements visual artists and music composers have a common platform from which they can work in trying to build a coherent combination of materials in a single work.

Using simple mapping procedures the composer is able to create a variety of musics, many of which can prove effective as partner with the visual materials. With the same algorithm as a foundation, correlation with the visual counterpart is assured.

Direct digital synthesis systems broaden significantly the possibilities for sonic maps. Histograms of color distributions from graphic images could, through Fourier transforms, be converted into timbral spaces. Multidimensional output data could be mapped into other musical dimensions such as dynamics or location. These mapping techniques suggest areas for further study.

One field where the black box paradigm could be useful is in scientific visualization. With computer animation proving a valuable

Figure 1: Output array before and after the modulo operation is performed. This pitch progression is for voice 3 of Score B, with 240 maximum possible events or 240 eigth notes in 40 seconds. A repeated note is considered tied to the previous note.



performed on each output array value in score B before mapping. After the modulo operation the transformed values can be mapped directly.

Figure 1 shows a graph of the output array for score B before and after the modulo operation is performed. The basic nature of movement between stability and chaos, so prevalent in fractal processes, is maintained.

Each score in the studies uses a markedly different pitch domain with extremes of quantization from score A, using 96 possible pitches, to score D which uses only 24. The pitch domains used in Sonic Map Studies can be seen in Table 3. Each score maps the data over a four octave span.

Time Domain

In graphing the output array as seen in Figure 1, pitch values lay on the y-axis with time (the array indices) plotted on the x-axis. In choosing the time divisions for a score the sampling increment along the x-axis was chosen based primarily on the quality of musical language the pitch domain suggested. As the pitch domains move toward a more consonant space from score A to score D the rhythmic feel becomes more periodic. Each score lasts 40 seconds and each voice samples that total time at a different rate depending on the maximum number of events to be calculated.

In score A with the four octave quarter-tone span it was felt that a more traditional rhythmic structure would be inconsistent with the musical nature of the pitch domain. To avoid this an overall aperiodic rhythmic structure was used. This was accomplished by having the beat unit of each of 4 pairs of voices divided differently. Time domains for each score can be seen in Table 3.

The goal in selecting the rhythmic layout of each score was to build a temporal feel that would establish a coherent musical expression when combined with the pitch domain selected. The resulting sonic map should reflect a musical space that the listener can accept as syntactically correct with respect to their musical experience. These decisions are of course based purely on the predilections of the composer.

The actual time values assigned to the pitches was done using the 96 divisions of a beat as specified by the MIDI file format.[8] Using mm. = 90 for each movement differing beat divisions were set up by dividing the quarter note (96 maximum divisions) or the half note (192 maximum divisions) into the time values wanted. To get septuplet or quintuplet divisions it was necessary to use slightly different counts for each subdivision in order to end up with exactly 96 or 192 total divisions of the beat. To construct a sixteenth note quintuplet, for example, a quarter note could be divided

$$19 + 20 + 19 + 19 + 19 = 96$$

These slight differences are imperceptible in the playback.

Aperiodicity is achieved by mixing odd and even rhythmic divisions in the same score. By combining voices using septuplets, quintuplets, triplets and 32nd notes, as in score A, an overall aperiodic rhythmic feel is established. If the output data indicates an tool in the realization of the huge data sets generated from a simulation, adding a sonic map could provide, at the very least, a musical score that supports the final presentation. A sonic map could also be used to represent a dimension of the output data not being expressed in the graphic.

In the three role model the scientist could construct the black box algorithm and create the input data. In the simulation of natural phenomena or in expressing mathematical abstraction the black box paradigm offers composer, visual artist and scientist a viable approach to collaboration in practical and aesthetic problem solving.

Bibliography

[1] Dewitt, T. 1987. "Visual Music: Searching for an Aesthetic." *Leonardo*. Vol. 20. No. 2. Pergamon Journals: Oxford.

[2] Evans, B. 1987. "Integration of Music and Graphics through Algorithmic Congruence." *Proceedings of the 1987 International Computer Music Conference*. CMA. San Francisco.

[3] Evans, B. 1987. *Marie Sets*. videotape 9 min. Distributed by University of Illinois Film Center: Champaign.

[4] Evans, B. 1987. *Sonic Map Studies*. videotape 4 min. Distributed by University of Illinois Film Center: Champaign.

[5] Goldberg, T., and Schrack G. 1986. "Computer-Aided Correlation of Musical and Visual Structures." *Leonardo*. Vol. 19. No. 1. Pergamon Journals: Oxford.

[6] Mandelbrot, B. B. 1983. *The Fractal Geometry of Nature*. W. H. Freeman and Company: New York.

[7] Mitroo J. B., Herman N., and Badler N. I. 1979. "Movies from Music: Visualizing Musical Compositions." *Computer Graphics*. Vol. 13. No. 2. ACM:New York.

[8] Opcode Systems. 1986. "Sequencer 2.5 Update." *Opcode Sequencer 2.5 Software Manual*. Palo Alto.

[9] Peitgen, H. -O., and Richter, P. H. 1986. *The Beauty of Fractals*. Springer Verlag: Berlin.

[10] Whitney, J. 1980. *Digital Harmony*. McGraw-Hill: New Hampshire.

[11] Zajec, E. 1984. "Computer Graphics: Color-Based Time." *Leonardo*. Vol. 19. No. 1. Pergamon Journals: Oxford.

Micro-Tonal Tuning via MIDI - a Proposed Standard With Implementation on the Ensoniq Mirage

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The reasons for micro-tonal tuning and the problems of implementation are discussed. Advantages of real-time pitch control are explored. A variation of the MIDI standard is proposed to support micro-tuning.

One of the amazing wonders of the present decade is the tremendous variety of high-technology synthesizers and sampling keyboards available at affordable prices. However, with few exceptions, these medium priced keyboards have all been manufactured with the equal-temperament scale permanently burned into their little silicon brains as if there were no alternative known or possible.

If you understand how tuning is accomplished in most modern digital synthesizers, it is difficult to comprehend why alternate temperaments aren't included. Pitch is determined by loading numbers into registers. Use a different table of numbers and you have a different temperament. Contrast this to the formidable task of re-tuning a harpsichord or pipe organ and then ask yourself why so few maufacturers of synthesizers have provided this useful option.

A skilled violinist, when playing chamber music, is able to make small (micro-tonal) adjustments in pitch to produce perfect harmony. With keyboard instruments, this is much more difficult. The physical principles of musical harmony do not allow a fixed 12 note octave to be consonant in all keys. Throughout the Renaissance and Baroque periods, many tuning systems were tried that would extend the pure non-beating harmonies to more than a few keys. The almost universal "equal-tempered" scale of today is a clearly audible compromise that achieves equal amounts of dissonance in all keys.

An alternative that has been considered for several centuries is the addition of more notes within each octave. Keyboards have been built with anywhere from 17 to 121 keys in each octave and a

During the past few years, a fortunate change has begun to emerge. Several significant articles on temperament have appeared in major publications. YAMAHA has introduced a somewhat usable version of programmable tuning into the TX-81Z and new DX7-II and TX-802 FM synthesizers. Also, third-party developers have begun to offer upgrades to add this capability to existing machines. There is hope that this trend may continue.

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

Some MIDI modules allow a separate instrument and pitch table to be defined for each MIDI channel. One possible solution would be to have several copies of the same instrument appear on different channels, each with its own individual pitch table. Different tables would be accessed over different MIDI channels. This method could allow some flexibility, but for most applications the channel assignment would require a complex algorithm. If poly-timbral capability were desired, this would become even more complex, requiring a separate MIDI bus for each MIDI module. The same pitch tables would have to be implemented in each module, and a different set of tables might be required for each MIDI sequence.

A more direct solution that sometimes can be used with modules such as the TX-81Z, is to assign a separate MIDI channel to each note of polyphony and to send precise pitch-bend data for each channel. The same equal-temperament instrument is assigned to each MIDI channel. This method only works with multi-channel modules that allow separate bend for each incoming channel. It also requires that the bend amount be calibrated carefully and that polyphony be defined by the sequencer or master keyboard so that separate notes will be assigned to separate channels.

Each of these solutions requires complex programming of both the MIDI module and the sequence data that operates it. Live performance from a MIDI keyboard seems unlikely in this enviornment. A much more useful method of implementing micro-tonal control would allow the pitch of each note to be defined by a MIDI message specifically for that note.

There are well established MIDI standards for all codes except the system exclusive message. The sys-ex message, with its long identification header, would require too big a time-slice to send for each note event, but to attempt to redefine the entire MIDI standard to suit special needs would be suicidal. We must therefore search for a solution that can be implemented within the present MIDI data structure.

Such a solution is possible if we are willing to redefine the function of an existing MIDI message. The poly after-touch code normally represents key-pressure, but not all modules and keyboards make use of this function at present. This code is a note-specific 7-bit value that can be used for any after-touch effect. There is nothing in the standard that would prohibit its use for micro-tonal control.

If we consider that the note-on event will sound a note at equal-tempered pitch, then the after-touch code can then be used to specify the pitch deviation from equal-temperament in cents. If this pitch correction code immediately follows the note-on code, it will be processed in time to cause the note to be sounded at the proper pitch. The after-touch code can have a value ranging from 0 to 127. If this is interpreted as a signed number it can have a value from -63 to +63. Defined in one cent increments, this range is sufficient to span a semi-tone. Thus our 6-byte long MIDI message can define any pitch in a ten octave range to within one cent of accuracy.

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

```
90 34 7F  ; Note-on for E
A0 34 08  ; Correct E to +8 cents
.................
80 34 7F  ; Note-off for E
```

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

This extended range also allows someone to create a generalized micro-tonal MIDI keyboard controller. The several hundred keys of such a keyboard could send the correct pitch data without the 128 note limitation imposed by the present MIDI note-on command.

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

The disadvantage of this standard is that it is not a feature already incorporated in any existing product by the manufacturer. It will need to be recognized as useful, before any manufacturers will consider adding it to their modules and keyboards.

Fortunately, several MIDI instruments are built with disk based operating system software. This design allows third-party developers to create alternative operating sytems that add many useful features, including micro-tonal pitch capability. These enhanced operating systems are simply loaded into the existing product from disk. Third party upgrades are also offered for several ROM based instruments and modules such as the Yamaha DX-7.

As a third-party software developer for the Ensoniq Mirage sampling keyboard, I have had the opportunity to create several alternate operating systems that add micro-tonal capability to this instrument. My first product allowed the Mirage to be played in any of a dozen historical 12-tone organ and harpsichord temperaments. This led to a second disk that allowed the user to define the pitch of each of the 61 notes to within 0.5 Hz accuracy. This disk comes with the a number of exotic scales including the Alpha, Beta and Gamma scales defined by Wendy Carlos.

As a result of experiments with these various alternate tuning systems, I have begun to realize that fixed tuning may not meet all the needs of some of the more sophisticated micro-tonal compositions.

A fixed scale also cannot handle true just-intoned temperaments. This realization has evolved into the idea of real-time MIDI control of micro-tonal pitch and the proposed use of the poly-after-touch code.

I now have an operating system disk that adds this capability to any MIRAGE. It has been used to realize a micro-tonal piece titled "**-and, as I was saying ...**" written by Harvard University composer Ezra Sims. This piece contains one-sixth tone, one-eighth tone, and one-twelfth tone pitch inflections sharp and flat of equal temperament.

He played this composition from the keyboard into Professional Performer in equal-temperament and we then inserted the pitch inflections. Although the insert-event feature of Performer was not as efficient as we would have liked, we were able to go through the score in a reasonable amount of time. The results were exactly what he had intended.

I have not yet been able to explore the dynamic re-tuning of true just-intonation performances, or to look into exotic 122 note/octave MIDI keyboards, but I believe that this standard would support both these possibilities and more. A standard does not exist unless it has enthusiastic support from many voices. I can only propose this standard and provide tools to explore it on a few instruments. It is up to the micro-tonal composers and performers of the world to embrace this standard or help to create a better one.

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

SOME RANDOM REMARKS ABOUT MUSIC SYNTHESIS

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Most music synthesists regard Bob Moog warmly as *The Father of the Synthesizer*. Present-day detractors of the technology he pioneered are loudly wishing that the progenitor had availed himself of prophylaxis! Their litany has it that most things wrong in the musical universe can be traced to the offending *circuitry*. But behind the highflown talk about tradition, sociology, intellectual property, and aesthetics, the economics of self-interest rears its ugly head.

The early composers of *electronic music* met with derision or indifference largely due to the *style* of music they produced. But the lunatic fringe is tolerated or ignored, because its members rarely cause *economic* repercussions. Modern practitioners of *music synthesis* seem less doctrinaire, and have accepted the new electronic medium as a tool for realizing music in a variety of styles. Now the earth is beginning to move beneath our musical feet--you can make money with these things!

I hesitate to defend something like *music synthesis*, which soon may possibly occupy a majority position, at least in commercial music. And in these Proceedings, I'm probably preaching to the converted anyhow. But a few comments might help us better understand the new electronic medium, and give those who hate it a better picture of what the problem really is.

Musical conservatives miss the point when they damn the synthesizer as a musical miscreant that threatens to upset the established order. Isn't it the time-storage devices that have had the most radical impact on music? It's too late to mutter about Bob Moog under your breath. You should have stemmed the tide when Les Paul and Mary Ford did *How High the Moon*, and other smash hits in the early 'fifties, using the multitrack tape recorder. They used a time-storage device to multiply themselves into a full vocal/instrumental ensemble. Two into eight equaled millions (of sales). Incidentally, Paul pioneered the *design* as well as the use of the Ampex 8-track sel-sync tape recorder.

Later, Wendy Carlos used the Moog synthesizer and the multitrack tape recorder to create *Switched-On Bach*, aka the electronic orchestra. She seconded Les Paul's motion, and also proved that electronic sounds are not necessarily artifacts of a style, but products of a *way* of making sounds. She also demonstrated that electronic sounds could be pretty, and not incomprehensible to the public.

Perhaps this music synthesis juggernaut could have been nipped in the bud if we could have predicted the remarkable similarity between MIDI and player piano technology, and acted to stamp out all communication between machines back when. What is a hole in a paper tape, but a logical "1"? It's no coincidence that early synthesizers (1929, 1945, and 1955) had paper tape readers. What is a MIDI sequencer but a warmed-over reproducer piano roll, or a multitrack tape recorder with some interesting punch in and punch out capabilities?

Well, too late. So, what do we do--as composers, performers, and teachers? First we humbly recognize that a new medium may not make everything that preceded it "obsolete." We reinforce the performance tradition by developing virtuosity on electronic instruments. We help manufacturers understand the imperatives of this tradition. We also recognize that the interplay of the realtime performance tradition with the possibilities of time storage (what we call non-realtime), might be fertile with musical possibilities. We explore software like *Jam Factory*, *M*, and *Ovaltunes*, and evolve a new performance mentality that can coexist with the traditional. We also make an attempt to discover those elements that are unique to the electronic medium, and exploit them thoroughly. We admit into our thinking that amateur music-making has a long tradition, and we see how new technology can fit that tradition. We also explore how this technology may be used as an adjunct to music-making (e.g. making scores, teaching basic skills, etc.). And, finally, without flinching or apologizing, we recognize the present reality that new technology in the arts usually has an economic as well as an artistic impact.

When sound movies came in, thousands of pit musicians were out of a job. Some turned to the sound stage or composed film scores. Sound recordings didn't kill the performer--they redefined performance. Video hasn't killed radio. We evolve--we survive. Music is a healthy, big business today. And on it will go, as one medium telescopes into another.

The Cybernetics of Extended and Intelligent Instruments

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The last few years have seen a great flurry of activity in what may be called 'computer-based interactive music systems'. In this period the adoption and exploration of the MIDI standard has coincided with a dramatic improvement in the expressive potential of the commercial synthesizer, enabling focus on the real-time control of sound by those without enormous financial resources. The spectrum of musical activities with "fixed" composition and free improvisation as its two endpoints has become increasingly densely populated, including activities which have variously been termed 'interactive composition' (Chadabe 1984), 'extended instruments', 'intelligent instruments' (e.g. Polansky, Rosenboom, and Buck 1987), 'hyperinstruments' (Tod Machover), and 'real-time performance synthesis' (David Mash). By these terms is meant an arrangement of people, musical instruments, computers, synthesizers and other hardware designed to produce music whose details are modified in real-time by the interaction of distinct parts of the system. The different terms propose different points of view about the activities involved, but they typically have in common computers, synthesizers, and MIDI. The issues go beyond music, for MIDI is also being used for the control of light displays, robotic motion, animation, et. al. Hence the goal of this article is to survey approaches to the design of such musical performance systems, show their relationship to more traditional models of instrument building, and try to identify and generalize the cybernetic issues which underlie the many approaches different workers have used.

An analytical and historical framework

To understand the development of interactive systems, we need to first look at their origins in traditional music making. We begin therefore by looking in detail at the human-instrument interface. Basically the process involved is the transfer of spatial and temporal information from the central nervous system/mind to the system that physically produces the sound. Any such information transfer operates from within complex traditions of culture, musical design and performance technique, and is shaped by human cognitive and motor capacities, as well as personal experience. In nearly all instruments, the information transfer from human to instrument begins with its dynamic encoding in human movement. The parts of the body that interact with the instrument are here called the body control source, or BCS. The parts of the instrument which are directly controlled or manipulated, and to which information is directly transferred, are called the control interface. The parts that actually produce the sound are called the effector mechanism. Intervening between the control interface and effector mechanisms there is often a processor of some kind that converts information in control format to effector format (yielding appropriate form, range and sensitivity). The remaining parts of the instrument (the housing) have decorative or structural functions, and most commonly relate to cybernetic issues only peripherally, through their aesthetic or historical associations. See Figure 1.

Playing An Instrument

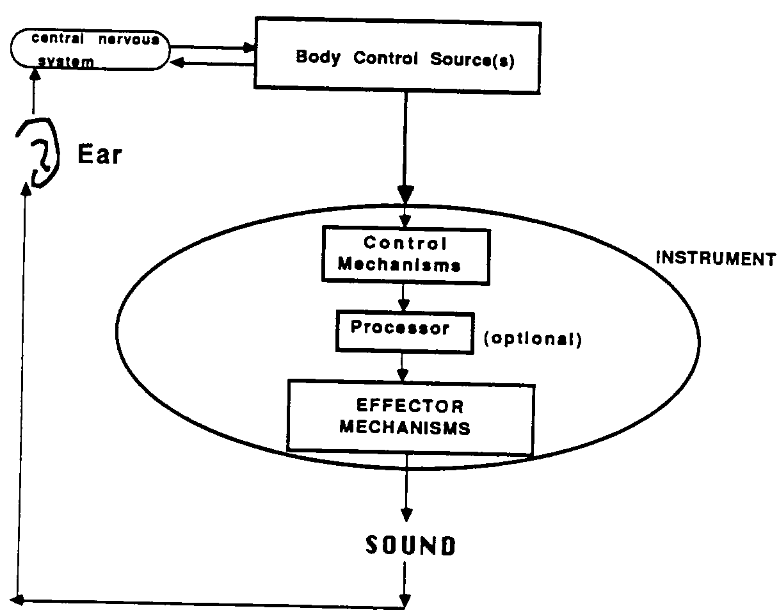

Figure 1

To take an example: consider the piano, an instrument which is arguably a beautiful sonic and cybernetic "composition". Here the BCS is normally the hands and feet, the control interface includes the keys and pedals, the processor is the piano action mechanisms, effector mechanisms are the strings and sounding board, and just about everything else is housing. This descriptive model, I believe, will fit any instrument.

If we take for a moment the general perspective, there must be few clearer tributes to human resourcefulness than the variegated history of instrument building and adaptation (cf. *The New Grove Dictionary of Musical Instruments* 1985). The astonishing variety of playing techniques, control interfaces and effector mechanisms, aesthetically inspiring housings, as well as the rich diversity of underlying theoretical and musical perspectives, show the deep and heartfelt concerns of musicians aiming to build expressive musical intelligence into instruments. In comparison, development of even the most sophisticated contemporary electronic instruments is at a comparatively rudimentary phase, and, as Michel Waiswicz has pointed out (Waiswicz 1985), the recent digitalization of synthesizers has in some ways decreased their overall real time controllability relative to the 1 knob 1 function design of older analog machines. It is wise to keep what we are doing in perspective. Yet the introduction of digital design and intelligent system components has allowed the systematic relaxation of some (often unrecognized) assumptions which underlay traditional instrument performance, and has enriched the spectrum of possible musical protocols lying between composition and improvisation.

Body control sources include all movable parts of the body in principle. But there can be little question of the heightened control sensitivity of the hands, mouth and vocal tract/diaphram, relative to other parts of the body. If these BCSs are primary, then the feet and arms are secondary, and other parts tertiary. This is confirmed by both a cross-cultural survey of instrument virtuoso traditions, and neurophysiological studies of the amount of cerebral cortex used to process sensory data from various parts of the body. (In many psychology texts this is illustrated by a standard diagram called the motor homunculus.) The design of new instruments has throughout history has followed these facts. We find no significant eyelash or toe controlled instruments, to the best of my knowledge, for example.

Two alternative performance protocols

But before looking at the next step in the information chain of 'person physically manipulating instrument', two other performance protocols deserve mention. (The reader in search of further historical detail in this area is advised to consult Mumma 1975 and Davies 1985a and 1985b). The first of these fundamentally different conceptualizations relies on using information from the human body not produced by voluntary physical movement, that is, it is either traditionally considered to be involuntary, or doesn't directly involve motion in space. This information is monitored, amplified and/or transduced to be used either as 1) a sound source, or 2) a control source for sound production. Examples of the first usage are Pauline Oliveros' Valentine (1968) or Merce Cunningham's Loops (1971), which are based on the amplified heartbeat. The second usage has most commonly been based on brainwaves (EEG) or myoelectric signals from muscles (EMG). Alvin Lucier's Music for Solo Performer 1965, David Rosenboom's Ecology of the Skin (1970) and later suggestions

(Polansky, Rosenboom and Buck 1987), and electronic devices in works by Richard Teitelbaum have exploited brainwave control. Myoelectric control has been outlined, for example, by Gillett, Smith and Pritchard (1985). Polygraphic body status-monitoring has been used by Ruth Anderson in Centering (1979).

The second type of novel instrumental control occurs when the human operator shapes some external ongoing process or its effects (naturally occurring or designed) that is being concurrently amplified or transduced to function as, again, either a sound source or a control source. Shaping can be simply turning on and off, filtering, or various types of parametric control; a simple but familiar example is the operation of a mixing console at a live concert. If the external process is not affected by the manipulations, we have a kind of instrumental control model. If it is affected, we approach an interactive system, but one with only monodirectional intelligence flow.

This second type of control is actually very ancient, since it includes some of what is usually called sound sculpture, which almost certainly dates to prehistoric times. Wind-driven sculptures, for example, are mentioned in many cultures, such as the case of the statues of one of the Colossi of Memnon, Amenhotep III, erected about 1375 BC in Thebes, whose head 'sang' every sunrise for the period 27BC-200AD, following an earthquake. Some water clocks and musical fountains also belong to this tradition. Yet most such sculptures are not people-powered, and hence are not directly relevant to this discussion. Neither is the rich history of musical automata (Bowers 1972). However, some sound scultpure *is* meant for human interaction, such as the foot pressure activated carpet of Horst Gläsker's Tret-Orgel-Teppich-Objekt, or Stanley Lunetta's Moosack Machine, sensitive to light, temperature and proximity, or some of Michel Waisvisz' sound machines. While preparing this article at MIT, an interactive sound sculpture of large vertical hollow metal rods was installed at my regular subway stop, Kendall, operated from either side of the tracks by a handle which set the rods into irregular collision with each other.

Outside of the confines of the term sound sculpture more exotic information sources, often relying on relatively sophisticated scientific sensing devices, have been used. These include electronic disturbances in the ionosphere (Alvin Lucier's Whistlers 1966), the earth's magnetic field, vibrations in the earth, and pulsars (Annea Lockwood's World Rhythms 1975), the radio (John Cage's Imaginary Landscape No.4 1951), a Geiger counter (Cage's Variations VII 1966), moves on a chessboard, a variable speed turntable, incoming telephone calls to a radio station (Max Neuhaus's Public Supply 1966), voltages from plants (Ed Barnett, Norman Lederman and Gary Burke's Stereofernic Orchidstra), and so forth.

Both these unusual performance protocols have in common strong elements of unpredictability, where musical production is controlled to a considerable degree by neither performer nor composer. The listener is left in some cases to provide the sense of the resultant sounds, without reference to any tradition.

Cybernetics of the control interface

We turn now to the next step in information transferral in the traditional instrument design of Figure 1. This is an examination of the issues involved in the control mechanism of the instrument. The performer's body parts interact with the control interface, and information is passed on for further processing. It is not possible to completely disengage this part of the control chain from subsequent parts, since an aural feedback loop controls the entire system. But it is possible to list some fundamental issues which must be addressed by anyone designing an interface for human interaction. We consider here the following ten fundamental issues:

1. Physical variables carrying the information, as a function of time
   -position, force(pressure), acceleration, velocity, area(shape)
2. Dimensionality of control
   -1-D, 2-D, 3-D or greater; strong/weak dimensions
3. Multiplicity of control
   -how many parallel streams of independent information(e.g. musical lines) can be sent simultaneously from a specific controller?
4. Control modality
   -discrete, continuous, or quantized continuous (meaning that the control interface is physically continuous but it dispatches only a limited set of discrete values)
5. Control monitoring
   -one-shot or continuous time; hold last value or zero return; skips out of the continuum possible or continuous output only
6. Control distance function
   -monotonic, nonmonotonic, partially recursive; mono/bipolar
7. Literalness of control
   -one-to-one = WYPIWYG (what you play is what you get), one-to-many, many-to-one, unpredictability (stochastic, chaotic), response delay, time dependence
8. Historical foundations
   -using an existing technique, modifying an existing technique, or creating a new technique
9. Design appropriateness
   -design efficiency, ergonomics, motor and cognitive loads, degree of sensory reinforcement and redundancy, appropriateness of gestures to expression
10. Psychological nature of control
    -perceived naturalness of the link between action and sound response; reflexive-creative continuum; exploratory or goal-oriented

The issues will be explored selectively, initially by looking at some well-known examples. Consider the violin played arco, issue by issue. The physical variables carrying information are primarily downward bow force (coding for dynamics), horizontal bow velocity (primarily affecting timbre), bow distance from the bridge (affecting timbre) and finger position on the fingerboard (coding for pitch). Hence there are 3 or 4 control dimensions in total for a single melodic line. Control multiplicity is 2 (in the hands of a first-rate player, 2 independent lines are possible). Control modality (the spatial nature of control) is continuous, as is control monitoring (this means continuous time read-out of what the performer is doing). The distance function is partially recursive. This last term means that each string when stopped is a monotonic pitch controller, but there is more than one place to find each note. Control is traditionally highly literal on the violin, given good technique, with the exceptions of certain types of extended techniques, such as bowing sul ponticello (actually on the bridge) or on the tailpiece. Otherwise, what you play is what you get (WYPIWYG).

The origin of the technique used for the violin was clearly based around existing techniques on previous instruments like the viols (Issue 8). Of the design appropriateness of the violin for expressive sound production there can be little doubt (Issue 9). Visual feedback of position is clearly quite adequate for the musicality of a seasoned professional; but it could be called insufficient for those below this standard, to a discerning listener. Its ergonomics can certainly be called into question, as many violinists with stiff necks will readily testify. The violin is seemingly well-designed gesturally, and can be used profitably with various psychological playing protocols, as most traditional instruments (Issue 10).

Let us take as a second example the trombone, and focus on the first seven issues, since the last three are similar for most orchestral instruments. The trombone responds to embouchure (shape, area, pressure variables--affecting pitch and articulation primarily), slide position (one-dimensionally affecting pitch), and breath pressure (affecting dynamics). Hence it has 3-4 independent control dimensions. Its pitch control modality is continuous/discrete (slide + overtone choice with embouchure), it has a fixed physical zero (the slide first position), its distance function is partially recursive, control multiplicity is 1 (with the exception of various sing and play techniques) and control is highly literal given good technique (WYPIWYG). Some recent techniques, such as using a saxophone mouthpiece in place of the usual one, produce novel stochastic results within a certain class of sound events.

As a third example we look generically at the current crop of synthesizers and synthesizer controllers, which form the essential control and sound production components of most current intelligent music systems. These machines, with few exceptions, have their primary variables (always including pitch) controlled by an interface that imitates a traditional instrument: keyboard, guitar, wind controller, percussion controller, violin, etc.. Ancillary controllers add to this, and include the wheel, joystick, dial, knob, lever, drawbar, strip, ribbon, foot pedal, foot switch, button, 2-D touch pad and surface, struck pad or bar, slider, breath controller, pressure sensor (single channel or polyphonic), proximity detector (body capacitance or resistance based), pitch to MIDI converter, and accelerometer. Most synthesizers are keyboard synthesizers, with basically two control dimensions per voice (key #, key velocity) plus channel pressure, for a possible total of 2 x 3 + 1 = 7 dimensions, if we somewhat arbitrarily say that a performer's two hands at the keyboard can play 3 parts with complete independence. (This figure obviously can vary with performer, and is musically context-dependent; it seems a best compromise value for the rough calculations involved here.) If we add in controller effects (2 feet and breath controller), the number rises to 10.

Keyboards(and other controllers) with polyphonic aftertouch have potential for greater control. Taking 3 as the nominal number of independent parts, this can yield up to 10 dimensions of control from the keyboard alone, a potential that remains largely unexplored, since instruments with polyphonic pressure are still not common (but see discussion below). If ancillary controllers can be used simultaneously, as in the case of foot and breath controllers, then an additional 3 dimensions are possible, for a total of 13.

The ancillary MIDI controllers have become fairly standardized, perhaps partly since they are almost all based on either position or force (a few less common ones, not discussed here, respond to area or acceleration). Their control features are listed in Table 1.

physical controller	dimension	modality	zero return/ hold?	skips possible?	sensory reinforcement	fully independent?
mod wheel	1	mono	hold	no	good	yes
pitch bend wheel	1	bi	zero return	no	good	yes
joystick	2	mono/bi	zero return	no	good	yes
slider	1	mono	hold	no	very good	yes
strip/ribbon	1	mono/bi	both	yes	very good	yes
breath controller	1	mono	zero return	no	good+	yes
foot controller	1	mono	hold	no	fair+	yes
channel pressure	1	mono	zero return	no	good+	no
poly pressure	multi	mono	zero return	no	good+	no
note selector (keyboard, etc.)	1 or multi	variable	---	yes	excellent	yes

+ entry describes tactile feedback only; visual reinforcement is nil

Table 1: Controller Features

The first two columns are, I hope, self-explanatory. Column 3, modality, refers to whether the range of control is monopolar (moving only one direction from zero) or bipolar (moving both directions from zero). Zero return or hold refers to whether the control keeps its position on release or snaps back to zero. Most controllers cannot skip to arbitrary points in their ranges, but must send out intervening values; those that can skip have a yes in column 5. The sensory reinforcement of controllers is mostly good, but it has two components. First, there is the direct tactile feedback of the body part in contact with the controller; second, there is sensory redundancy, usually visual, that promotes accuracy of performance by not having the player put all his or her eggs in one sensory basket. In other words you see as well as feel and hear the control. Four controllers have limitations in this area and are marked with † in column 6. Finally, some controllers are only usable in tandem with other controls and are therefore not fully independent: this refers to the pressure variables, since they are inaccessible without a previous key depression.

Given these examples let us consider issues 7-10 above more fully. Just what are the optimum ergonomic, philosophical and psychological principles of instrument design? This question is too vast to address comprehensively in this single article. But it is useful to look at some of the points of reference before proceeding on to extended and interactive systems.

The desirability of literalness of control is an implicit or explicit design principle in the instruments of every known musical culture. Exceptions are extremely rare until 20th century Western culture, and are even so a question of degree only (as in some rough hewn folk instruments like the gut bucket bass). Yet literalness is in another sense more an attitude to music than an absolute factor in musical design, since such unpredictable effects can be readily achieved on all traditional orchestral instruments: col legno or sul ponticello strings, woodwind multiphonics and reed biting, the properly prepared piano, etc. Electronic instruments can also function this way, by overloading, feedback, or pathological choices of parameter values, as in the 'mistreated' oscillator circuits used in compositions by Louis and Bebe Barron since the early 1950s. But I have seen such effects achieved most readily with either lo-tech mechanical/electromechanical conglomerations, or extended string instruments, for example the stringed sound devices of Jon Rose, where multiple and movable bridges (and bizarrely constructed single and multiple bows) mean that the instrument is really continuously evolving under one's hands during performance, so that technique must be continously upgraded during playing. A joyfully risky form of improvisation at its best.

The remaining issues above (8-10) are interrelated. One central design question is whether the control mechanism should use an existing technique, modify an existing technique, or propose a completely new technique. It is of course a question of degree, since very little is really without precedent in this world. But the short answer historically has always inclined towards conservatism. The tendency is the same today. The reason for this is not hard to find. As William Hazlitt (1778-1830) said ca. 1820: "We never do anything well till we cease to think about the manner of doing it." A new technique takes that much longer to master to make sub- or unself-conscious. Until that stage is reached, real musical expression does not emerge. Yet new technical procedures do come forward when the time is ripe, often blossoming several places independently. In recent times one can point to the popularization of two hand hammer-on technique for the guitar, and the development of such technique for Emmet Chapman's new instrument The Stick.

Another way to look at the issues is from the perspective of transformation of gesture. People act expressively by way of gesture, by which I mean the integrated producton of motion shapes, characterized by parametric control and accuracy of approach to goals. Cadoz (1988) has discussed these issues with regard to MIDI systems, pointing to an incomplete classification of gesture into modulation (parametric or sound object shaping control), selection (picking from a range of discrete values), or exciter (putting energy into the system, e.g., with a violin bow) gestures. Gibet and Florens (1988) have modelled gesture using simple mechanical systems. Azzolini and Sapir (1984) used a gestural system for real-time control of the Digital Processor 4I. Other gestural descriptions can be based on associative kinetic images, like *scrape, slide, ruffle, crunch, glide, caress*, etc., as used in modern dance instruction. Such ideas have been implemented by some dancers by the use of special costumes or body position monitoring effects(e.g. Gillett, Smith, and Pritchard 1985). Other workers have focussed on the idea of a spatial *trajectory*. What is clear is that gesture is complex, diverse, difficult to systematize, and strongly related, when used as a control source, to what it is routed to control.

This is apparent in the difficulty encountered in playing certain instrument sound types via a MIDI keyboard. For example, playing sets of drums is very challenging, because the small finger motions characteristic of piano technique do not seem to provide the right type of gestural link to the power and required rhythmic precision of percussion. Consequently, either a large amount of special practice is necessary, or a two arm technique which uses the fingers primarily like the mallets in classical multi-mallet percussion technique. Some synthesizer players who emphasize expressive real-time performance use breath controllers and strap-on type keyboards, and have evolved a system of 1-1 gestural mapping between musical effect and body motion, linking the small appropriate finger motions to larger and expressive body gestures. It not only makes for a more engaging performance visually, but is objectively effective in increasing the reliability and integrated musicality of performance.

An Imaginary Superinstrument

The question can also be asked, just how much control is humanly possible? The limitations in principle are apparently both motoric and cognitive. To frame an answer to this we perform a Gedanken experiment, by building an imaginary superinstrument. We quantify the control issues in a very rough way by using our idea of dimensionality, with the underlying possibility that an active dimension of control requires something like an active channel of attention or considerable focussed preparatory rehearsal to diminish the real-time cognitive load (Pressing 1984). This supposition has its limitations, but it should do for our purposes here.

Discrete switches with a few states will be disregarded in this calculation in comparison to continuous variables or switches with many states, many meaning at least a dozen or so (e.g. woodwind fingerings or the keyboard). But one needs to also consider how much sound modification is expressible in the dimension in question. If this is intrinsically limited, either by the nature of the mapping to sound, or by the limited resolution of the dimension, we will label that a weak control dimension. In making such an evaluation, it is necessary to look at the entire chain of control. For example, one-shot monitored dimensions are often weaker than those based on continuous time. Yet perceptual factors can work against this tendency, notably with regard to the attack portion of envelopes (typically controllable by key velocity directly, or indirectly via the layering of sounds, a one-shot monitoring protocol), which has disproportionate influence over perceived timbre relative to steady state sound (typically controlled by continuous time monitoring). It is also conceivable that one could design superstrong control dimensions that had atypically powerful control capacities, perhaps with the aid of commercial micromanipulation devices. I have not yet heard of anyone doing this with music.

As we saw earlier, monophonic traditional instruments have something like 2-4 dimensions of control, with one of them possibly weak; polyphonic instruments have 2-3 per independent voice. A historical survey of a wide variety of traditional musical instruments is consistent with this. It is also true of a majority of contemporary instruments based on synthesis. But confirmation that performers have often wanted more control is provided delightfully by such stories as that of J.S. Bach using a stick in his mouth to play additional keys at the organ (Lebrecht 1985).

To see what might be possible, we first note that it is a physical fact that each controlling body part could in principle code six dimensions (3 of position, 3 of orientation). Since traditional instruments have 2 or 3 controlling body parts, 12-18 dimensions total are readily available in principle under this simple design. But let us carry this further. Of what might an imaginery superinstrument be capable?

We may try to estimate the dimensionality of control possible for human beings as follows: Accepting hands as the most sensitive controllers, and focussing on traditional physical variables, we assume that each finger of each hand could in principle act independently (against an external reference frame) over 2 dimensions of position and a third dimension of pressure, as could each foot; breath pressure could provide one additional control and perhaps positions of the knees could add one or two dimensions. Hence there is no reason that $(10+2)\times3+1+2 = 40$ independent dimensions of control not operate simultaneously, on purely physical grounds. However, as suggested above, all existing forms of music performance (and similarly for dance and sport) use so much less than this capacity that there must be a strong suspicion that cognitive limitations impose far more restrictions than motor control limitations.

A discussion of the cognitive limitations that pertain to performers would be pertinent here, but it would take us too far from our central concerns. The issues are very similar to those encountered in the cognitive modelling of improvisation, and these have been discussed in depth in two of my recent publications, to which I refer the interested reader (Pressing 1984, 1988b).

Likewise, this article will not discuss in any systematic way the effector mechanism part of the music synthesis control chain, for the simple reason that this would require a full survey of current synthesis techniques, a vast undertaking. Instead, we illustrate with examples drawn from recent work on extended, reconfigured, and intelligent instruments, looking particularly at widely accessible MIDI-based systems.

Extended and Reconfigured Instruments

We define these terms here as follows. An extended instrument is one which adds new physical controls to an existing (traditional) control interface. A reconfigured instrument is one which has an unchanged control interface, but has been reprogrammed or rebuilt so that traditional technique gives distinctly different results, necessitating technique modification. If control mechanisms and resultant effects are changed radically, we have essentially a new instrument, rather than an extended or reconfigured one. But in this section we restrict ourselves to a few chosen topics.

We look first at extended keyboard interfaces. The term raises the question: extended relative to what? All synthesizers are extended relative to the piano, due to their ancillary controllers (even as they are more limited in certain ways, such as pedalling). Here we use as our reference instrument the generic MIDI keyboard synthesizer. Keyboards of greater than normal control capacity include the Kurzweil Midiboard, which has 4 dimensions of control per voice: key number, key-on velocity, release velocity, and polyphonic pressure. A step beyond this is Key Concepts' Notebender keyboard, where keys can move in and out as well as up and down, giving 5 dimensions of control for each note, 2 of them of continuously monitoring type. Big Briar's multiply-touch sensitive keyboard goes even further, sensing key number, key velocity, release velocity, polyphonic pressure, and two further dimensions of control derived from 2-dimensional finger position on the chosen key (Moog 1987). This yields 6 dimensions of control per note, and if we assume that a player can control 3 such note streams with full independence at once, and also operate 2 foot pedal controllers, we get 6x3+2 = 20 dimensions of simultaneous control. That's a lot to think about, and it approaches half of our superinstrument's control capacities. The full potentials of such systems have barely begun to be explored.

We look next at the reconfigured instrument approach, which will be treated in more depth, since the instruments involved are much more widely accessible.

Consider the DX7-II as an example, since it is typical, widely known, and keyboard-based. Despite the increasing use of non-keyboard control interfaces, keyboards still remain the most widespread synthesizer performance device. In the interest of space, we reluctantly omit any detailed discussion of these other controllers.

DX7-II real-time control mechanisms and, in parentheses, their respective functions are: keyboard (pitch selection, key-on velocity); pitch bend wheel (pitch bend); modulation wheel, breath controller, foot controller, aftertouch (all 4 assignable to modulation and volume, some to pitch bend); 2nd foot controller and 2 control sliders (almost arbitrarily assignable); 1 foot switch (sustain); 2nd foot switch (limited assignability) and the 32 (performance) or 32 x 2 (single) program change switches. The two wheels can be played simultaneously with the left hand, but their engagement halves the potential for keyboard control (although a few bass notes can be simultaneously accessed for specified circumstances); likewise, the two control sliders largely use up the left hand's control potentials. If both hands are maximally engaged with the keyboard, we have 3 x 2 + 1 (aftertouch) + 2 (foot controllers) + 1 (breath controller) = 10 control dimensions. If only the right hand plays, with the left hand on two controllers, we again obtain 2 x 2 (2 independent lines) + 1(aftertouch) + 2 (l.h. controllers) + 2 (foot controllers) + 1 (breath controller) = 10 control dimensions.

The kinds of modifications of traditional keyboard technique achievable can be fit into the following categories, and are demonstrated by examples:

1. Key velocity effects--For example, the components of a sound can be given different velocity dependence by putting different velocity sensitivities on different stacks of operators. This requires a conceptual readjustment from velocity as a dynamic control to a timbral selection control.

2. Keyboard reconfiguration-- The many possibilities inherent in split and layered keyboards are one aspect of keyboard reconfiguration. These have been widely discussed elsewhere (e.g. Pressing 1988c, De Furia 1988); here we focus on the DX7-II's built-in microtuning function. This allows the keyboard to be assigned any arbitrary tuning system on a note-by-note basis. Keyboard reversal is one possibility. In one of my pieces, Constellation, a commission for the Melbourne group Pipeline, the keyboard is configured to preserve 12-note tempered pitch classes, but with an irregular pattern of multiple octave displacements up and down. With this set-up simple physically conjunct patterns map into radical leaps. In another movement of this same piece, 1/4 tone and semitone tunings are layered together, enabling the improvising player to think in either tonal space. Thus either the semitones can be heard as 'overtones' for the 1/4 tone organization, or the reverse, depending on volume and envelope settings, which are changeable in real time by using control sliders or pedals. Fingerings for familiar musical materials must then be learned for both tuning systems (Pressing 1988d). Other possibilities include micro/macrotuning(increasing resolution at the expense of range, or vice versa), key redundancy (many-one mappings to make errors difficult to make),

quasi-redundancy (to allow microtonally different versions of the same note to be accessible) and tuning by distinct interval cycles within selected ranges(e.g. C3 --> C1, C#3 --> F1, D3 --> Bb1, etc.; C4 --> C2, C#4 --> Eb2, D4 --> F#2, etc.), to single out only a few possiblities.

3. Articulation changes--For example, staccato and legato can be reversed by putting carrier envelope settings in certain ranges, e.g. rate(level) 90(99)42(85)82(0)38(0). Or, hypersensitive technique may be required with certain sounds consisting of streams of notes, such as those produced by LFO square-wave pitch modulation.

4. Pedalling--features such as portamento can be turned on and off during performance. Technique is limited here relative to the piano, say, since the synthesizer foot pedal is a switch and not capable of the piano's range of subtle gradation.

5. Interactions with unpredictability--this idea, well-known to those who habitually operate in the low-fi end of the technological resource spectrum, means that the performer gets out (at least partially) unpredictable output for the same input. Three ways to get this on the DX7-II are

a) by using the random pitch function
b) by using the LFO sample and hold function without sync at very low rates
c) by using pathological envelope generator values: e.g. slow attacks, with level 1 = 0, which produces erratic sustaining sounds and other effects on most patches

Of course, in addition, the many ancillary controller effects that distinguish the synthesizer from an instrument like the piano can be brought into play. Their cybernetic features were surveyed earlier, and they will be discussed from this point on only in the context of examples.

All of the above effects can be vastly expanded by using external real-time MIDI transformation devices, such as the Yamaha MEP4, Digital Music Corporation's MX-8, or seemingly the most versatile of all, the Axxess Mapper. Equivalent software is in the offing. Such devices allow MIDI data to be altered by multiplication or addition, modulo 'filtered', range limited, inverted, time delayed, or completely reinterpreted by changing MIDI status bytes. Data lists may also be triggered, with variable entry points, and the effects can be compounded to produce a remarkable variety of instrument transformations. Increasingly, some of these types of effects are being built in to synthesizers.

To give a simple example, it is possible to configure a keyboard to have 2, several, or many completely different sounds under each key, with the choice between sounds controlled by key velocity, or, with some systems, an ancillary controller. Such velocity crossfading and switching generalizes the DX7-II case discussed earlier, and requires a radically different playing technique.

A second simple example is the editing of sound synthesis parameters in real-time, which can remove much of the problematical envelope monotony implicit in an unsophisticated approach to commercial MIDI products. These programmed control functions can be accessed externally by specially designed master controllers like the Yamaha KX88, or from any controller by using an appropriate MIDI transformation device. The DX7-II provides such real-time control of any 2 of nearly all of its synthesis parameters by using the built-in control sliders CS1 and CS2. I chose this type of set-up in a piece I recently composed and performed in Melbourne and Perth, Rotating Gesture, where the keyboard was reconfigured with a split and transpositions so that it was redundant at the double octave. This greatly simplified the playing of repeated note and hand interleaving patterns. Interacting with the played notes was a Macintosh computer, which had pre-recorded changes in programs, envelopes, and oscillator frequencies. So the performer was responsible for the notes and the computer for the timbral shifting.

A third example shows the potentials of altering MIDI status bytes, so that commands sent out by the hands are received completely reinterpreted by the synthesis module. If polyphonic pressure messages are converted to note on commands, repeated notes are produced from each key at a rate proportional to the rate of change of pressure, and with a key velocity given by applied pressure. If the poly pressure messages are converted to note on commands with the data bytes swapped, pressing on a key after striking it produces hypervirtuosic chromatic glissandi. These can be changed to scales or arpeggios by filtering out some note on messages. This technique should only be tried with sounds with nonzero steady state, since the note on commands produced are not followed by note offs. In general, status byte conversion is an area rich with possibility.

The Colour Organ and Beyond

An interesting aside to the above tale of development is provided by a brief look at the history of 'colour organs'. These are keyboard devices designed to 'play' the colours of projected light. The dimensionality of sensory product is different from music, since although colour may be viewed as 1-dimensional and monotonic (like pitch), two dimensions of shape are also available for control. Since such organs can also play music, the nature of the relation between music and light projection is also raised in a number of cases. Quite early on inventors of such machines realised the unsatisfactoriness of a literal isomorphic relation, although a certain number of models with this simpler relation are found in every era, as in today's disco.

An early attempt in this field was the clavecin oculaire ('harpsichord for the eyes') of Louis-Bertrand Castel (1688-1751), developed about 1725-30, which used an arrangement of coloured tapes through which light passed. Later notable products were the Rimington Colour Organ (1895) of British inventor Wallace Rimington, and Thomas Wilfred's Clavilux (1925), which projected colours directly onto a screen, and was widely used in collaboration, as in a 1926 performance conducted by Leopold Stokowski of Rimsky-Korsakoff's Scheherezade. Compositions featuring a notated colour line include Scriabin's

Prometheus (1909-10) and Schönberg's Die Glückliche Hand (1913).

With the advent of the laser new kinds of projection have become possible. An early installation was Iannis Xenakis' light and sound spectacle called Polytope de Cluny (1972); the laser light show has now become a commonplace. Other systems using light-emiting diodes, banks of light bulbs, liquid crystals and holographical projection are also widely used. For the most part, however, these seem to be compositions where controlling data are stored on tape or computer disk; they do not use the instrument-live performer protocol. This too may be changing. Video synthesizer technology provides real-time control, but this has for the most part not relied on traditional music control-type interfaces. The Fairlight Computer Video Instrument is an interesting exception, used, for example, by Michel Waisvicz. Another is Ralph Abrahams' MIDI keyboard-based image processing machine, which processes images by means of mathematical transformations (convolutions, functional operations), one to a key. The area is rich with possibility.

Interactive and Intelligent Instruments

We tackle the concept of intelligent instruments by considering the fundamental process to be an 'interaction' between 2 or more 'agents', to borrow and use somewhat differently a term Marvin Minsky has revitalized. By interaction we mean mutual influence. By agent we mean anything capable of displaying intelligence in the control of music production. This can be a person, non-human living thing, computer program, robot, sequencer, hardware box or invoked process(naturally occurring or designed). The simplest set-up is one with 2 agents, and larger set-ups can be readily generalized from the basic case. A schematic representation of a basic 2-agent interactive music system is given in Figure 2.

In simple terms, sound(S) and performance data are produced by the two agents. The agents' choices are shaped by previous output, and by a variety of operating constraints, including cognitive and motoric limitations, stylistic and formal adherences (score, referent, plan), knowledge of interpretive traditions, etc. The performance data they produce are of two types: representation (R) and transformation (T). Representation data describe or represent the musical output of an agent. Transformation data are data produced by one agent, designed to affect the output of other agents. These are the data that make the system interactive. Sound is either produced directly by manipulation of a musical instrument, or with the aid of an intermediary representational form, using some kind of control device. This intermediary representation is most commonly MIDI code, but traditional music notation, graphic notations(e.g. 2-D computer displays as in Laurie Spiegel's Music Mouse), Music N type event lists, spectral display schemes, as well as other designs, are also used. The reverse procedure also happens, not indicated in the figure: representations are

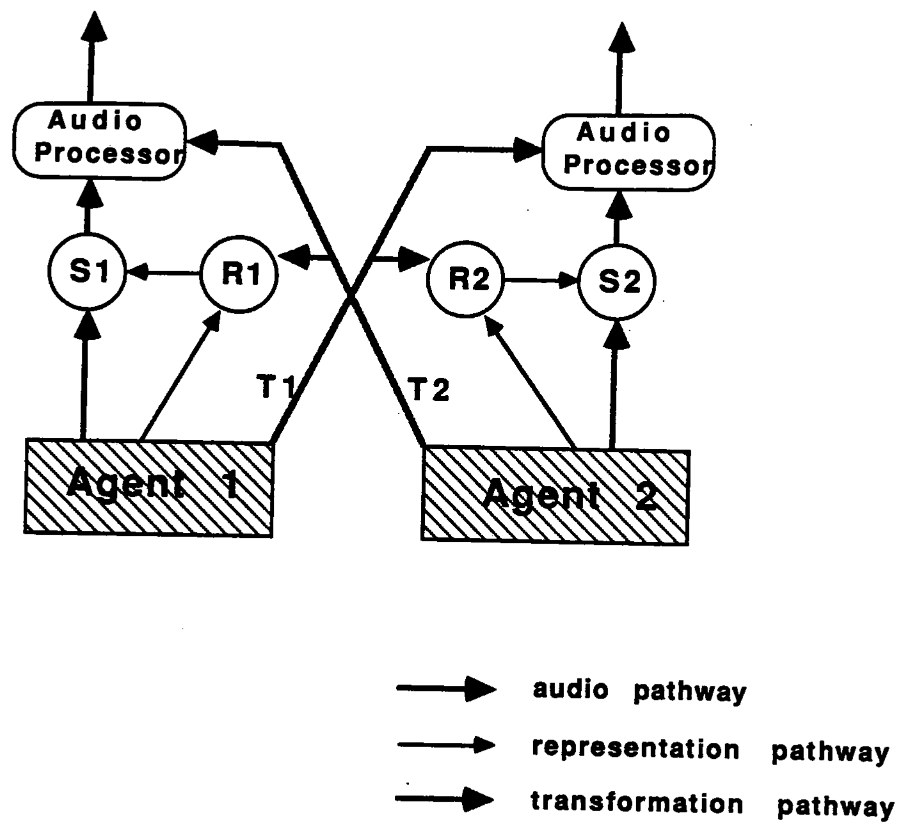

Figure 2: The Interaction of Two Musical Agents

produced by directly converting sound from the instrument, most commonly via pitch-to-MIDI or amplitude/spectrum-to-control voltage converters.

The essential interaction process involves transformation data from one performer affecting the output of another performer. The transformation data operate either directly on the sound (via real-time controllable audio processing devices), or on its representation (most commonly, via MIDI-based processors). This means that MIDI remains the dominant means of control used, since there is a strong recent tendency for audio processors to be MIDI-driven(e.g. MIDI mixers like the Yamaha DMP7 and digital effects units like the Lexicon PCM 70). Although MIDI has noticeable bandwidth limitations (Moore 1987), these are not often very significant when each performer uses a separate MIDI routing. Work not based on MIDI includes Gordon Mumma's Cybersonic Consoles (Mumma 1975), older 'analog' systems with plentiful knob-twiddling possibilities, existing devices using a QWERTY keyboard for real-time input (e.g. the DMX-1000 DSP, cf. Truax 1984), and Morton Subotnick's Ghost Boxes (a series of real-time controllable audio processors).

If we look critically at what distinguishes an intelligent or interactive instrument from a traditional one, we find that the boundary is rather fuzzy. In insisting on the creative intelligence of the instrument, we open ourselves up to familiar criticisms about the difficulty of defining the nature of intelligence. We'll avoid the debating traditions on this issue here for reasons of space. There is also the question of historical perspective. Who will deny that the piano's success is not due to the sonic and mechanical intelligence built into it by a long series of designers? We have come to accept struck string sounds coming from the pushing of levers, with no memory of an earlier period when that was a radical novelty. The argument, of course, must be that it is the reconfigurability and real-time decision-making capacity of such instruments, and the use of software to do it, that makes the current approaches novel. Yet since the ideas of instrument extension and reconfiguration go back far in time, a perspective that emphasizes the conection with earlier acoustic traditions, like *luthier nouvelle*, seems historically more valid.

A particular configuration of connections, instruments, computers and processing devices functioning as an extended instrument we call a set-up. Each set-up will call for appropriately de- and re-fined technique from the human performer(s). "The problems .... are those of defining a compositional algorithm and deciding which of its variables are best controlled by a performer and with what device." (Chadabe 1984, p.26). One common case, for example, is where one agent (e.g. a person) produces only sound events (e.g. notes at a MIDI keyboard) and the other agent (e.g. a computer) produces only transformations. The reverse assignment of person and computer is also possible, but rarer.

Issues and Instances

As earlier, we adopt the approach of constructing a framework of design issues, exploring what kinds of MIDI-based transformations are theoretically possible. Existing work by different artists will be placed in this scheme, as will some suggestions for development. I will assume that the reader is familiar with the general aspects of the MIDI message protocol.

A number of central design issues underlie the construction of computer-based interactive or intelligent instruments. Here are six such issues, phrased as questions:

1. Range of operation: Does the transformation operate on each sent message

alone, or on groups of messages? Can data bytes of different messages be combined? Example: note-by-note transposition vs. note group permutation.
2. Status change: Is the MIDI status byte (message type) preserved under the transformation, or not?
3. Use of Precomposed Materials and Processes: Does the transformation incorporate other composed or pre-recorded material or processes, or not? Are the stored musical materials algorithmically defined, or produced intuitively?
4. Time Independence: Does the nature of the transformation change from moment to moment, or is it fixed?
5. Unpredictability: Does the transformation contain elements of unpredictability, or not?
6. Design Flexibility: Is the set-up hard-wired, or does it provide a readily reprogrammable environment for refining the control relations in dialogue with musical outcome?

The simplest and most common computer transformation effects are those also achievable by MIDI processing boxes like the MEP4, as discussed earlier: the range of operation is single note, there is no use of status change or precomposed materials, and the transformation is time independent, predictable, and flexible in design to only a limited degree. Examples are the velocity switch effect, echoes and delays, data filtering, controller-based transposition, pitch re-mapping, and 'riff attachment', by which is meant the attachment of a distinct riff (motive, lick, etc) to each key. In its simplest form the riff is just transposed along with the fundamental note. This effect is also readily obtainable with samplers, older tape loop technology, and in a basic but modified form - the variably repeated note - on certain instruments with retriggering sensitivity (the Kurzweil Midiboard, for example).

Transformations requiring more intelligence are ones that do things like automatically excise errors, change with time, use global criteria to filter notes, apply permutations to groups of notes, integrate the received input with stored data, apply tests to the data before deciding how they shall be transformed, use models based on unpredictability or nonlinearity, etc. We discuss some of these possibilities by example.

Status change examples were mentioned earlier. However, the possibility of using this effect on groups of MIDI messages was not, since it requires a more flexible design environment than nearly all available commercial MIDI transformation boxes. An example of this effect is: (For use with a sequencer and pre-recorded patterns)--Key depression starts or continues the sequence, with note number controlling song position pointer, key down velocity determining the length of time before a sequencer stop command is sent. Foot pedal is used to turn on and off a pitch inversion function. Modulation wheel controls the selection of sequencer tracks. Breath controller controls transposition. Effect: This allows creation of a real-time mosaic of different bits of a piece stored in the sequencer's memory.

This example also illustrates the use of pre-recorded note material, which forms an essential part of many actual interactive systems. The most common strategies here are based on the riff attachment idea mentioned above, but with additional real-time control features and note input. Here are some further examples:

1. Key velocity calls up one of a number of rhythmic patterns that articulate notes, or is used to choose between a stored list of processes. (Tod Machover's Opera Valis (1987), Joseph Chung programmer, using Mac II, TX816, and KX88).
2. Each key or switch calls up a different rhythmic pattern or sample which can be extensively shaped in real time (e.g. key velocity determines tempo of triggered motives). (Machover and Chung, Michel Waiswicz's 'Hands' or his 'Lick Machine', Rick Bidlack and Bob Willey of UCSD).
3. Key number (from pitch-to-MIDI conversion) is used to affect tempo of motives stored in tables (François, Chabot, Silber 1987).
4. Windows on stored note data are chosen by using the amplitudes of conventional instruments (François, Chabot, Silber 1987), or other controllers (Waiswicz 1985).
5. Special fingerings trigger sequenced patterns; otherwise, playing produces notes as in the normal instrument configuration (Gary Nelson's MIDI Horn, with John Talbert).
6. After storing played material, tests are run that filter out notes in accord with designed long term criteria (Gresham-Lancaster 1987).
7. General selection of tempo, timbre, prestored patterns, and other variables in real-time. Pre-MIDI control of this kind, using theremins, was used by Joel Chadabe in his pieces Solo and Rhythms (Chadabe 1984). Commercially available interactive software, notably Intelligent Music's M and Jam Factory (David Zicarelli, Joel Chadabe), provide such features. M, for example, allows switching between sets of sounds, 4 distinct note sequence sources, and many snapshots of a host of transforming variables like note velocity, note density, note order, time distortion, etc. It also allows the individual keys of a standard keyboard to function as switches that control a wide variety of features.
8. Interaction of several computers via sequencing and transformation programs. (Paul Lehrman's Songsuite).

Where the player is improvising, there is a qualitative difference between the situations where up to 2-5 motives or data lists are involved, and situations where many (> a dozen or so) motives or lists are involved. This is so, since most controllers except keyboards, guitars and strips have insufficient visual reinforcement to allow the reliable calling-up of individual lists in this second case, and these controllers are often reserved for pitch anyway. Hence certainty about output diminishes, and from the performer's perspective we approach a situation of unpredictability.

Yet another variation on these themes emphasizes MIDI transformations that use groups of messages (primarily notes) as their basic material, rather than just single messages. A parsing (segmenting) control is needed to define the messages belonging to the group. Typical operations on such a group include, using the terminology of note messages: changing a specific order number of the set (e.g. the third note, if present), permutation of notes, arpeggiation, order reversal, selected transposition of a subset, time reversal, deleting or adding material, delaying specific notes in the set, various mathematical reordering processes, and "convolution" (e.g. interleaving) with stored material.

Systems featuring such group transformation include :

1. Order processors. Permutation techniques are widely used, for example by Salvatore Martirano (see below), and Gary Nelson in his Quintessence and Variations on a Process of Frederic Rzewski. In the second piece the input group of n notes is exposed in note-by-note additive fashion as follows: 1, 12, 123, 1234,.....1234....n, 1234...n-1, ...123, 12, 1. The technique, credited to Rzewski, is actually found in India many centuries earlier.

2. Extended arpeggiators. These allow more programmable control than commercial arpeggiators, and seem to be widely found as components of intelligent instruments. The basic idea dates back to the early electronic organs. An instrument built by Machover and Chung draws its arpeggiation patterns from the depressed pitches, using a lexicon of patterns whose succession is determined by principles of similarity, with aftertouch controlling timbre by successively bringing in more TX816 modules. Rick Bidlack and Bob Willey's arpeggiation instrument arpeggiates through different octaves of the depressed pitch classes. A natural feature in such systems is for another 1-D controller (foot pedal, modulation wheel) to control arpeggiation rate.

3. Variation generators. The computer takes dictation from live instrumental performance and spits back variations. Many workers have used this approach: e.g. Gary Nelson, Martin Bartlett's pieces for trumpet, computer and various synthesizers (Roads 1986), or the MIRV collaboration of Daniel Scheidt and Claude Schryer (Logemann 1987). Richard Teitelbaum in his piece Digital Piano Music (1982) uses the Marantz Pianocorder system with two microcomputers to transform data played at one piano into control instructions for two others. Other researchers have focussed on various jazz improvising systems, such as those by David Levitt, André Hodeir, or (analytically) Roger Dannenberg and Bernard Mont-Reynaud (1987). The program M, mentioned earlier, allows unpredictable variation production, as does Emile Tobenfeld's Algorithmic Composer program for the Atari. The basic approaches to variation production have been diverse, but the two most common approaches, often combined, are to use controlled randomness and style rules. Recent discoveries in non-linear dynamics offer an alternative that has not yet been fully explored (Pressing 1988a).

4. The synthetic accompanist. The computer takes dictation, as in case 3, but the computer produces an algorithmic accompaniment rather than, or as well as, composing variations on the dictated material. George Lewis' work with trombone, Apple II and TX816, and Michel Waisvisz' Hands are well-known examples. Another is Salvatore Martirano's recent SAL and Yaha Sal ma Mac systems, where a Zeta Violin MIDI controller and DX7 interact with a Mac II via a number of group processes (order inversion, note deletion, extraction from

source arrays, contour preservation et.al.) Other workers have used this concept to execute notated accompaniment (e.g. Vercoe and Puckette 1985).

5. The computer as musical director. Here the computer monitors information put out by the performer(s) and other parts of the system, and applies tests, which are used to decide whether to invoke interruptions to ongoing processes, or issue commands to performers. Michel Waiswicz has outlined a number of possibilities for the first case, including: GoWi - a go wild algorithm that generates wild information and mutilates the original control signals if a certain threshold of sent control information is passed; T.E. - a that's enough algorithm that decides that things are boring and stops execution of the current state (Waiswicz 1985). The second option has been used to effect long before MIDI, for example in Gordon Mumma's Conspiracy 8 (1970), where a computer participated as a decision-making member of an ensemble by remote data-link (Mumma 1975 p.300).

The incorporation of unpredictability has, as mentioned previously, been well-exploited with earlier acoustic instruments. Unpredictability has some association with lo-fi lo-tech artists, such as Paul Berg, who has, in his own words, 'an affinity for junk'. Most commonly, unpredictability has come from either tapping explicit random processes via software or physical monitoring, erratic interface design or sound production apparatus, unrememberable complexity, or interprocess competition with equally matched protagonists. To the performer the source is largely irrelevant.

Time dependence has so far been used nearly always as a sectionalising device, that is, as a switch between different musical ideas. A shrinking of time scale to changes every few notes might produce very novel effects, but so far I am unaware of workers using this technique. It would rapidly converge to effective unpredictability unless the time dependence could be conceptually modeled in some way (e.g. as a repeating series of discrete 'instruments', or ones steadily changing along one or more timbral dimensions).

With the final issue of design flexibility we enter the stronghold of software. Particularly impressive in this regard would seem to be the idea of a multifunctional environment allowing both instrument design and the interaction of definable musically intelligent agents. An environment of this type can encompass learning, and self-improvement. Eric Johnstones' Rolky (Johnstone 1985) had some of these features. Peter Beyl's Oscar (Beyls 1988) models a number of human qualities, from boredom to musicality, to create a computer persona with which a human performer can interact. The most complete such designs, to my knowledge, are those of Lee Boynton, formerly at IRCAM and MIT, and the Polansky/Rosenboom group at Mills College. Boynton's preFORM is a high-level interactive programming environment that integrates graphics and music. It can work with graphic and MIDI inputs, and intelligent instruments can be constructed in a LISP environment powerfully enriched by special tools for time management and complexity management. The system is object-oriented and features ready intermachine portability.

The HMSL (Hierarchical Music Programming Language) real time environment developed at Mills College (Polansky, Rosenboom and Buck 1987) has high-level features thoroughly informed with recent ideas from the fields of artificial intelligence and cognitive science. Controllers may set into motion and control parametrically a world of interacting intelligent musical agents. The system includes implementations of action networks (having some similarity to neural nets), interactive subintelligences (analogous to parallel-processing), heuristic learning networks and informational feedback processes. Other features include the use of gesture, musically traditional ideas like range splitting, ornamentation, inversion, etc., and generalisations of these, such as the smooth mapping between a starting and final dynamic shape by organized origin-to-target motion.

Final Comments

Where does this all take us? Into some new territory, at a rather alarming speed. The main hope is for powerful new ways of expression; the main danger, that technique outraces musicality. My opinion is that the music produced has not, so far, lived up to the potentials of the instrumental conceptions. It *is* difficult to produce work that is both new and fully-developed. My bias is that music of quality will only be produced through a long period of work and refinement in the area of instrument building, when coupled with the dedicated work of performers who are willing to give years of their life to the establishment of new traditions of musical virtuosity, and composers who can maintain sound sonic judgment amidst the vast and alluring technological distractions. The future will tell; there are great traditions of the past we have yet to equal.

References

Azzolini, F. and Sapir, S. 1984 . "Score and/or Gesture - the System RTI4I for Real Time Control of the Digital Processor 4I." In W. Buxton, ed., *Proceedings of the 1984 International Computer Music Conference.* San Francisco: Computer Music Association, pp. 25-34.

Beyls, P. 1988 'Introducing Oscar' in C. Lischka and J. Fritsch, eds., *Proceedings of the 1988 International Computer Music Conference,* Köln: Feedback Studio Verlag, pp. 219-230.

Bowers, Q.D. 1972. *Encyclopedia of Automatic Musical Instruments.* Vestal, NY: Vestal Press.

Cadoz, C. 1988. "Instrumental Gesture and Composition', in C. Lischka and J. Fritsch, eds., *Proceedings of the 1988 International Computer Music Conference,* Köln: Feedback Studio Verlag, pp. 1-12.

Chadabe, J. 1984. "Interactive Composing: An overview." *Computer Music Journal* 8(1): 1983, 22-27.

Dannenberg, R.B., and Mont-Reynaud, B. 1987. "Following an improvisation in real-time." *Proceedings of the 1987 International Computer Music Conference.* San Francisco: Computer Music Association, pp. 241-248.

Davies, H. 1985a. "Sound Sculpture." In Stanley Sadie, ed., *The New Grove Dictionary of Musical Instruments.* London: MacMillan, pp. 429-433.

Davies, H. 1985b. "Electronic Instruments." In Stanley Sadie, ed., *The New Grove Dictionary of Musical Instruments.* London: MacMillan, pp. 657-690.

De Furia, S. 1988. "Unison Tuned Keyboards." *Keyboard,* 14(10): 126.

François, J.-C., Chabot, X., Silber, J. 1987. "MIDI Synthesizers in Performance: Realtime Dynamic Timbre Production" *Proceedings of the 1987 International Computer Music Conference.* San Francisco: Computer Music Association, pp. 238-240.

Gibet, S, and Florens, J.-L. 1988. "Instrumental gesture modeling by identification with time-varying mechanical models." in C. Lischka and J. Fritsch, eds., *Proceedings of the 1988 International Computer Music Conference,* Köln: Feedback Studio Verlag, pp. 28-40.

Gillett, R., Smith, K.C., Pritchard, B. 1985. "MADDM--Dance-directed Music." In B. Truax, ed., *Proceedings of the 1985 International Computer Music Conference,* San Francisco: Computer Music Association, pp.329-330.

Gresham-Lancaster, S. 1985. "Macintosh as a Live Performance Tool" In B. Truax, ed., *Proceedings of the 1985 International Computer Music Conference,* San Francisco: Computer Music Association, pp. 307-312.

Johnstone, E. 1985. "The Rolky: A Poly-touch Controller for Electronic Music." In B. Truax, ed., *Proceedings of the 1985 International Computer Music Conference,* San Francisco: Computer Music Association, pp. 291-295.

Lebrecht, N. 1985. *The Book of Musical Ancedotes.* London: Sphere Books p.19.

Logemann, G.W. 1987. "Report on the last STEIM Symposium on Interactive Composing in Live Electronic Music." *Computer Music Journal* 11(3), 44-47.

Moog, R.A. 1987. "Position and force sensors and their application to keyboards and related control devices." *Proceedings of the AES 5th International Conference: Music and Digital Technology* John Strawn, chair, Los Angeles, pp. 173-181.

Moore, F.R. 1987. "The Dysfunctions of MIDI." *Proceedings of the 1987 International Computer Music Conference.* San Francisco: Computer Music Association, pp. 256-263.

Mumma, G. 1975. "Live Electronic Music." in J.H. Appleton and R.C. Perera, eds., *The Development and Practice of Electronic Music* , Englewood Cliffs, New Jersey: Prentice-Hall, pp. 286-335.

Polansky, L., Rosenboom, D., Buck, P. 1987. "HMSL: Overview (Version 3.1) and Notes on Intelligent Instrument Design." *Proceedings of the 1987 International Computer Music Conference.* San Francisco: Computer Music Association, pp. 220-227.

Pressing, J. 1984. "Cognitive Processes in Improvisation." In W. R. Crozier and A. J. Chapman, *Cognitive Processes in the Perception of Art.* Amsterdam: North Holland, pp. 345-363.

Pressing, J. 1988a. "Nonlinear Maps as Generators of Musical Design." *Computer*

Music Journal 12(2): 35-46.
Pressing, J. 1988b. "Improvisation: Methods and Models." In J. Sloboda, ed., *Generative Processes in Music*. Oxford: Clarendon Press, pp. 129-178.
Pressing, J. 1988c. "Split Keyboard Technique", *Keyboard,* 14(11).
Pressing, J. 1988d. "Quartertone Technique and Beyond", *Keyboard,* 14(12).
Roads, C. 1986. "The Second STEIM Symposium on Interactive Composition in Live Electronic Music." *Computer Music Journal* 10(2), 44-50.
Truax, B. 1984. "Models of interactive composition with the DMX-1000 Digital Signal Processor. In W. Buxton, ed., *Proceedings of the 1984 International Computer Music Conference.* San Francisco: Computer Music Association, pp.173-178.
Vercoe, B. 1985. "Synthetic Rehearsal: Training the Synthetic Performer." In B. Truax, ed., *Proceedings of the 1985 International Computer Music Conference*, San Francisco: Computer Music Association, pp. 275-278.
Waiswicz, M. 1985. "THE HANDS, a set of remote MIDI-controllers." In B. Truax, ed., *Proceedings of the 1985 International Computer Music Conference*, San Francisco: Computer Music Association, pp.313-318.
Zicarelli, D. 1987. M and Jam Factory." *Computer Music Journal* 11(4): 13-29.

Musical Applications of the Yamaha MEP4

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Many of us involved in music synthesis hoped that MIDI would relieve a problem that plagued earlier electronic systems–that of compatibility. We were told (and we believed) that any MIDI-equipped instrument would function properly with any other, regardless of said instrument's manufacturer. To a great extent, this has proved to be true. However, sophisticated users have often found that many popular instruments are not *completely* compatible with each other, and that often this discrepancy prevents them from getting the most musical results from their setups. The Yamaha MEP4 MIDI Event Processor is a device designed to correct many of these incompatibilities, and I believe it can enhance the musicality of a great many MIDI configurations.

We've all had the experience of trying something with MIDI gear that turns out to be difficult, if not downright impossible. We are not surprised, just frustrated. I've used the Yamaha MEP4 to get around a variety of MIDI "problems", and I hope to pass on some of this experience. I will not detail the operation of the MEP4; the button-pushes are dealt with reasonably well in the manual. What I hope to convey is how flexible this device is, and how it can unlock the musical potential in your system.

The Technical Thing

The Yamaha MEP4 MIDI Event Processor is a single-rack-space device that allows real-time alterations of the MIDI data stream. It has four separate processors, each having four stages of data modification. Each processor can address any one of four MIDI outputs on the back panel. In addition to data modification, the MEP4 can do a number of "housekeeping" tasks, such as patch mapping and channelization. It can also delay the MIDI output of any processor up to three seconds.

Within a program, each processor can modify only one type of MIDI data at a time. The possible data are: note on/off, key velocity, channel pressure, polyphonic pressure, program change, pitch bend, and any continuous controller (such as modulation wheel or foot pedal). Each processor has six data modifications: *expand*, *step*, *offset*, *limit*, *reverse*, and *convert*. *Expand* multiplies the chosen MIDI data event by one of the following values: 2, 4, 8, 16, 1/2, 1/4, 1/8, 1/16. *Step* allows only data values that are multiples of an integer between 2 and 16 to pass. *Offset* adds a fixed value, either positive or negative, to incoming data values. *Limit* allows only values within a selected range to pass. *Reverse* inverts incoming values around a selectable point. *Convert* changes the selected type of MIDI data to another type, such as modulation wheel to note on. *Convert*, if it is used, must be the last modification in any processor. Many MEP4 values are displayed in hexadecimal. A hexidecimal/decimal conversion chart is printed in the back of the manual.

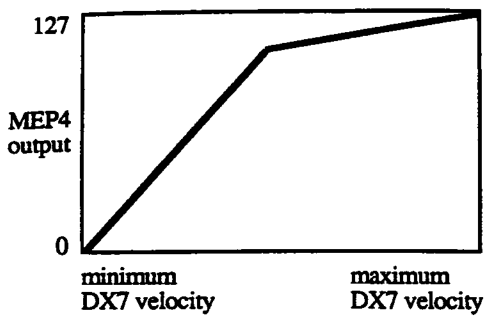
Most MIDI modifications are quite simple on the MEP4. To invert the keyboard around C3, for example, we would choose note number as the message to modify, and *reverse* the data around a value of 60 (3C hexidecimal). To thin the data stream of, for example, a pitch bender, select that controller as the message to modify, and *step* it with a value of two. This will thin every other data event. Higher values of *step* will pass fewer events. *Expand* key velocity by a value of 1/2 to compress an instruments dynamic and timbral range (assuming it has timbral range–samplers beware!); use a value of 2 to make that instrument more responsive to velocity. *Limit* note numbers into two different ranges (with two processors) and send these limited ranges to seperate tone generators to get splits on instruments not otherwise capable of doing so. *Offset* and delay note number to produce a transposed delay; four processors set in this manner will produce delayed chords or arpeggios. *Convert* allows us to make controller assignments not possible on a given instrument, such as pressure to pitch bend. As I am a big fan of the breath controller, I am constantly using *convert* to access the aftertouch of instruments that don't respond to this device (such as the Roland D550). Simply *convert* controller 2 (the breath controller) to channel pressure, and *voilá!* Wind-powered dynamic filtering!

Most of the above examples use one stage of one processor. Using multiple stages of several processors can produce very sophisticated results. One example: *reverse* aftertouch around hexadecimal 40 (decimal 64–the midpoint), *convert* it to controller 7 (MIDI volume), and send to channel one. With another processor, *convert* aftertouch to controller 7 and send to channel two. If the resulting data streams are sent to a multi-timbral sampler with two different sounds assigned to channels one and two, we will a hear real-time crossfade between these sounds with aftertouch (breath or foot control could easily be supplemented). If these samples are identical except for bandwidth, we will hear something resembling dynamic player-controlled filtering (treat one of the samples to some non-traditional equalization via Sound Designer and this technique can get quite dramatic). If the two samples are of the same instrument played with two different techniques (say, soft- and growl-tenor saxophone), we can begin to approach the dynamic variations of timbre and intensity that characterize most acoustic instruments. This technique is covered in Bob Moog's column in the March 1988 issue of Keyboard magazine in greater detail.

The DX7 Thing

Ironically, a glaring violation of the compatibility issue comes from Yamaha. The MIDI spec defines key velocity values between 1 and 127, and most manufacturers have stuck to this scale. There are variations in velocity *curves* (an issue which I hope manufacturers begin to address), but the majority of MIDI keyboards will put out velocities of around 1 for very soft keystrikes, and 127 for hard strikes. The exception, of course, is the DX7. Although there is some variation, this instrument seems to put out velocity 11 for the very softest strike, and (on my DX7IIFD) a velocity of 108 for an inhumanly hard whack. Fine, for DX7 patches; they're programmed for this velocity scale. But hook the instrument up to just about anything else, and you get a grossly attenuated dynamic and timbral range. The slave instrument just doesn't sound very good. Why did Yamaha do this? We may never know; when queried in a recent issue of Aftertouch, they evaded the question. Fortunately, they manufacture an indirect solution.

A simple *expand* of velocity will not do the trick. If we *expand* with a value of 2, then a soft keystrike will yield an output of 22 (even worse), and any strike above *mezzo-mezzo* (64) will be doubled to 127 (the MEP4 limits values that exceed the maximum allowable by the MIDI spec). In musical terms, our action will start at *piano* (instead of *ppp*), and jump unmusically to *fff*, with hardly any middle ground. To get an effective velocity response from the DX7, we must first "break" incoming velocities into two sections, and then process each one separately. The new velocity curve coming out of the MEP4 will look something like this:



The break in the velocity curve is where we switch from one processor to another: the left side of the curve is being *expanded* (by 2) and *offset* by processor one; the right side of the curve is only *offset* by processor two so that it both reaches 127 (so we have full dynamic range) and "meets" with processor one (so there are no gaps in the keyboard response).

To determine *offset* and *limit* values, we must work backward. We must *offset* processor two by at least +19 to extend our velocity 108's to 127. Similarly, we must *offset* processor one by -21, so incoming velocity 11's (which have been *expanded* to 22) will be dropped to 1. We know the two curves meet at a point along the DX7 velocity (horizontal) scale; let's call it x. At x, processor one will output $2x-21$ (x *expanded* by 2 and *offset* by -21). Also at x, processor two will output $x+19$ (x *offset* by +19). We can now make an equation, namely: $2x-21=x+19$ (I known algebra was years ago, but *try*). Solving for x yields a breakpoint of 40; this is our *limit* value. *Limit* processor one velocities between 0 and 40, processor two velocities between 41 and 127 (convert these decimal values to hex first). We now have a passable full-range keyboard.

I get better results by driving my MIDI slaves a little harder, using *offset* values for processor two as high as +40 (and calculating a new value of x). This way I can get velocity 127 without excessive banging. Using a different *expand* value (such as 4) for processor one will yield very different curves; putting the *expand* stage in processor two (instead of one) will also give a dramatically different response. Note also that this curve reshaping can be done to *any* incoming controller. With four processors, you can think of the MEP4 as a pair of Oberheim Xpander-style tracking generators that can be applied to any MIDI instrument. Some fantastic non-linear things can be done by sending an unaltered controller to one slave, and a "twisted" one to another. Two different things will happen at different locations through the range of the controller. Keep in mind that no acoustic instrument is linear in response, and that this non-linearity is an important factor in perceiving the instrument as an expressive one.

The Conclusion Thing

It is perhaps unreasonable to expect manufacturers to account for every possible use of a given piece of MIDI gear. This would be impractical and expensive, and inevitably some obscure application would be omitted. We are beginning to see more MEP4-like functions built into new instruments, such as patch and controller mapping, and velocity curve editing (on the Kurzweil 1000 series). I doubt, however, if the need for devices such as the MEP4 and its brethren will ever go away. It is in our nature as musicians to push our tools to their limits, and the MIDI processor is well-equipped to assist us in this task.

Old Fashioned Composing from the Inside Out:

On Sounding Un-Digital on the Compositional Level

by

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Abstract

This is a personal subjective survey of traditional pencil and paper composing and editing techniques from one traditionally educated composer, to try to better communicate the freedoms and abilities fostered by these techniques to authors of music composition software who may have had less experience with music composition per se. It attempts to describe what a notational composer is accustomed to being able to do and how and why. This is only one composer's view, and other composers' experiences should be sought as well because no single artist's experience can ever be comprehensive.

This description hopes to give authors of compositional software food for thought in designing extensions and alternatives to both the currently-dominant sequencer model (which simulates multi-track tape recorders), and the process-oriented methods of logical algorithmic generation which have finally begun to be more widely accepted and in which I have specialized in my own software.

Introduction

Despite my 20 years experience composing primarily in electronic and computer media, I often still compose on paper the old way because of the freedoms and depths and kinds of expression the paper and pencil give me which are still unavailable to me in any computer composition system I know, not excepting those I've created myself. I usually write music on paper at a keyboard or other instrument, but not always, since for me the imagination is still the ultimate unparallelled creative tool, and the processes of envisionment, focusing, clarification of detail, and external realization of whatever one holds and elaborates in the imaginative memory is, in my view, an irreplacable creative experience of the highest level, providing freedom and expression well beyond any other technique I've tried.

The "improvise and edit" method of composing is now becoming the dominant compositional technique of our culture, in large part due to the tremendous proliferation of recording technology, both tape and computer based. Though I use both recording and algorithmic generation often in making my music, I would not want to be limited to them. What follows, therefore, is an attempt to describe from subjective experience some composing and editing methods which have worked for centuries so well that we can't afford to neglect them in our new software tools. Some of these observations describe simple direct operations, and others just try to give a feel for the compositional process. Much that they refer to has been somehow left out or misunderstood in the design of most music composition software currently available.

Appending

I know of no commercial software with this function.

Appending to the end is the commonest technique, usually to all voices (what would be called all "tracks" these days) together. You add small enough amounts that you can safely hold them in your head without losing them until you can write them down.

The major skill practised in the formal study of composition in my opinion is the ability to expand as much as possible the amount of musical material you can hold clearly in your memory. Music theory, harmony, etc. are in part mnemonic methods for increasing the amount one can remember. They enhance this central mental skill. The amount of music you can keep clearly in your head at a time grows with years of practise.

Nonetheless, you still keep the chunks you append small because they are concentrated areas of intense decision making activity, multi-dimensional, and very context dependent.

Non-Sequential Addition of Material

You usually add at the end of the piece or section, but not always. Sometimes you skip beats or measures and go back to fill them in later when you've gotten a better idea of the whole context, what something is leading toward. Sometimes you go back before the beginning of the entire piece and write introductory material that works up to it.

Scanning for Context when Appending

When adding material at the end, you generally back up in the piece and take a running start reading or playing through what you've already written and then continue beyond it creating new material. You stop playing beyond the written ending point when you've done as much new stuff as you can keep in your memory, or have accumulated enough indecisiveness in the transition and the material to require some testing and deciding. Then you write down or merge in the new stuff, back up and repeat the process again.

If you can't decide on something, you may back up further and do a longer run through to provide a greater sense of context.

Where to Start Scanning

The point at which you start playing the written stuff that leads up to the place where you'll start appending is not a single hard and fast place specifiable by rule. You might go back a phrase or a couple of measures, or sometimes more. You might start at a simple 8-bar phrase boundary, but not usually. You may have to chase a lot further back in some voices than in others to set up the context for where your mind will take the piece next, for example, getting long-sustained bass notes sounding, setting up the rhythmic feel, or the experience of a tempo change such as an accelerando. You might run through the material further back in harmonic reduction (playing just the chords on the strong beats of the measures), and when you get closer to what you're working on now, start playing literally everything that's written before coming up with new stuff to write down at the end.

Not Just a Plain Append Operation

This is not really like having your sequencer automatically punch into record mode at the current end of a multi-track piece for several reasons.

One is that you are reviewing what you've already written as you run though it, and you refine it as you go, adding to or changing it, because you've clarified your ideas in the meantime and also you now have some idea what it's leading up to. You look at the score, pick a starting point for the run through and "record" (remember or notate) any differences between what's already written and what you are playing (or hearing in your head).

The second reason is that the stuff you come up with to add at the end is less likely to be added like a splice than via some fairly complex merge, modify, and filter operation. When you stopped appending the last time, you didn't know where the piece would go next, and couldn't write in preparation for it.

You hear changes and buffer them mentally, trying variants, before you decide exactly how and what to commit to paper. It's as though you've recorded them alongside the score in a separate synchronized sequencer in your head. After you merge and append the new stuff, the result probably contains the previous material modified slightly at its end, the new material with it's beginning modified to make a good transition, and possibly some altogether new bridge material, created during the actual written appending process to make a good transition.

A third reason is that you usually try several takes of this "running start" operation, as exploration, clarification, and experimentation, and as part of your decision making and refinement processes, and you may wait a while to decide and want to keep all of them in the meantime.

If you write down several alternatives, you find yourself with a branching piece to deal with (usually branching to several sheets of paper with different versions). So you take a break, or else start another scan from further back to try to decide, or else skip some blank space in the score and go on, figuring you'll fill in the missing transitional part later.

You may also just decide to use whichever one of your branches turns out to be easiest to extend. Some material just seems to take off by itself and other stuff just dies and won't go any further no matter what you try.

Sketching: Shorthands, Symbols, and Speed

Sometimes you jot down just enough to capture the new stuff or changes in very rough sketch, in order to keep going and not lose the music's flow and momentum. Then later you'll go back and fill in the details. This means writing a first pass leaving out notes, voicing, dynamics, phrasing, orchestration, lacking exact rhythm, maybe marking just single pitches here and there, or chord symbols for the downbeats, or drawing visual curves for dynamic contours or for pitch patterns. You may have personal symbols and private notational shorthand you've invented for new or non-standard things you often do.

Parts may drop out and back in again as you sketch. Some areas will have more detail filled in that others. You may leave some sections completely blank, to be filled in later, in order to capture as much of the total concept of the piece as fast as you can.

On Interdependencies and Top Down Design

Composing can be thought of as a bit like doing a crossword puzzle. There are hard words you leave blank the first pass through because you know that after you've filled in context, the words that cross them running the other way, they'll be a lot easier to get. This rough-it-in-and-refine-later composing method is also a bit like doing computer psuedo-code first then conforming it to proper syntax later. It's also to some degree like "top down" structured programming, except that, once you've started actually writing, doing an overview just about always gets triggered by specifics on the most detailed micro-event level of a what's already written down, instead of the other way around.

Sometimes you design the overall structure of a piece top down and then fill it in, especially in scoring accompaniments for dramatic material such as film. But in composing for concerts or records, pre-structuring often ends up sounding forced or artificial. More commonly, the overall structure of your work only becomes clear afterwards, in retrospect of the process, as an accumulation of moments built up intuitively during the your immersion in moment-to-moment detail.

Multiple Passes and Harmony versus Line

You can't think about all aspects of the section you're working on at once. Usually harmony, line, shape, pitch, or rhythm, or some combination of these are first. Voicing (the distribution of the notes among the parts), dynamics, orchestration, and the specification of articulation and phrasing tend to be done in later passes, but notes for them may be made in places in the rough draft at any time.

The technique of doing all aspects of each voice (each instrument) as a separate pass, as in tape overdubbing or MIDI sequencing, hasn't been used in European composition since the *cantus firmus* technique of the medieval Notre Dame School died out. It's death can be strongly linked to the evolution of tonal harmony, which gives the relationship between all pitches sounding at one time (chords) a higher priority than it gives the integrity of each melodic line which runs through the chord.

Free Movement Between Data Types

The idea that you are making multiple passes through the score working on different dimensions of the information in it is an oversimplification. You may be working mainly on pitch-time stuff, or dynamics, or whatever, but your access to other types of information is unrestricted.

You freely make pencil notes about any other aspect, or add information of any other type, at any time, without any experience of interruption such as is created by having to switch modes in a computer based editor. All information of all types is available random access at all times for all relevant editing operations. It is also open to you for the attachment of verbal comments, asterisks to mark inter-connections, or whatever else you find useful.

Non-Sequential Groupings

The groupings you work with are not commonly sequential in time or restricted to one part (one "track"). One moment across all the parts for some dimension is probably most frequent (harmony, loudness, instrumentation, ...). You might put accents on all the downbeats of the measures in a section. You might write chords or put rests on the strong beats for all the voices, and then make melodies and rhythms within the measures later. You might specify dynamnics for the whole orchestra or make all the strings go pizzicato at once.

You often group the material for one of your editing operations non-sequentially by musical dimension, timbral similarity, or temporal placement. Sequentail grouping for editing is probably just a carry-over from word processors that was never well thought through for musical use.

You don't always compose the notes in the order in which they'll be played. If you rough in just the chords on the downbeats first, you may not think at all about which specific notes will fall in which instrument. You have no idea how many events you'll break those chords into later when you write them out and fill in, working out melody, counterpoint, and rhythm from them.

Filling in Abreviated Sketches

Aside from voicing between chords, there are other ways of placing events then interpolating between them later. For example, you might choose a few pitches that will be high points in a series of successive upward-running melodic lines, then go back and write the lines that run up to each of these successive high pitches later. In this case, the last note of each measure may get composed first for several measures in a row, then the earlier notes in each bar that lead up to them are composed after. Or you may decide on a series of musical arrival points, then figure out the best routes by which to approach them later.

Not Getting Carried Away with Improvisation

Improvisation can be limiting in that it prevents you from working easily with materials too complex to play, or perhaps wrongly spaced for 2 hands on any single instrument, or which require several instruments you don't play at all. Your muscles and nervous system have formed reflexes and habits which will lead you down paths you've already tried, which is counterproductive. Improvisation may be an indespensable technique for composing, but it is only one techniques among others.

Improvisation may also put you at risk of getting carried away, of developing too large an amount of new material in a singe take to append or integrate well. For one thing, you may not be able to remember all of it when you go to write it down. Just as importantly, you can get off on tangents, wander, get lost, jeopardize the continuity or distend the proportions of your piece.

You can lose the mood or momentum of where you began when improvising extended takes, and may have to spend a lot of time re-establishing the feeling of the starting place in your mind before you can decide on what you did or can try alternatives. You may need to go back to the beginning of the entire work and read through it all, possibly several times, to put the new stuff into perspective within the piece, to ensure its continuity, appropriateness, and proportionality.

Often a fair number of changes must be made while appending new material on both ends of the transition. With music of any complexity, working with too much new material at once can be disorienting and inefficient. Each composer knows their own limits on this, and they change considerably with the type of material being written too. Some things are written one note at a time. On the other hand, with very simple material, one can sometimes "append" an entire piece start to finish to a completely blank page in one pass.

Forest or Trees? Multiple Perspectives

Other reasons to compose bit by bit on paper rather than taking down long improvisations are to maintain selectivity about material, and to optimize for qualities that can only be gotten by constantly changing your perspective on the piece. Qualities such as controlled complexity, consistency of material, or integrity of form can be kept in adjustment because you can step out of real time. You can see the overall piece from a vantage point outside of time. You can jump around freely within time as it is represented on paper.

Composing is the process of designing an experience for others. It requires a designer's overview perspective as well as a builder's preoccupation with detail. You're always outside of the work, objectively viewing it, pretending you're hearing it for the first time, at the same time as being lost and immersed in the full detail of all the parts and dimensions each moment contains. You simultaneously maintain and ignor both levels of view.

Outtakes and Separate Starts

Often the new stuff you compose doesn't work where you intended, but it might belong in the piece somewhere else, so you put it aside and go on writing other stuff. You keep a little heap of such outtakes - chord sequences, melodies, rhythmic figurations, counter-melodies, variations, sonorities, etc. Some get used later and some don't. Some may end up in other pieces or turn into pieces themselves eventually.

Sometimes you take such an axe to a piece that you virtually start all over and the whole first draft goes on the scrap (resource) heap as an outtake. Or there may be several generations of sketching which successively approximate or refine a vision. Parts of all of these may get reworked into the final piece, so access to multiple piece (or fragment) files from within a music editing program would be essential. Sometimes pieces which you start as totally separate turn out to be part of the same unified work (the subconscious mind again) but you were completely unaware of their relationship when you wrote each of them, and are surprised to find that they fit together perfectly (with a bit of transitional or other editing).

You may need to start over with a clean piece of paper and build the final piece from scratch while referring to all the other bits and pieces that somehow are part of it. This can be done in a very premeditated structured fashion or it can be done spontaneously, intuitively, so that you never know moment to moment what you're going to try putting where next as you brainstorm on what to try. There is a lot of comparative looking back and forth among 2 or more pieces or parts of the same piece in such processes. (Multiple window displays are optimal if a screen is big enough, but hardcopy will do, as it has for centuries in the past.)

You may want to try re-using a line, a rhythmic, an articulation pattern, a sonority, etc. from an outtake scrap or another piece you did last year, or maybe a line, or a rhythmic ostinato or other material from a different movement of this same piece or from your stash of out-takes and related ideas. You want to be able to get at anything you've ever written fast, with minimal interuption to what you're working on now, and review it or copy whatever aspects of it you want to reuse, while changing what you need to about it (key, tempo, meter, timescale, rhythm, ...). It's almost as though each aspect (pitch, rhythm, articulation, doublings, ornamentation, etc.) were independently recyclable.

Debugging a Piece

After you've added the latest extension, you realize that the pacing is wrong. A climax was reached too fast, too early, and you go back and rework one or two measures into a half dozen to make the climax happen later. Or a section feels like it's moving too slowly after what was before it, so you try breaking up the longer notes into shorter ones, or adding rhythmic density by repeating notes, or find other ways to increase the density of activity without altering the rate at which the basic pitch content (the "harmonic rhythm") moves. Or you might delay the problem section by inserting a repetition of earlier material, changing it to prevent it's getting boring.

You may try various solutions to a problem on separate pieces of paper instead of erasing and rewriting. If none of them work, you may get rid of the offending part altogether and stash it someplace just in case.

Unity and How it Gets There

As you work more and more with material, you sometimes realize that fragments of the music which you thought were unrelated are actually all variants on some simple or central theme that you just had not been aware of before. (The subconscious does a lot in composing.) Then you might go all the way through the piece looking for other such similarities and do some editing to clarify them. You might create a section at the beginning or end which makes the camouflaged commonness more explicit, which plays whatever has been recurring in a clear and distilled form, making it easier for the listener to experience unity in the work.

When they analyze scores, musicologists often think that composers have intentionally made variations on a single theme in places that a composer would suspect they may have just found or exploited similarities they wrote without planning to.

Computer and electronic compositional tools have strong biases toward musical repetition (looping, copying, etc.). Just about all music editing programs, both scoring and sequencing, support the technique of copying and changing to create variations. But they universally lack even the most simple support for finding and grouping similaritites (such as pattern-oriented search or search-and-operate functions), let alone highlighting or increasing similarity.

Unplanned similarities among different parts of a piece also happen consciously or unconsciously within single dimensions, such as a second melody having either the pitch line or the rhythmic pattern of an earlier one, but not both. It's hard to pinpoint the similarity and yet there is a vague familiarity of feeling in the second one when it's played which somehow enhances the emotional experience of the piece. You find you've re-used something as abstract as a melodic shape, maybe even upsidedown, or in major instead of minor the second time, or with different harmony or rhythm, or in another key or sound. I sometimes find things like this which I was unaware of in my pieces even years after I finish writing them.

Sometimes you realize that what you just wrote leads back to something you wrote earlier, so you try appending a variant of it. This may be anything from a literal repetition of the earlier stuff to something which only vaguely resembles it. Some kind of transformation is usually needed, because the key, rhythmic structure, position in the bar, density of surrounding material, meter, or other factors are likely to be different. Even if it fit perfectly, it would not have the same impact in its new context.

Sometimes something done earlier seems like it might be good in counterpoint with (simultaneous to) what you've just done, and you copy it there, and edit pitch and rhythm in both to make them fit each other.

You want to be able to get rid of such attempts at least as easily as you can try them. You try many many more things than you end up using. You want to be able to make multiple versions of many of the changes you make to your score, and quickly and easily try them one after another while deciding. Paper is not much use for this but is of some help. A well developed musical memory and visualization technique are vital and there is no technology outside of the body that I know of which has its properties. This deserves much more study.

Polyphonic Writing

If you're writing polyphonically (in distinct parallel parts each of which has real coherence) instead of homophonicly (which is what is too often meant by synthesizer people by "polyphonicly" - "homophonic" means several sounds at once but not arranged into a fixed number of distinct parallel voices), sometimes you write one or more voices way ahead of the others, and then you go back later to fill the others in to catch up. You need to be able to leave gaps and spaces, and actually just hang bits of music "in thin air" on the page. You might know that at the end of 8 bars you're going to be in a certain octave or chord and write a melody starting on it there, leaving space on the paper to fill in later whatever will work toward it well.

Sketching in Time

It's sometimes easier to compose a stretch of music if you've left yourself verbal notes, or hints, or a map of where you're headed further on. Blank music paper maps the time which lies ahead waiting to be filled with information. Just as the invention of "zero" as a placeholder for numbers increased our arithmetic ability, blank time-space on paper facilitates our composing. The opposite of written music is neither blankness nor silence. It is unfilled metric (or temporal) structure, and that's what blank music paper shows.

Barred music paper can be written on, vaguely or precisely, at any timepoint, no matter how discontinuous from anything already written. I can draw large-scale dynamic curves pages ahead of where I'm composing in orchestral writing. I can draw this curvature of musical intensity in real time, counting through the bars as my pencil draws the curve, using no actual musical notation symbols at all till I fill that curve much later with specifics. I can write partial notations, symbols, curves, chord names, and patterns across a blank metric page and have much of the actual composing done before I write a single note.

Polyphony and Imitation in Open Score

If you're writing polyphonically in "open score" (doing the voicing and orchestration at the same time as composing the notes) you tend to write one voice till it's longer then the others, then while reading it, you go back to a shorter one and write it until it's longest then while reading those, you go back to another shorter one and write it forward until it's longest, etc. You may copy material from one voice to another, so it's heard at a time delay and usually at a transposition too, with or without inversion or some other transformation,. (That's how you build things like fugues.) But more often you just write freely.

When you're extending one of the shorter voices, it has to fit in with what's already going on in all the others. You need to be able to see its immediate past, its present, and also, importantly, its future context - the parts which have been written ahead of it. If you can't see where you're going (you can't in tape overdubbing), you have work from the limitations of memory and can't read ahead. (Notation is an adjunct to memory as much as a communications medium.)

The part written farthest out ahead of the others, is free to move wherever it wants. The others will conform to it when they catch up. But each note you write limits your choices for the notes after it, and must drag the other voices along in the directions it goes, so you don't want to write any voice too far ahead of the others. Though you're writing lines, you still want to stay fairly close to working beat by beat across all the voices in the piece at once.

Homophonic Writing

If you're writing an accompanied melody instead of polyphony, you sometimes make some kind of filler material, such as chords or repeating patterns, to give your melody harmonic and rhythmic context. Then you go back after you've written your line against it, and replace or change the filler, perhaps breaking the pattern into several melodic lines, or otherwise making it seem to respond to the melody you wrote on top of it. Then you may make further changes in the main melody. You may work on them alternately or both at the same time, to make them seem to respond to and rely on each other. You use and edit all their musical parameters: orchestration, pitch, rhythm, dynamics, phrasing, articulation.

Integrating Algorithmic Material (An Aside)

This doesn't pertain to normal pencil and piano composing, but sometimes, when I've composed at a keyboard that links to a computer, instead of standard musical patterns (arpeggiations, etc.) as filler. I've used computer algorithms to provide a texture as background to something I'm working on. (Algorithms can be viewed as a new kind of musical descriptive shorthand.)

I've tried to work rules into these logical processes that let them respond to what I do live, as a simulation and shortcut of the process described above. I also use them to generate material which will be used strictly for background, for example, to a voice-over for a commercial announcement. I sometimes record or write down a length of such a texture, then go in and change individual notes, and add lines that stand out and have real character against them. I may orchestrate from that. Or I may use them as spring boards for my auditory imagination, fantasizing material from them which I then write out.

Symbols, Shorthands, and Standard Terms

Standard symbols (chord symbols, old fashioned figured bass, ornaments) are often used as "shorthand" for groups of notes. Substitutions of many fast notes for single long ones (trills, tremolos) are done by writing a symbol for what is to be substituted by the performer when he plays it. You don't ever have to write out all those little fast notes. Chord names or other symbols for groups of notes speed up writing, making it closer to realtime or to the mind's creative speed.

I sometimes just write the stems and beams for the rhythmic aspect of a passage without any pitches at all, and then come back, often much later, after the rest of the piece has been worked out and the context for the section is clear, to fill in the actual notes.

You write verbal reminders to yourself on the score about things you're not bothering to work out now - instruments you might want to use at certain points, interpretive ideas you might forget later, names of pieces or composers you're reminded of, qualities of sound you're after. You also often notate on the fly, while concentrating on something else, articulations, fingering, tempo changes, dynamics, phrasemarks, possible alternative notes or lines you just can't make up your mind about right now, cross references to other parts of the piece or to stuff in your heap of outtakes, references to film action cues, or lyrics. All these kinds of things can easily be marked anywhere on a paper score with a pencil at any time. It's as though there were "comment fields" or linking mechanisms available for every aspect of your piece.

Free Movement Between Operations

The particular process you're using while composing changes about as easily and quickly as the direction of your eyes can change. You find a note by looking at it and make it an edit point by putting your pencil there. You can write with one hand while playing notes with the other, or you can hear all the notes in your head from reading what you wrote even if you can't play them all or at speed, and as you hear them in your head you try edits, changes, or additions in your mind without writing. (What you hear in your head can seem quite real.)

With a pencil, you are always in play, record, insert, delete, merge, and separate modes all at the same time. Not only can you change between these modes instantly, but it's as though there's always another sequence being recorded in your mind, from which you decide what to filter out and how to integrate new material or changes. What's stored in human short term memory is always remembered in sync with the piece as written, with whatever triggered the generation of its contents in the mind. (We night try to simulate it with a default sequence which is always recording whenever we play back a MIDI piece in progress).

Movement Within a Piece

You can move with equal ease from one stave to another or along one part, or in both dimensions at once. Jumping around is as easy as moving continuouslly. It helps that full page shows a lot of material.

You refer back and forth throughout the score as you work. You might re-read and improvise on something early in the piece to make something new which is related to it, or you might simplify it down. You check on exactly how you did a similar thing before, such as how you spelled some accidentals, how 2 voices fit together, how long it's been since a theme recurred, or to refresh your memory about earlier sections of the piece.

Orchestration

There are by now tens of thousands of people composing, often for the first time, with MIDI sequencer software which assumes that notes are members of various "channels" each of which has the same sound for all it's notes. I am not aware of any sequencers which model the "channel" as a property of the note though it would be easy to do so. The implication of notes belonging to channels is that orchestration is both first, before notes are composed, and fixed for the notes once entered. It's prohibitively difficult to write material and then freely distribute the notes among various instruments afterwards as would be easy if a channel were viewed as a property of a note.

This is an even bigger problem for professional orchestrators and arrangers I've talked with about MIDI than for composers. Sometimes pitch and timbre are composed simultaneously instead of the notes being done first and then orchestrated. This may ultimately be more efficient in some ways because you conceive the pitch-time stuff already properly fitted to the instruments which will play it.

But it has always been common practise to write a piece unorchestrated (in "reduction") and then to orchestrate it in a later compositional pass. (Much Hollywood film scoring is done this way; the composer credit is accompanied by an orchestrator's credit.)

If the association of sounds with notes is done after the pitch-time content is determined, you can concentrate completely on on melody, harmony, and rhythm, writing your "piano reduction" freely and quickly. You can think about instrumental ranges, voicing, tessitura, articulation and orchestral special effects later, when you're clearer on what it is you want to bring out and how you want to present it.

When you orchestrate, one of the commonest things to do is to move material up or down an octave, since accoustic instruments have different timbres in different octaves. Also, melodic lines may be simplified or elaborated during orchestration, since different instruments have different kinds of agility and awkwardness and tend toward different kinds of characteristic figuration. For example, it's hard to trill across register breaks on wind instruments, so you may need to rewrite a line when you decide to use clarinet on it. Orchestration as a phase often involves considerable editing and rewriting, and the filling in of sections still left sketchy.

Doubling one instrument with one or more others is one of the commonest things to do. The simplest way is to write the names of the additional instruments into your first-sketch score right near the notes. Later, when all the creative thinking is done, you'll have time to copy the doublings to the appropriate staves of the full score (usually at unison, 8va, 3rds, or 10ths). Right now you're just getting the ideas down while they're rushing through your mind.

You may put extra instruments on a whole line, or on just a few selected notes of it for emphasis, or break up a line altogether and have it go back and forth between several instruments. You sometimes move notes or melodic fragments back and forth between the voices, trying different orchestrations, switching the staves, octaves, and instruments of notes or passages repeatedly until you're satisfied.

Effectively, you are assigning, distributing, individual notes and musical gestures throughout a group of available sounds.

In general, larger media such as orchestra, are written for more simply than smaller media such as string quartets or solo instruments. There may be only 3 real melodic-harmonic voices in an orchestra piece, but built up for the 100 or so players through doubling, highlighting of specific notes in some instrument with other sounds (such as chimes, plucked strings, or percussion), gradual thickening of orchestration, extensive use of dynamics ("mixing"), and the recurrence of the same material in different registers or orchestrations.

Converting Orchestration to MIDI

In addition to each instrument having different timbres in different pitch ranges, each instrument also sounds different at different loudnesses. This makes the explicit composition of dynamics (loudness) absolutely essential when you orchestrate. Unless we can compose loudness exactly and unless our synthesizers are programmed to use these dynamics to modify their timbres appropriately, it is easier and truer just to imagine the orchestration in your head than to try to compose while hearing your delicate blends of sound color completely distorted in timbrally flat electronic simulation.

It's worth noting that a lot of the graphical score symbols for articulation (different kinds of accent marks, etc) are actually symbols for sonic qualities that a computer could use as envelope modifiers, mixing instructions, or in sound selection. The use of such specifiers as "pizzicato", "col legno", or the standard graphical symbols for brass mutes and percussion mallets in a computer-based score should imply their translation to their sonic MIDI equivalents when the computer plays the file. Not to be able to use existing standard musical symbols and language for timbral variation misses the boat in terms of trying to provide compositional fluidity via computers.

This is no less true for the description of abstract electronic sounds. Paper based composition makes it easy invent new symbols and notations for new sounds and effects. In a medium as conducive to inventiveness as computers, the absence of provision for users notations, macros, etc. is strange.

Musical Debugging: Tools and Techniques

There is a lot of problem solving in composing. Often you can ponder over why a passage isn't effective and try a million changes to it only to discover much later that something you did several measures back was the culprit and set up the listener's ear with certain unintended expectations, or that the material was fine all along but just happened a little too early or too late or too briefly.

It's not unlike debugging a computer program, and you want the techniques you use while doing it to be as transparent as the most ideal operating system and editor would be while programming - simple, direct, customizable, and with some facility for the grouping of operations into frequently used combinations. Editing operations should be learnable to the point where they become reflexes. You need to be able to concentrate on the musical problem you're solving.

The editing function group should be extensive enough to do everything you need (and probably a lot you don't need) even if it takes a considerable period of learning and study to master them. There should always be more techniques available than any one person can master or use, more left to explore, and enough that different composers can specialize in the subsets of available technique which fit each of their musics best and don't all end up having to work the same way.

Having spent at minimum 10 to 15 years becoming fluent in notation, musical structure, and instrumental technique, composers as a group are more than willing to invest time learning in order to increase their ability and power to create. The idea that no program should take longer than about 20 minutes to learn seems meant to make computers and software sell quicker by making them seem easier and "friendlier". As a design philosophy, it may work against making computers as productive as possible for a specific task once their ownership is assumed.

Afterward

Working on a piece for a long time (a symphony can take years), you keep going back to the piece, and finding that it's not as you remember it. Your sensativity to and vision of its potential have grown, and your memory of it has changed with them since you left it. You keep refining and changing it to bring what is recorded (notated) up to the standard of (into conformity with) what is now in your memory/imagination as your mind has refined it.

What you've created in the end is a written hypothesis. Your score is a set of instructions to be read by others who will translate your description into sound. Hopefully those sounds will be the same as what you think you wrote, what you imagined.

WHY DO PEOPLE ENJOY MUSIC? A SPECULATIVE ANSWER LEADS TO A MUSIC COMPOSING PROGRAM

Bill Struve

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Abstract

I propose that the pleasure center is stimulated by a hypothectical pattern recognizing and generating center in our brains. I've used what is known about processing of visual images to develop a computer program which composes music.

"Why" is one of those dangerous words which will often stop people from processing, or get them into an infinite loop of "why...because", so let's ask a more personal question.

What causes you to enjoy music?

I've asked this question to lots of people since 1975, when I first became interested in the questions of what is music, and how does it affect people. At that time I assumed that all people enjoy some form of music. It was not long before I learned (again) that the only universal truth about people is that there are no universal truths about people. Yes, someone said to me that he did not enjoy any form of music and considered it all to be a distraction. Although he is the only such individual I know from personal experience, there are others like him.

Many people respond to the question quickly with something like, "Because music gives me a good feeling.", but get rather stuck when they realize they have just replaced "enjoy" with "good feeling".

Let's propose that music is a nearly universal characteristic of our species because there is a neurological connection between the "music center" and the pleasure center of the brain.

Most of you know about the pleasure center, which when stimulated, gives the emotional sensation of extreme pleasure. The pleasure is so extreme that if rats are provided with a lever which they can press to stimulate this area of their brains, they will select pressing the lever over any other behavior including eating, drinking and sex, until they die.

Pleasure is a powerful motivator of behavior. It is obvious to most of us that pleasures derived from eating, drinking and sex have evolutionary advantages, but what about music?

You can understand that music is sound with a pattern, so let's replace "music center" with a generic "pattern center". This hypothetical and yet to be discovered "pattern center" would function to recognize and perhaps generate patterns of sound. But why stop with sound? Let's be even more general and let our "pattern center" work with all of our senses.

What does the pattern center do and how can its connection to the pleasure center be of evolutionary advantage?

The pattern center would be constantly searching for patterns coming in from our senses. When it found one, it would send a signal to our pleasure center, but if the pattern were repeated too many times it would stop sending, and may even send an "unpleasant" signal. Theme and variation is characteristic of much music, The theme is the pattern and the variation keeps the pattern center form sending the "unpleasant" signal. If the pattern center can also generate patterns, you can feel pleasure just by generating and recognizing your own patterns.

Years ago I was taught that humans were different from the other animals because humans made and used tools - "Man the tool-user." Later I learned about "Man the language-user.", and "Man the music-maker."

You may have guessed that I would say "Man the pattern-enjoyer." But how can this be an evolutionary advantage?

Spoken language as well as music can be thought of as patterned sound. You might think of written language and mathematics as visual patterns. Dance and athletics are motor patterns

GRAPHICS

to the dancer or athlete and visual patters to their audience. I feel much of what we do which differentiates us from the other animals is directly linked to our enjoyment of the perception and generation of patterns.

Enjoyment of music may not have any survival value itself, but enjoyment of patterns has motivated us to our greatest achievements.

How does this hypothetical pattern center help us compose music by computer?

If the pattern center allows us to generate as well as recognize patterns, biological conservation would suggest a similar mechanism for the two functions of generation and recognition. We could then use an inverse of a sensory mechanism to compose music.

Vision is perhaps the best understood of all of our senses. Two simple principles seem to recur during the processing of visual information (patterns). I'll call these two principles "interaction" and "mapping". An example of interaction is the lateral inhibition of neighboring rods in the retina when a rod is stimulated by light. This lateral inhibition helps us define edges in a visual pattern. The signals from the optic nerve are mapped on to the lower parts of the visual cortex in the brain. As the signals pass to higher layers of the cortex, they are re-mapped and expanded, i.e. one of the lower cortex neurons connects to more than one of the upper neurons.

Recognizing a cow in a field involves much more than a series of such mappings and interactions and leaves out prior experience, etc. But let's not get hopelessly bogged down in reality for the moment.

How can we apply the simple and simplifying principles of mapping and interaction to pattern generation? Let me first get the two into a form which is easy to use in a digital computer.

My definition of "mapping" not only includes re-mapping, but also optional expansion and negation (inversion) of binary signals.

In the visual system, interaction is analog. In a computer, digital interaction is easier, and binary interaction is almost trivial. I've chosen the binary interaction functions of AND, OR, and EXCLUSIVE OR for my "interaction" function.

Specifically, a byte pattern of 10101010 will produce 00110100100100 after passing through a certain fixed map, and 00010100 upon a fixed interaction of the bits coming out of the map. Changing the input pattern to 10101011, and then to 10101100 leads to 00110100100011 and 0001010101110 out of the same fixed map and to 00010101 and 00110110 after the same fixed interaction. For those of you who are more at home with decimal numbers, the numbers 170, 171 and 172 were changed to the numbers 20, 21, and 54 by passing their binary representations through a certain, fixed, map+interaction unit. Of course we are not limited to 8-bit patterns or to just one map.

What has this to do with composing music?

The timing of much of our music, especially that played in 4/4 time, is binary. We have whole notes, half notes, quarter notes, etc., so a binary timer can serve as the input to a series of fixed map+interaction units. The output of the last such unit is then used to control which notes are on at a given time, which octave or octaves they are in, which scale (major or minor) the notes are in, etc.

Note that the whole composition is finished when you decide how many map+interaction units are going to be used, and what the map is in each unit. The length of the composition depends on how many bits you use for the timer, and how you use the bits from the last unit. You are not composing music in the normal sense since you don't select any individual notes at all.

I hope that you are wondering how music composed like this sounds, because I've brought a tape I'd like get your opinion on...

COMPUTER GRAPHICS: A FINE ARTS APPROACH

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Abstract

This paper is a description of a computer graphics course that I developed as part of a proposal for an entire computer graphics program. The program was written for grades one through twelve; however, only the high school segment has been instituted at this time. The course developed for the high school level is currently being offered at Hicksville High School, located in Hicksville, New York. This paper includes a description of the course, equipment used, approach to instruction, and course content.

Description of the Course

Studio in Computer Graphics is a full year computer graphics course written for a fine arts department. The course is designed for art majors and for those students who have a strong interest in art. As a result, Studio in Art, the foundation course of the visual arts, has been made a prerequisite, along with the strong recommendation of a drawing course.

The structure of this class allows for two students per workstation. In this environment, students learn, share, and develop ideas together; assignments, however, are solved independently. Class time alternates between lectures, video and slide shows, demonstrations, tutorials, exploration time, execution of assignments, class critiques, and written examinations. This course has been designed to comply with the New York State Art Regents Action Plan of 1985. Therefore, it emphasizes the history of computer graphics and the appreciation of traditional and computer created art, as well as challenging the intellectual and the aesthetic development of the student.

Equipment Used

Currently, our equipment consists of: ten Amiga 1000 workstations, each including a second disk drive and an Easyl digitizing tablet; a digitizing camera; genlock; and a Xerox 4020 ink jet printer. The software for Studio in Computer Graphics I encompasses Easyl, Deluxe Paint II, Aegis Images, Digi View, and T.V. Show.

Approach to Instruction

Computer graphics is very appealing to the young artist and images can often be full of gimmickry or cliches. The single most important concept I emphasize to my students throughout the year is the integrity of the image. Critiques occur during and after each assignment, creating an awareness of aesthetic concerns within each student. The composition, content, concept being explored, or statement wishing to be expressed is constantly contemplated. These critiques also encourage students to focus on their interpretations for each assignment. Classmates also help by suggesting which specific computer functions can help clarify the image and which ones distract from it. The clarity of the image and its communicative ability is examined in this class, just as it is in any visual arts class.

Due to the nature of this class, it is imperative that students attain a level of self sufficiency. One of the ways in which students develop self sufficiency is by being able to understand the background and the mechanics of a computer system. In this class, I convey its short history, stressing the major developments and their repercussions in the art world. By describing the efforts of the early pioneers, students gain an appreciation of the systems that are available to them today. Although current programs are user-friendly, I still find it necessary to teach basic computer literacy. In conjunction with this, the function and the use of the operating system is reviewed. An exposure to the specialized computer graphic hardware and software is provided. Some of this information can be overwhelming at first, but repeated references will eventually bring an understanding. As students become familiar with this medium, they are more able to think for themselves, troubleshoot minor problems, and excel beyond assignment requirements. The students who grasp these concepts quickly are often working in the lab on their free time, using programs not yet offered for classroom use. Educating students with a foundation exemplifies my belief that the more one knows about a medium, the more one can create, manipulate, and achieve an intended result. By the end of the course, I expect my students to have a good understanding of what computer graphics is, as well as to be competent in creating images on a paint system. I also expect them to feel comfortable when they walk into a college or any other computer graphic environment.

Course Content

The actual course begins with an introduction to computer graphics, which comprises the basics I have just mentioned. I use the elements of art while instructing the many tools of a paint system in order to keep my emphasis on the fine arts. I coordinate specific tools with the exploration of a specific element. By limiting both the tools and the concept, students have an opportunity to familiarize themselves more thoroughly. An example of this would be to use the freehand draw, paint, straight line, and spline functions to explore the elements of line (Plate 1). After some exploration time, students are then given an assignment using that particular element as the basis for a composition. Computer and traditional art examples illustrating the various ways in which the element can be employed are shown and discussed. Most of the basic tools coordinate well with the elements line, shape, and color (Plate 2). Texture and value integrate well with the paint modes shade, smear, or blend. The more sophisticated functions of the system, such as stencil and perspective, accommodate the teaching of form and space. Not every function will coordinate with an element, nor do I necessarily wish to explore every element. I do, however, wish to enlighten the student as to how the Elements of Art and the Principles of Design are used for effective visual communication.

After all the functions have been explored, I assign projects that offer a different perspective and encourage individual direction. As with all of my assignments, I supply a basic structure for a starting point, yet leave it open ended to allow for personal interpretation. Two of my favorite assignments are what I have titled as "An Ode to a Master" and "Using the Computer as a Tool." The assignment "An Ode to a Master" combines a mixture of art history, research, personal opinion, interpretation, and oral communication. Students are encouraged to find a master artist and make a personal visual comment about the artist or their style (Plate 3). This project can easily take advantage of the computers digitizing and manipulation abilities. Students present their findings orally, along with their image, giving everyone a different exposure to the various artists.

The assignment "Using the Computer as a Tool" offers a different kind of perspective. Students are exposed to the many ways in which artists use the computer in creating artwork finalized in other mediums. Besides being fun, this assignment exposes the students to a variety of mediums and techniques (Plate 4). It also integrates in their minds as well as in the department that the computer is another art medium, not a separate entity. Since only one person can work on the computer at a time, these lessons also creatively utilize the time of students while not working on the computer.

The last project assigned is a color cycle animation. In this assignment, students explore the use of time and movement in a piece of art work. This also establishes an introduction for Computer Graphics II, which includes more sophisticated paint systems, image processing, and two dimensional animation. Three dimensional imaging, ray tracing, and three dimensional animation are also planned, providing the school district can afford the necessary memory. Studio in Computer Graphics I concludes with discussions on careers and college programs. The final examination is both written and practical. The written part tests the students intellectual comprehension of computer graphics and the fine arts. The practical aspect requires the students to compile a digital portfolio. Students use a video sequencing program to professionally display their works created during the year. This class is demanding and full of new information; yet I find this yields an atmosphere of seriousness, productivity, and respect for the medium. In looking back at the first year of this course, I am very pleased and proud with the growth and development of the students and with the images they have produced.

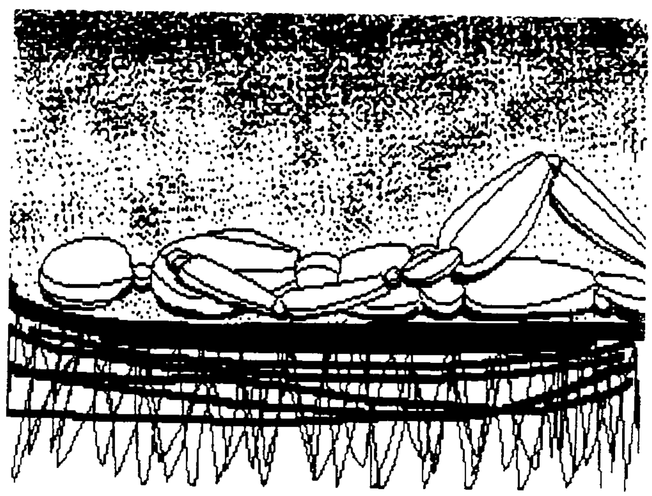


PLATE 1: Garrett Hallock 10/87
Composition emphasizing the use of line

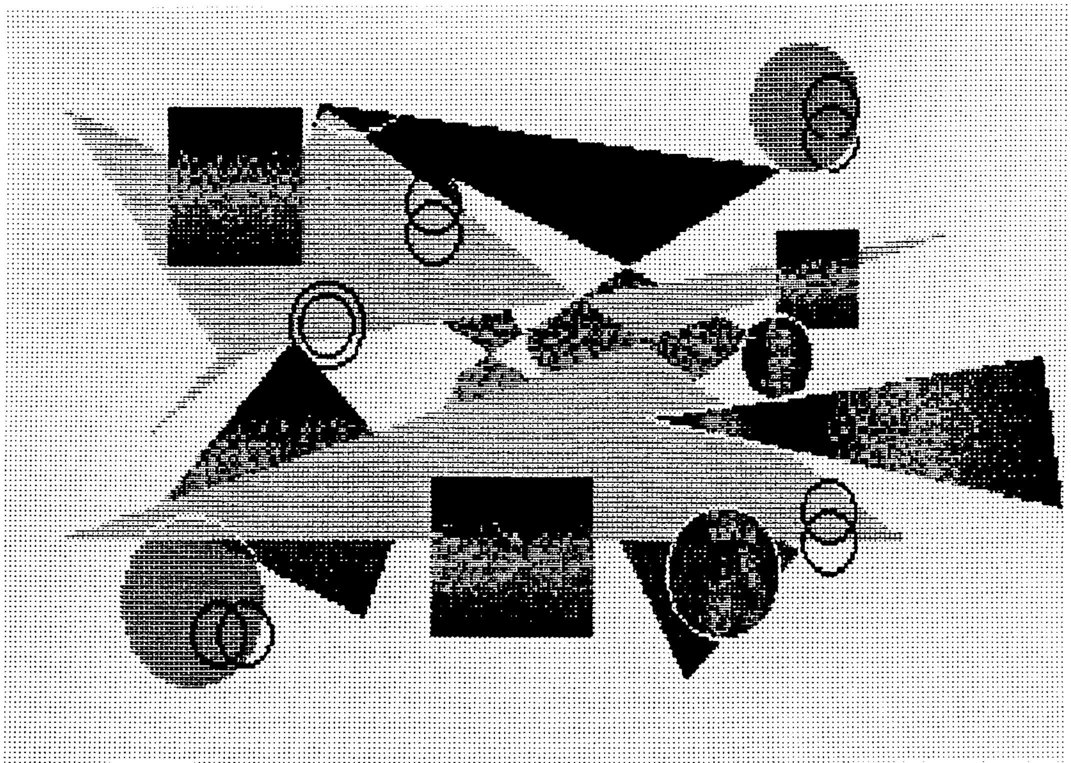


PLATE 2: Robyn Price 11/87
Composition exploring shape

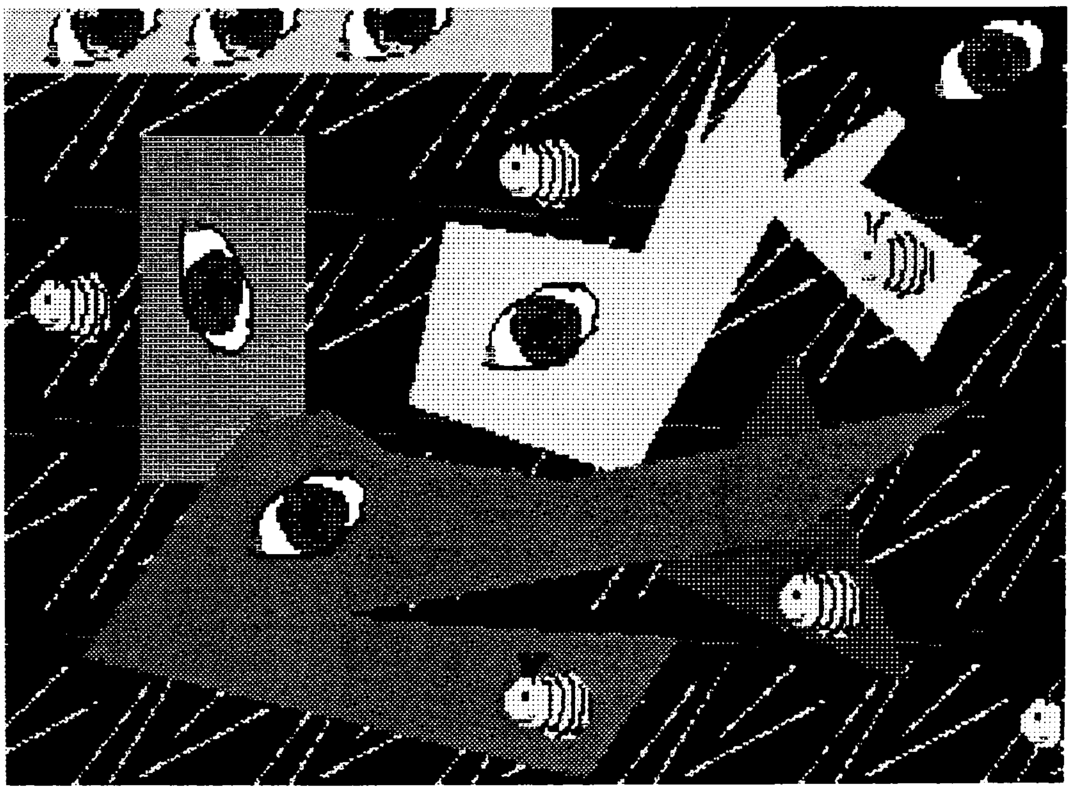


PLATE 3: Jean Harkins 5/88
An "Ode To A Master", the Master - Joan Miro

Reference Materials

Books:

Computer Images: State of the Art, Joseph Deken, Stewart Tambori and Chang Publishers, Inc.

Computer Graphics, Computer Art, H.W. Franke, Springer Verland

Digital Visions, Computers and Art, Cynthia Goodman, Harry N. Abrams

Artist and Computer, Ruth Leavitt, Harmony Books

Computer Graphics, Survey of Current Techniques and Applications, John Lewell, Van Nostrand, Reinhold Company

Art and the Computer, Melvin Prueitt, McGraw-Hill Book Company

The Computer and Art, Jasia Reichard, Studio Vista

Slidesets:

Available from: Siggraph
Ordering Department
111 East Wacker Drive #600
Chicago, Illinois 60601
800/342-6626

or SCAN
Box 1954
Philadelphia, PA 19105

Videos:

"Computer Magic" Cinemagic Productions
537 Jones St. #898
San Francisco, California
94102 - 415/861-1984

"Graphic Horizon", "How It Works", "2-D Graphics", and "3-D Graphics"

from: Educational Dimensions Group
Box 126
Stamford, Conn. 06904-9981
800/243-9020

"Siggraph 86", "Creative Computer Graphics", and "Computer Graphics Special on T.V. Commercials and Animation"

from: Frost and Sullivan
106 Fulton Street
New York, N.Y. 10038
212/233-1080

Additional videos may be purchased through:

ACM/Siggraph
address above

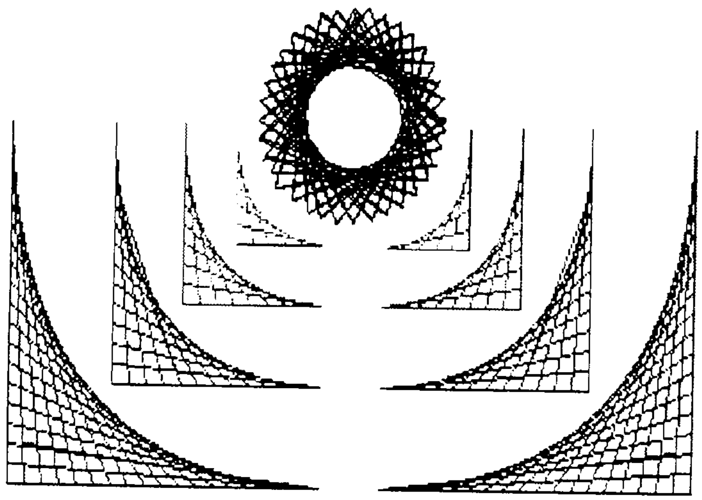


PLATE 4: Ron Atienza 5/88
"Using the Computer As A Tool"
Preliminary sketch for a "string" composition

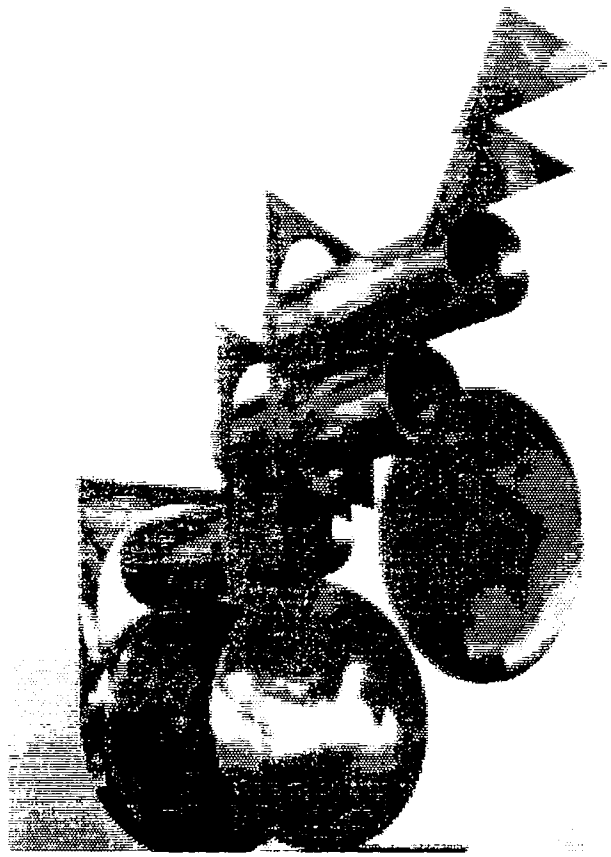
SMALL COMPUTERS AND THE SCULPTOR

Enhancement for the Sculpture of the 21st Century

by

Jon Fordyce

Until recently, highly capable 3-D solid modeling computer graphics had been the exclusive dominion of a few computer programmer/sculptors who reside within corporate or academic walls. Access to quarter million dollar systems has been restricted. The interested sculptors of the world have faced the obstacle of being forced to learn computer programming if they could find access to a machine. That era in technology is now essentially gone. Many of the 3-D computer design advantages that have entranced us in television advertisements are now easily within reach. For under $1,000.00 any of us can have truly amazing 3-D computer graphic systems in our studios. There is no longer a requirement to be a computer programmer to gain access to this formerly exclusive club. This has been made possible through the confluence of at least two complimentary trends in the computer business. One trend has been to package ever greater computing power into ever smaller physical computer chips. The megabyte plus computer memory requirements of 3-D solid modeling can now fit into competitively priced table top computers. Secondly, computer software writers are becoming increasingly aware of the 3-D design needs of fine artists. Despite the fact that these new products have been developed primarily for commercially oriented designers who will use them to produce inexpensive animated computer graphic television advertisements, the sculptors of the world also profit.



study for
MANDALA of TRANSFORMATION I
1988, stainless steel
Jon Fordyce

WHAT SMALL COMPUTERS WILL OPERATE CAD SOFTWARE?

Less capable but potentially valuable 2-D drafting software and 3-D wireframe modeling software can be found for the 16-48k computers such as the original Apple and it's evolutionary models, Atari 400 and 800, Commodore 64, Texas Instruments 994A, and a few others.

Sophisticated 2D and 3D drafting and 3D solid modeling CAD software can be found in profusion for the IBM PC (and clones). However, it is the continuing rapid development of powerful and comparatively easy to use 3-D solid modeling CAD software for the Amiga, Atari 520 and 1040, and the Apple Macintosh that will likely open up the creative potential of 3-D computer graphics for most of the sculptors of the world.

FEATURES OF SMALL COMPUTER CAD SOFTWARE

Each of the software packages for the Macintosh, Atari 520 and 1040, and Amiga 500 and 1000 models are unique, but they typically offer many of the following features and in some cases, much more.

1. stretch, compress forms
2. multiply or clone forms
3. merge forms
4. lathe like capabilites for creating 3-D forms
5. extrude or jig saw like capabilites for creating 3-D forms
6. overlay computer graphic images on top of photo-video imagery
7. texture mapping (electronically wrapping a 2D texture around a 3D sculptural form)
8. instant color change of 3-D forms
9. sophisticated digital sound capabilites
10 animation capabilites
11. instant measuring capabilites
12. Add pattern or unique 2-D designs to the surfaces of electronic models by loading views of 3-D images into 2-D paint software

HOW ARE THESE MACHINES LIKELY TO BE USED BY SCULPTORS?

Sculptors will be immediately attracted to the tremendous power, speed, and ease in using these software packages to create 3-D models for potential sculptures. At the same time, they will see significant potential for using the capabilites to prepare and present video images of their design in front of the client's desired sight. It will require very little additional effort to offer a client views of the same image in an assortment of colors and scales.
With the Atari 1040, for instance, it is easy to make photographic-like digitized images as a background for your CAD sculpture models. This can be important to sculptors who wish to make exacting

presentations of how their work will look in front of a patron's site. Such images can be printed out and/or used in sequence to produce video animations that take the client around and through the CAD generated sculpture.

Potentially 3-D graphics programs may incorporate random selection or artificial intelligence techniques to create endless variations on either a given sculpture or the objectively analyzed stylistic characteristics of a given sculptor's work. Further, it is within the bounds of technology to have robots fabricate such sculptures through the use of computer integrated manufacturing techniques. Would the public buy new Picasso or David Smith like sculptures? At this time, developing these computer capabilites would likely be expensive in time and money...but possible.

This author repeatedly introduces small computer graphics capabilities to sculptors who arrive at my studio in doubt and leave a few hours later saying they will buy one of their own.

Beyond serious creative capabilites, a large measure of the art making process for most artists is the prospect of finding pleasure in the process. These new 3-D modeling packages are, of necessity, somewhat complex to learn to operate, and the learning can range from frustrating to consuming stimulation.

TEMPORARY LIMITATIONS

1. Design or rotation require the computer to recalculate the entire form. With fairly simple forms, these calculations might take as little as one second, however processing complex 3-D forms is very slow (several minutes for a fairly complex form.

By using wire frame mode while developing your forms, the computer will be faster, because it has fewer calculations to make. Adding a math coprocessor chip in the computer will speed up image processing further, but time required for processing might still be seen as an irritant.

2. Capabilities for simulating textures is presently quite limited, but second generation small computer software promises to provide texture mapping capabilites along with other improvements.

3. Small computer (Atari, Macintosh, Amiga) dealers offer the buyer the choice between color or monochrome monitors. Standard monochrome monitors often offer sharper images (higher resolution) for less cost than the standard color monitors. If color is important to your work, you will have to pay several hundred dollars more for a lower resolution standard color monitor. If you insist on a very high resolution color monitor, expect to pay thousands of dollars more for your total system.

4. Some sculptors perceive that the sensitivity and "magic" that occurs as they work with tangible traditional materials couldn't possibly be achieved with a computer. Such concerns are not without a degree of merit.

ROLE FOR COMPUTERS IN FINE ARTS CURRICULUMS

Art schools, until the past few years, have offered a wait and see kind of resistance to the inclusion of computer graphics in the curriculum. Ohio State University's Art Ed Dept., began their computer investigations out of a desire for pure research and development of the medium. Among the first schools to incorporate computer graphic courses were those with commercial art and architecture programs. These schools began to offer computer graphics courses because of the design advantages and the fact that computers are increasingly used in professional commercial art and architecture studios. In general, Fine Art Departments of the world's art schools and universities have not faced the same kind of "outside world" pressures as business world oriented programs like commercial art and architecture, therefore resistance is slower in passing. One might also consider that fine arts has a history of manual approaches to media. The

tangible interaction between concept and medium is an important one. By enhancing the design phase, the computer may actually maximize this interaction.

If creative sculpture students can easily investigate $1000.00 machines which offer many of the same 3-D capabilites as larger computers...significant change in the appearance of computer designed art will likely soon appear. As more sculptor/teachers become aware of these powerful new tools, the walls of resistance are likely to crumble.

SOME FUTURE POSSIBILITES

INCREASING COMPUTER POWER FOR LESS MONEY

This might be viewed as a high probability considering that there has been a clear trend in this direction. Others say that computer prices are leveling off. In an industry where it has been said that a 20% monthly rate of change is the norm, it is tricky to make any long term forcast.

NEW ART FORMS MAY EVOLVE

- Holography holds limitless possibilites for incorporation in tangible sculpture as well as becoming a medium for presentations of CAD designed sculpture models.
- Consider the possibility of cross discipline art forms which can be coordinated or enhanced by both CAD and computer controlled operating systems techniques.
- Sculptor/scientist collaborations might lead to projects such as sculptor input in the limitless possibilites of genetic engineering. Would CAD designed life forms be considered as art?

NEW INPUT METHODS

New methods of input are currently being used for other computer applications. Some of the following are under development or are developed and waiting to be purchased for CAD or other applications.

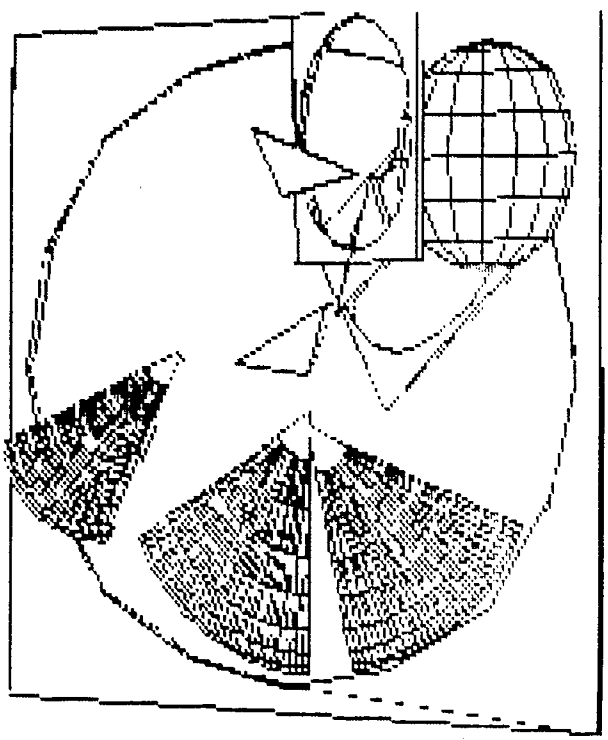
- Voice actuated input will allow CAD work to be accomplished by talking to the computer.
- Gloves containing motion sensors will allow 3-D CAD work by the motion of a human hand in space.
- 3-D ultrasonic wands will allow CAD work to be done by waving a wand in space.
- Eye movement input will allow operation of CAD software.
- Experiments are underway for direct thought control for computer input.

NEW SCULPTURE CONSTRUCTION METHODS!

The possibilites of computer integrated manufacturing (CIM) have been under development for at least 15 years. This variant of computer technology, in a best case situation, allows a designer to create a 3-D CAD design at a graphics work station and transfer the electronic information to computer controlled machine tools which in turn carves a positive of the electronic model from a block of some material. Similarily, the technique might just as well carve a mold into which a moldable material like plastic can be automatically injected.

The evolution of robotics is closely tied to computer integrated manufacturing (CIM). To date, robotics technology has been slow partly because of the expense of research and development. Other impeding factors include the cost of powerful computers to run these complex systems. Until now, only huge corporations like GM, Toyota, Ford, and Chrysler have been able to afford the full advantages of CIM. The ever falling prices of increasing computing power might well usher in a resurgence of robotics research and development. Such prospects offer the high tech oriented artist reason for excitement in considering the possibilites and reason for all factory workers to consider career changes.

MANDALA of TRANSFORMATION II CAD image

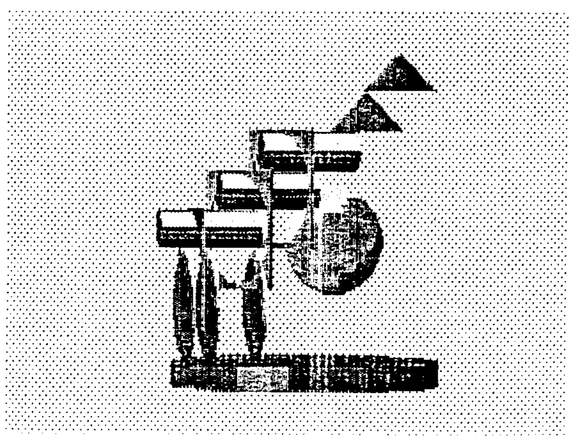


SOME IDEAS ABOUT THE FUTURE OF COMPUTERS AND SCULPTURE

As the major blocks of cost and accessability are rapidly dissolving we can look forward to a probability of ever greater computing power in smaller packages and probably for less money. Also consider the constant evolution of a combination of easier to use and ever more powerful CAD software and computers. Join those prospects with the continuing development of computer programs that can create custom applications software from normal language commands and the barrier of computer languages might soon largely disappear. All of the earlier obstacles to exloring creative computer possibilities will likely soon be gone and that prospect will strongly encourage growing use of computer technology for the design, fabrication, and even operation of sculptures. Beyond those prospects, imagine future computer assisted artistic cross disciplinary and sculptor/scientist collaborative possibilites and let your mind soar. We are all free to participate in these exciting new directions that will take sculptor's involvement with computers far beyond CAD. The September 1987 issue of SCIENTIFIC AMERICAN magazine provides an excellent and readable indepth look at trends in computer technology.

CONSIDERATIONS FOR DEVELOPING AN OUTLINE FOR YOUR FUTURE COMPUTER USE

It is hoped that you will not consider the following as irratatingly presumptuous. It is intended for the reader who might appreciate some ideas on how they can get involved with computers either before or beyond CAD for sculptural use and where that involvement might lead.



CAD study for MANDALA of TRANSFORMATION I

Assess what you have done to date with media and stlye and assess in detail the capabilities of small computers and consider if your directions can be enhanced by incorporating the technology into what you wish to achieve with your career. If you are committed to a rather clearly prescribed style, CAD can help you to explore variations of your concept/form. If you are open to significantly expanding your creative explorations, the following scale, suggesting degrees of computer absorption, might act as a starting map for this largely unexplored territory.

THE FOLLOWING SHOULD BE VIEWED AS A SCALE

1. Continue to make art in your existing manner.

2. Creating tangible sculpture that addresses the theme of computers and or their influence on society, but do not use a computer to design the work(s).

3. Develop ideas germinated from experiments with 2-D or 3-D graphic software which leads to tangible work that is influenced, yet not fully designed, with the use of a computer.

4. Use 2-D computer paint software to create surface treatments for sculptures that are created spontaneously and tangibly.

5. Use computers to help manifest a preconceived design, but allow for the unique capabilities or limitations of CAD to influence your design decisions.

6. Translate either or both 2-D or 3-D photo digitized images into solid metal cut outs and assemble them.

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7. Use computers to electronically manifest a preconceived sculpture design. This is the process for which most CAD software has been developed for architects and engineers, yet this fundamental and possibly fulfilling approach only scratches the surface of the possibilites for sculptors.

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8. Evolve designs through a spontaneous process where computer color capabilites is the dominant influence

9. Allow the gravitation free conceptual space of 3-D computer graphics to inspire new design ideas.

10. Allow computer animation to influence how you design sculpture movement in time.

11. Evolve sculpture ideas spontaneously by playing with the building blocks of stored 3-D polygons.

12. Gain increasing knowledge of computer programming and begin to write your own custom applications software.

13. Dream of a form or project which would require computer solutions, but exceeds your present computer

knowledge and find a programmer/engineer/scientist who will work collaboratively with you toward realization.

14. Explore the tremendous creative potentials of CAD designed holographic displays, robotics, computer integrated manufacturing technologies, artificial intelligence, etc.

15. Explore the increasing number of information brokers who can provide information on almost any topic and they can be accessed through small computers which are equipped with telephone modems. These brokers bring unprecedented access to information into the comfort of your studio.

These ideas are intended as possible starting points for computer investigations for sculptors and are not intended to be either complete, mutually exclusive, or as prescribed steps. Sculptor's use of Computers need not be limited to either typical engineering or architectural CAD software approaches, or for that matter, to creating custom applications software. This is a dynamic new medium that encourages computer incorporation in endless variations by sculptors. Currently 3-D computer graphics offers tremendous value to helping scholars, scientists, and students to better visualize a wide variety of subjects. Soon this powerful medium will be of significant help to both sculpture students and practicing sculptors in their quest of the elusive and ever moving avante garde of art.

SUMMARY

If Leonardo Da Vinci were alive today, there is little doubt that he would embrace computer technology. This is a medium that offers greater potentials for synthesis of art and science than has existed since Leonardo's exceptionally visionary example. At last we see the the doors of evolutionary change opening to the beginnings of a new era in which art and science can both compliment and enhance each other to a degree never possible before the advent of powerful, accessible, and inexpensive computers. The introduction of these machines will likely usher in profound changes in how art is made and how it looks in the 21st century. Increasingly, small computers will open the doors for art/science and cross discipline collaborations that might well alter the very nature of artistic forms.

I hope that I have provided an article of interest to you and I welcome your response.

Jon Fordyce
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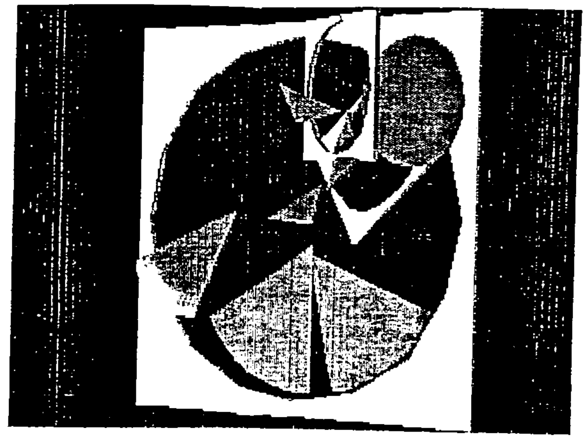
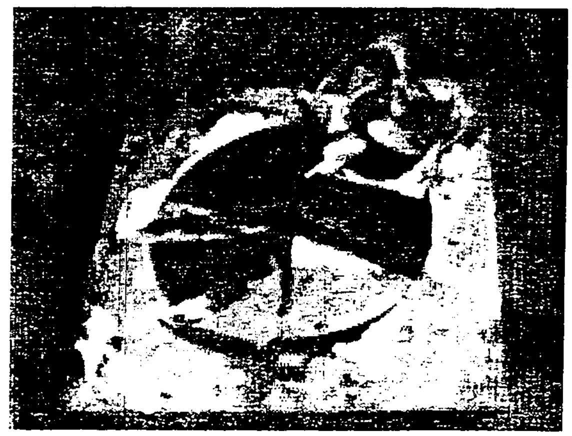
New Carlisle
Ohio
45344
(513)845-9096



MANDALA of TRANSFORMATION II CAD image



MANDALA of TRANSFORMATION II
1988, Jon Fordyce, stainless steel

COMPUTER	SOFTWARE	MANUFACTURER	RETAIL PRICE	LATHE (SPIN)	EXTRUDE	NUMBER OF POSSIBLE COLORS	COLORS DISPLAYABLE AT ONE TIME	IMATION APABILITY	STD. MONITOR MONO	RESOLUTION COLOR STD. MONITOR	WITH PAINT SOFTWARE	TRIC FORMS INCL. IN SOFTWARE	ADJ. LIGHT SOURCE	AVAILABLE CLIP ART DISCS
APPLE MACINTOSH	PRO 3D	Enabling Technologies 312/427-0386	$349.00	yes	yes	mono	n/a	no	360/280	N/A	yes	YES	4	yes
	EASY 3D	Enabling Technologies 312/427-0386	$149.00	yes	yes	mono	n/a	no	360/280	N/A	yes	YES	4	yes
	MAC 3D	Challenger Software 312/957-3475	$249.00	yes	yes	mono	8 to a color printer	no	512/350	N/A	yes	yes	6	np
ATARI 520 1040	CAD 3D 2.0 (cyberstudio)	Antic Publishing Co. 415/957-0886	$89.95	yes	yes	512	16	yes	640/400	640/200 or 320/200	yes	yes	3 + 1 Ambient	yes
AMIGA 500 1000	SCULP 3D	Byte by Byte 512/343-4357	$99.95	yes	yes	4,096 hold and modify	16 or 32 or 4,096 *1	yes Public Domain	color only 320-200 640-400-16	740-460	yes	yes	unlimited	to be released
	FORMS IN FLIGHT	Micromagic 415/327-9107	$79.00	yes, + elliptical factor	yes	4,096	16 High Resol. 32 Lo Resol.	yes	704x440	320 x 200	yes *3	yes	5	Incl. on disc, letters numbers face
	VIDEOSCAPE	Aegis Development 213/392-9972	------DEVELOPING	3-D	CONSTRUCTION	SOFTWARE	------							
IBM PC and clones)	CAD KEY	Eliminate												
	XYZ-3D	Aurial Corp 818-609-1861	$295.00	not currently avail.	yes	B & W only	n/a	yes	supports 40 graphic cards		yes, with optional autocad link	no	1	no
	PRO PC	Enabling Technologies 312/427-0386	$395.00	yes	yes	Dependent on graphic Board: 256 VMI 8 or 16 w/EGA,VGA 64 w/Rendition 1	16,000 with TARGA graphics Board	no	640 x 200 1200 x 1000	640 x 3500 1000x1200	yes	yes	8	no
MACINTOSH II	DIMENSIONS II	Visual Information Inc. 818/918-8834	$2,495.00	yes	yes	16.7 million	256	forthcoming	640/480	640/480	yes	no	1	no
MACINTOSH II	MAC 3D	Challenger Software 312/957-3495	$249.00	yes	yes	256	256	no	512/350 to 1024/1024		yes	yes	6	no

1* Depending on graphic mode
2* Sculpted objects - irregular forms
3* with a 3rd program that creates an IFF image

*5 smooth shading - much more nat

PRO 3D, MAC 3D, CAD 2.0, SCULP 3D, PRO PC, DIMENSIONS II, all offer measuring and solid modeling features.

Present small computer 3D CAD software either offers excellent measuring capabilities with limited modeling features or software with a reverse emphasis. Selection of brand of computer and supporting software should probably be determined by which primary CAD feature is most important to each sculptor.

The illustrations in this article have been printed on a Gemini 10X dot matrix printer. Photo images directly from the monitor are dramatically sharper.

INSPIRATION: THE ANATOMY OF AN IDEA: A PERSONAL VIEW

Barbara Nessim

Barbara Nessim
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Abstract

This talk is about how one artist, who creates art to reflect her personal view as well as employ her images for publication [ie: magazines, posters, books etc.], develops her concepts and creates ideas. It explains, in depth, the meaning behind each image and identifies the main idea.

The computer is one of the mediums Nessim chooses to use. Traditional mediums such as gouache, watercolor, pastel, oil, acrylic etc. are sometimes employed in combination with computers or as the single medium of choice. If combined it is deftly integrated within the one image. The medium, be it computers or paint on surface, is not the main issue in this presentation but rather a well integrated choice that help illuminate the end result, the work of art.

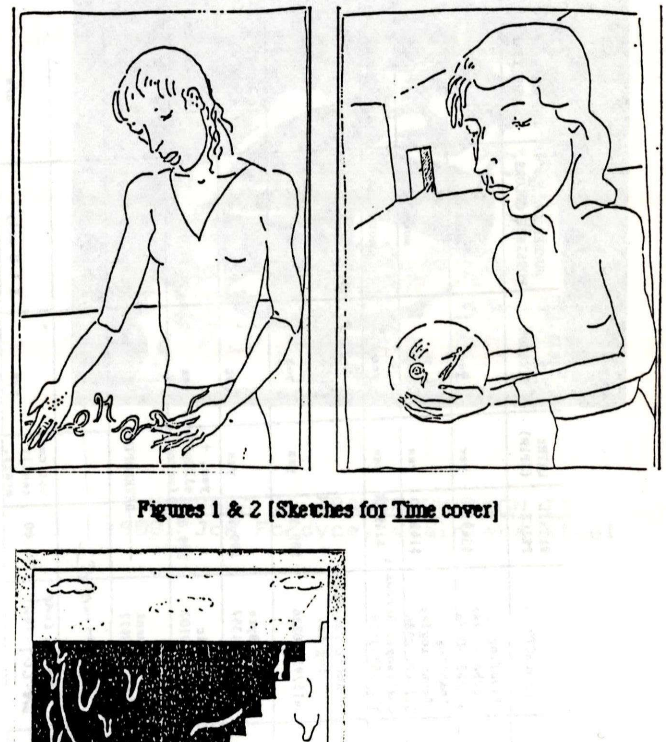
Creating art for publication has always been a great challenge [for me]. It combines two important elements. One being to illuminate anothers' idea, the second, to bring this idea your own personal view. A perfect balance must be created between the two spheres. Creating art, where the idea stems solely from ones own interest, forms another kind of balance. One where your subconscious perception mingles with your alert conscious self.

To express this I have chosen three examples from my presentation: A cover for Time magazine, an article for Newsweek and a personal work created in Japan, in conjunction with a solo exhibition of my work.

Time Cover

Time presented to me a cover story, an open ended assignment on the ERA. It was in July of 1982 when the Equal Rights Amendment was going to vote before the Congress. The idea was to "do something about the womens' movement." "It could be historical, it could represent the present, the future, or you may want to reveal your personal experience." A one page text was the only "story copy" available. My choice was to illustrate the present.

For almost three decades I have continually kept visual diaries. These diaries are kept in 6"x 9" sketchbooks and in a year I usually complete three or four. Although this year, 1988, the number has mounted to six. The books provide me with the source of my inspiration.



Figures 1 & 2 [Sketches for Time cover]

Figure 3 [Sketch for Time]

I went to my diaries and chose a few drawings that I thought would be appropriate for this ERA subject. I used these drawings as a base to submit approximately five ideas as sketches. [Figures 1,2,3]. From these sketches which were presented to an editorial board, one was selected to "work up" as a finish. [This process is about the same in each of the following examples].

The meaning of the final visual symbols I used in the final printed piece [Figure 4], is simply stated. My main focus, always is to use the least amount of lines to produce the maximum amount of meaning.

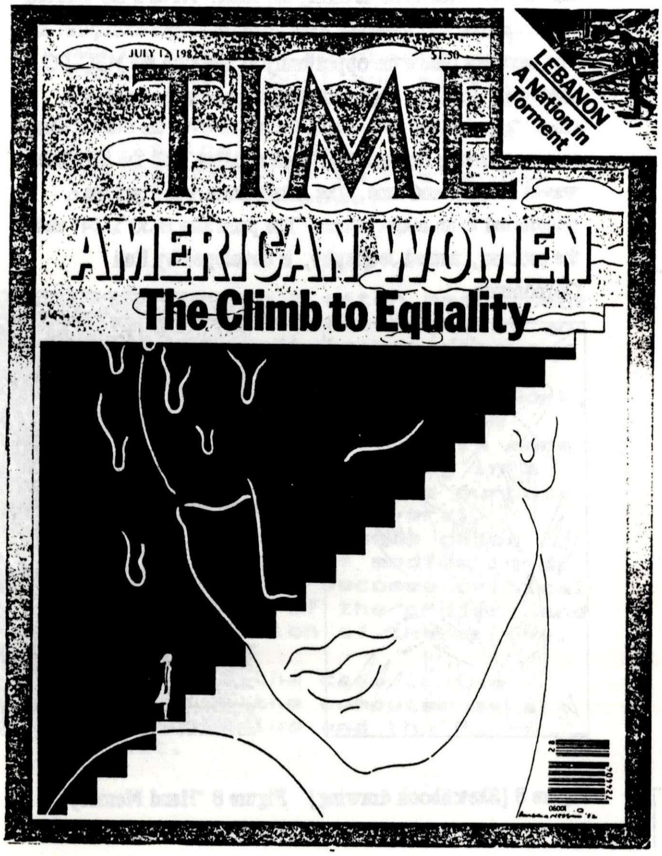


Figure 4 [Finished Cover]

Here I focus on the female gender and use the Black and White theme to identify women of all color, economic backgrounds and social status. Black and white represents contrast, rich and poor, upper and lower class, etc. In short the ERA effects all women.

During the two weeks I was doing the sketches, to the time I started working on the finish, the ERA was defeated and the ten year struggle to get it pasted was slated to begin all over again. To exhibit this I created a large stairstep effect and now placed the woman at the bottom of the stair. I greatly reduced her stature in relation to the stairs' riser, leading to the utopian blue sky above, her goal.

I placed black over white. The black represents the darkness that she still is in. A positive and negative line drawing of a large, thoughtful, sadly expressed, omnipresent, womans' head represents all women and how they are felling about the ERA not being passed. The hair also mirrors the tears and the sweat that went into the ten years of work.

The smaller figure is standing on top of a hill [represented by her shoulder], all in red, her dress and hair blowing in the wind, showing her determination to climb the stairs once again. The line of copy, "The Climb to Equality", was written after my art.

<u>Newsweek Art</u>

The [March 31, 1986] <u>Newsweek</u> story "Feminism's Identity Crisis" was physically approached in much the same way. Three drawings were commissioned. Only two were used. Here, I include all three.

Again, there was no "story copy" to illustrate. A long talk with the writer Eloise Shalholz, help define the parameters she would later write about. We discussed many issues. Some of my ideas were incorporated along with those of other women who worked on the article in San Francisco, Boston, New York and Washington.

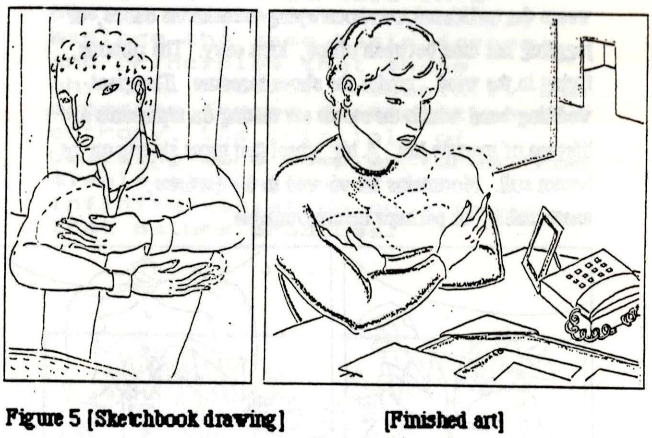


Figure 5 [Sketchbook drawing] [Finished art]

The first drawing [Figure 5] pictures a women holding an imaginary baby. An empty picture frame sits on the desk and the telephone's handset cord is severed from the main instrument. The background shows an empty room symbolizing her home. This picture has multiple meanings. The woman could be marries or divorced and has a child at home or in day care. She worries about, missed, and mentally caresses the child. Or she is yearning to have a child and can't for the myriad of reasons we have become all too familiar with.

The second piece [Figure 6] speaks of a womans' biological clock. It pictures her holding an"egg" clock. The time has arrived, the eleventh hour. She gases at the timeless clock, above her, without hands. On the shelf below sits a bowl of eggs representing fertility and the apple pie is home. She is worried, perhaps she may never have the children she so desires.

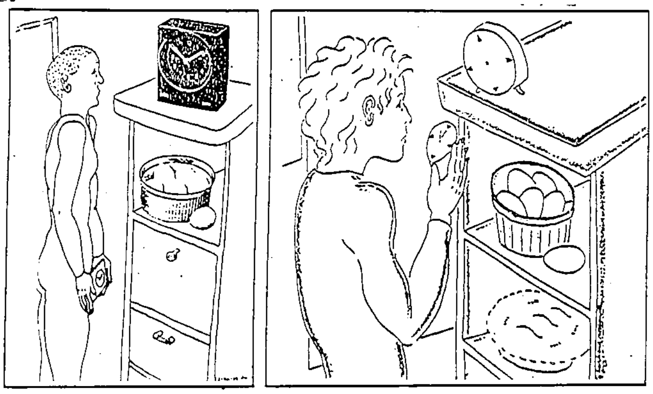


Figure 6 [Sketchbook drawing] [Finished art]

The last, [Figure 7] in the trilogy, identifies the increasingly hard roles people must assume in marriage. The husband and wife sit, facing each other, nude, on stools, which are different in shape, implying individuality. Both their hands are looped through the wedding band reaching one goal. Working together this smaller ring identifies daily life. She wears the traditional toe shoes trying to make the dance, of juggling her time between office, look easy. The ribbons, flying in the wind, render the shoes insecure. The giant wedding band which the stools are resting on represents a lifetime of marries life. A big wheel that turns slowly on the barren soil. Mountains are viewed in the distance, unattainable, or perhaps insurmountable.

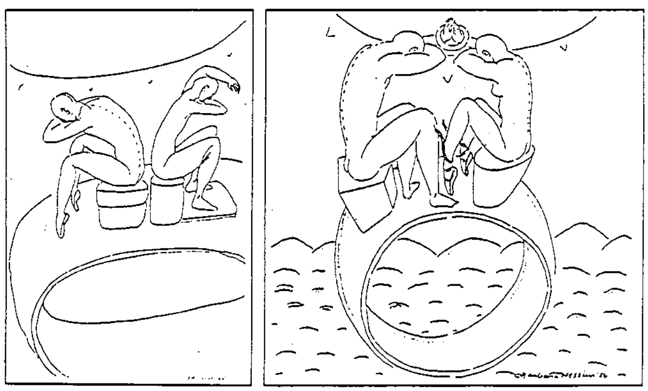


Figure 7 [Sketchbook drawing] [Finished art]

Personal Work

The third,[Figure 8] and last example, evolved when I was in Japan. This "computer painting" is a personal work. When visiting a foreign country, watching television has always been a fascination for me. Images emerge without the understanding of what's being said. Your fantasy constructs the meaning of the visual. On the screen a man and woman are participating in a talk show. They are holding up to the camera, an open page in The National Geographic. Displayed is a group of rocks. On the rocks are images of hands. The hands were used as a stencil to form the image. I think it's a prehistoric cave painting. I study the forms and quickly draw something in my sketchbook with notes detailing the color. It starts me thinking about the past and present, from cave painting to computer art. The next day I have the opportunity to work on the NEC-PC computer. I start to draw still thinking about the hands. I create "Hand Memory". Stenciled hands over the human form, energy coursing through the figure melding with the invisible waves of wind and time. The information was digitally transferred to an inkjet printer. The print size is 30"x 24" and the process, named Jetgraphy, is developed by Fuji Corporation.

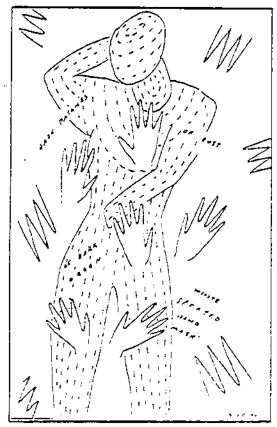


Figure 8 [Sketchbook drawing]

Figure 8 "Hand Memory" [Jetgraphy Print]

•Note - All "Finished art" appears in color when printed in its' respective magazine.

THE PERFECT MARRIAGE --THE MEDIUM AND THE MESSAGE

Notes on the Faces Project

Nancy J. Freeman

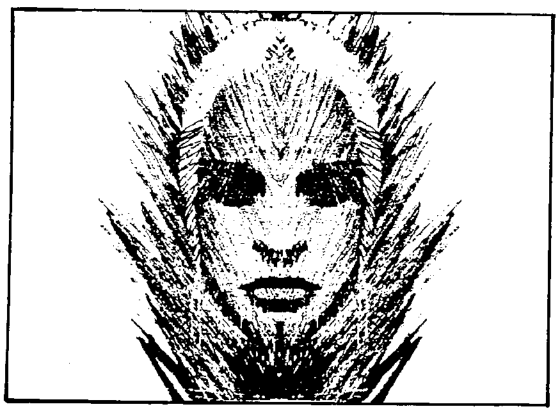
Artist

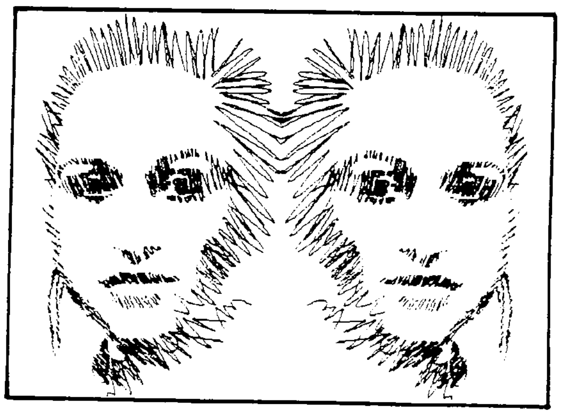
Today's artist has many media options to choose from, both traditional and hi-tech. Each artist searches for that medium which is best suited stylistically and philosophically to his or her particular purpose.

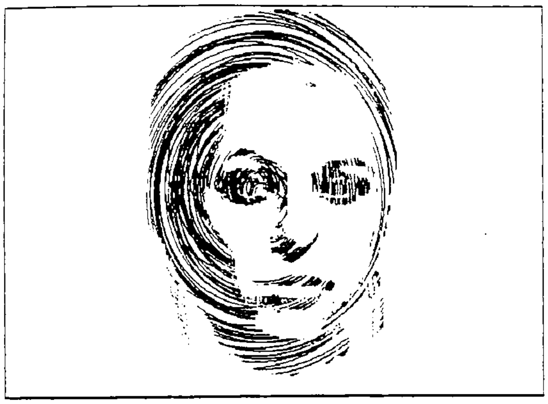
One doesn't often hear about the philosophical aspects of an art medium. It is not always a relevant issue. Yet the more levels of meaning in an artwork, the more the medium must be right. As an artist, it is more satisfying to be working in a medium which serves the purpose of the artwork on several levels. There are some cases when the choice of medium is so correct that it becomes critical to the intent of the project and to the direction of the artist.

Such is the case in the marriage of the computer as a painting medium and the Faces Project.

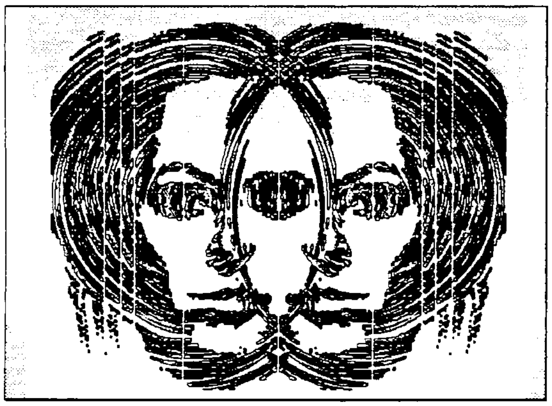
The Faces Project, begun in 1984, had its genesis in a desire to use art to visually explore the same basic forces and principles that shape physical reality, especially the opposing forces of evolution and entropy, the principle of building more complex forms from simple elements, and the infinite variation on a theme that nature produces.



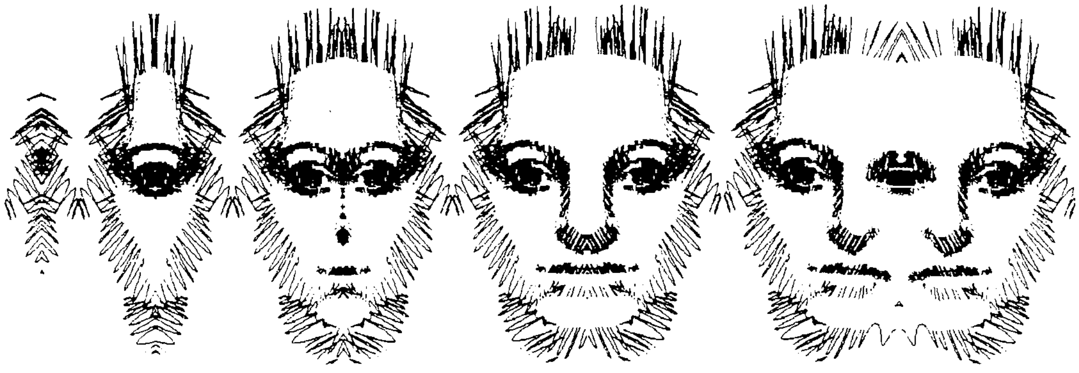




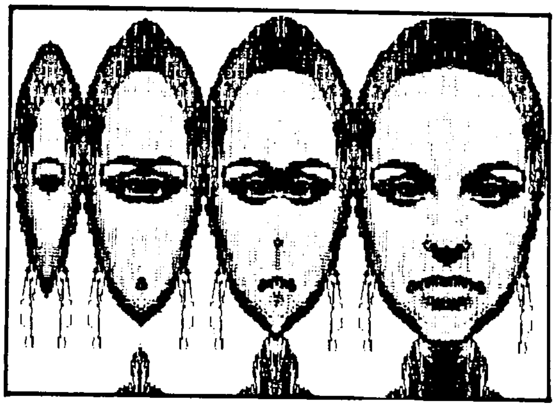
A single image accommodates the rather broad scope of this project. It is a face, a rather ordinary one with a neutral expression. This same face is put through multiple variations,processes, and sequences. Faces are one of the strongest patterns that humans recognize, and can withstand a tremendous amount of manipulation, distortion, and process --yet still be recognizable as a face. The choice of a face also serves to focus on the intellect necessary to observe and analyze the workings of the universe, and the psychological/social aspects of our existence which, in its multiple levels and variations, reflect the action of the same forces.



My purposes required images in large enough numbers to suggest infinite possibilities. This led to the use of a wide variety of media. The exploration of sequences and processes required images that were related yet varied. I developed a water-color monoprint technique that could do sequences. I used every medium I could get my hands on.

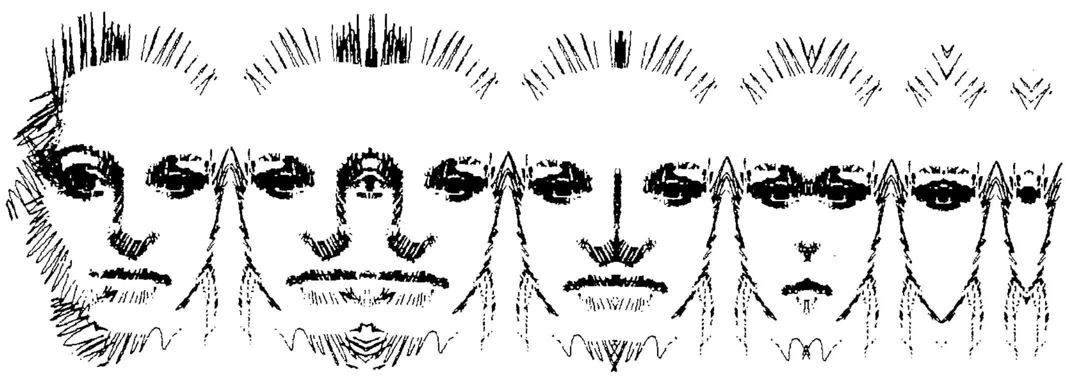


But it is the computer that is proving to be the ideal medium. Both functionally and philosophically, it is absolutely correct.



Functionally, painting with a computer is ideal for this project because each image can be changed, yet can remain the same. Processes such as destruction or transformation can be developed with each step recorded. These types of processes can be frozen sequentially, or even shown in motion. The process of evolution is greatly enhanced, since each generation can serve as the exact base for the next. Some images are now in the 9th generation. And it is ideal because it is so powerful. Many, many kinds of manipulations are possible at all stages of development --many more than any other medium, maybe more than all other media combined.

It is also philosophically ideal, on several levels. The binary system that is the basis of the entire amazing computer revolution is an elegant example of increasing orders of complexity built from simple elements. Even the display terminal, with its Red-Green-Blue units, and the printer's output, with its four-color inks use this principle. The world of the computer is in many ways a compelling parallel to the physical world. The forces that shape the "real" world are at work here, too; but in the computer world, the processes are greatly speeded up, and the results therefore more readily noticeable.



ARCHITECTURE, MEMORY AND COMPUTER-AIDED PHOTOMONTAGE

Terry Gips

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ABSTRACT

Digital imaging and processing offer an effective way to make art concerned with contemporary issues of information, experience and memory. The parallels between human and computer memory are expressed through shared terminology and in the common use of architectural metaphors. Modified buildings and human figures are montaged in computer images to comment on the relationship between architecture and memory.

Since about 1980, I have used photography in combination with a variety of other media including the computer to grapple with issues of information, experience, and memory: how we accumulate and sort the bits of data from our experience; how we process those bits; how we store them; and how we retrieve them from memory in order to construct new ideas. More specifically, this work has been about images of memory which have architectural connotations. We talk about allocating and structuring space in memory, we put things into memory and search and recall from memory. It is as if memory were some physical space, an enclosure with dimensions, corners and recesses, surfaces and openings. These associations between architecture and memory are not new. Architecture as metaphor and mnemonic device goes back many centuries, but such roles for architecture are even more poignant when seen today in the light of computing technology. Like the human mind, electronic processing has an elusive and immaterial nature. However, many of the same concepts based on the concreteness and systemic quality of architecture are employed to understand the uncanny power of both human memory and computer memory.

I intentionally borrowed vocabulary from computing not just because I am going to talk about using the computer for making art, but because it seems important to note the dialectic which is going on between electronic technology and our conceptions of the world in general. Within this dialectic are two levels of mutual interaction. First, the words themselves: the terminology of computing has parallels in the current language used in a wide range of contexts from intellectual and philosophical discourse to the everyday exchanges in social, political, and even personal arenas. Although this may be due in large part to the fact that the computer has become a useful tool in nearly every field and that practitioners need the vocabulary to interact with each other around issues of technology, it is also due to the fact we live and work in an information-dominated culture.

Thus, on a second level of the dialectic, the language shapes our ways of conceptualizing, thinking, experiencing, acting and, I might add, being creative. In the other direction, new concepts, thoughts, experiences, actions and creations modify our speaking. One specific phenomenon in the middle of all of this is memory: personal memory, collective memory and what might be called a tangible public memory/record. The way we understand, experience and talk about memory is changing radically. This computer-fueled revolution can be compared with those revolutions which came respectively from the development of photo-mechanical reproduction about 100 years ago and the movable-type printing press in the 15th century. Most would agree, however, that the repercussions from the computer are enormous in proportion to the other two.

The remarkable power of the camera to "remember"—to record and save vast amounts of visual data—serves as an informing backdrop to the work of most photographers. Likewise, negative files are an efficient memory bank from which visual fragments can be selected at will to refresh memories and reconstruct the past. The computer is, however, a memory tool of an even higher order. On the simple level, my move to the computer as a means for making art grew out of a desire to construct visual spaces and montage images in ways which were more flexible and multi-dimensional than cut-and-paste collage or darkroom montage. But I also wanted to find better ways to articulate ideas about processing the deluge of information we receive on a daily basis, layering (recontextualizing) that new information with old information. I became intrigued with the idea of merging two technologies where memory was in each case a defining characteristic.

The first computer-constructed images I made resemble earlier hand-constructed works with titles such as Photoconstruction as Bricolage and Open House: Invitation to Flying in which I had cut black and white photographs into pieces and reassembled them to create new spaces. I was, in a sense, building pseudo houses for my ideas. It was a way of organizing ideas and giving them "residence," addresses to which I could return at another time. I was drawing on a variety of historical models, practices and intuitions regarding memory which linked it with architecture. It would be a lengthy exercise to describe and analyze all of these,[1] but a brief mention of a few key concepts will give some perspective.

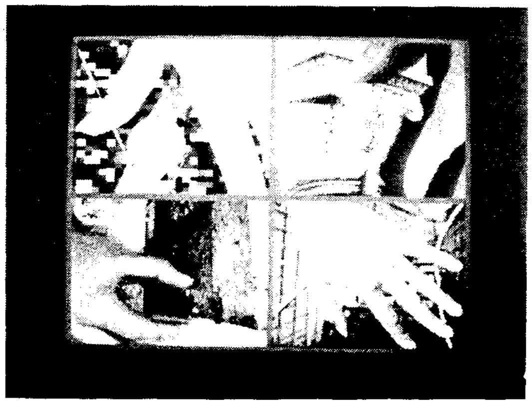
Among those who have connected architecture and memory, some have even suggested that architecture was necessary for memory. According to the 19th century art historian John Ruskin, "we cannot remember without [architecture]."[2] As one of his "seven lamps of architecture,"[3] memory referred to that memorializing function of buildings which Ruskin saw as one of their basic requirements. He felt that buildings were the primary carriers of metaphorical and historical meaning, passing information from one generation to the next. For him, the past resided even more in the stones of architecture than in the pages of literature.

Saint Augustine's poetic image of the "spatial palaces of memory"[4] is a more abstract concept; memory is envisioned as a grand space furnished with images where human intellect dwells. He, like many other literary persons through the centuries, has borrowed from the ancient traditions of <u>ars memoria</u> which were used to memorize material in the days before books, photographs and computers. The images of actual buildings with their particular rooms, structural elements and decorative details were committed to memory as spaces in which less concrete words and ideas could be hung like pictures. Because the human mind remembers visual information most readily, and because memory seems to be inherently modeled as an interior space, architecture worked well as this supporting device. Once the words or ideas were assigned precise locations in the building, the person could mentally walk through the space to retrieve the material for oration or other "processing."

Although I have not been interested in mimicking any particular practice of using architecture to represent or enhance memory, I have found myself drawn to images from architecture as key elements in recent work. With the computer, I began by digitizing photographs of whole buildings as well as isolated architectural elements. Once available in digital form on the screen, I rearranged these pictures, changed orientation and position, modified scale and color and edited or repeated sections. I layered my own photographs with those appropriated from various print media, merging architecture--particularly doors, windows, passageways, stairs and colonnades—with faces and figures. I used the software functions which gave images a degree of transparency so that one image could be read through another image.

"Memory Lapse."
Original 20"x24" Cibachrome print.

A Janus-like spirit inhabits these pictures, the architectural openings leading simultaneously back and forward in time. Figures float on steps, in doorways and across arches, occupying these metaphorical houses. Sometimes it seems that the figures are all at once in front of, behind and in the same place as the buildings. Body and house are equated as they mutually inhabit one another. In other montages, eyes, ears, and lips seem to be the human psyche pulling itself backward and forward, tracing its dreams and memories across the translucent surfaces of walls, vaulted ceilings, majestic columns, etc. Intentional disjointedness in subject matter also appears. For example, classical architecture gently collides with with contemporary media figures in one montage, and a giant hand in another is poised to gage the height of a tiny figure as it emerges from an arched stone passageway.



"Being, Building, Dwelling, Remembering."
Original 20"x24" Cibachrome print.

Although the technology of the computer is clearly not dominating the foreground of these images, the catalyst for the work is a kind of 20th century digital Mnemosyne. This Goddess of Memory is no doubt lurking around personal workstations and the labyrinth of global networking systems to assess the prospects for nurturing these new places of memory.

1. Two books which provide serious discussion of this topic are Francis Yates, <u>The Art of Memory</u>. Chicago: University of Chicago Press, 1966, and Ellen Eve Frank, <u>Literary Architecture</u>. Berkeley: University of California Press, 1979.

2. John Ruskin, <u>The Seven Lamps of Architecture</u>. New York: The Noonday Press, 1971 (originally published in 1849), p. 169.

3. Ibid.

4. St. Augustine as quoted in Francis Yates, op. cit., p. 31.

DIGITAL PHOTOGRAPHY

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Murray Hill, New Jersey 07974

Abstract

The art of manipulating and transforming photographic images with chemicals or with an enlarger in a darkroom has a long tradition that can be traced back to the earliest days of photography. This type of image processing can serve two purposes: to enhance and to entertain. With the traditional tools, however, it can take remarkable skill of a manipulator to hide the traces of his or her work.

But now we have computers. We can digitize existing photographs without any loss of resolution or dynamic range, store them in a computer and manipulate them in a 'digital darkroom.' All computer manipulations are reversible, and can be standardized with meticulous precision. Best of all: the digitized images do not age or fade and can be used at any time to recreate the originals perfectly.

The effects of computer manipulation of photographs at high resolution can be startling. The talk will give some examples.

An Overview

A digital darkroom worker can mimic every standard or special effect that a skilled professional can achieve in a conventional darkroom with chemicals. Even the goofs can be reproduced. Who hasn't turned on the light by accident and unintentionally solarize the prints that were in the developer? The process can be duplicated with a very simple transformation filter that simply reverses the brighter values in an image and leaves the darker values unaffected. Contrast can be expanded or compressed, as if we were using different grades of printing paper. The picture can, of course, be enlarged or reduced, as if we moved the enlarger head up or down. The picture can be warped into a curve, as if we twisted the printing paper. A combination print of two or more pictures can be reproduced. And so on, and so on.

But, this is only where the really good part begins! In a digital darkroom, it is just as easy to improve the focus in a picture as it is to enhance contrast. And it is just as easy to twist the picture into a spiral or a sine wave, as it is to twist it into a regular curve. It is also just as easy to make a combination print of a negative and a positive as it is to print in the odd cloud. That's where the digital darkroom leaves the conventional darkroom behind.

Pico — A Simple Digital Darkroom

With little effort we can build a darkroom program that can produce all the effects mentioned above, by using a simple picture transformation language, just like the computer language 'Basic,' that knows about x and y coordinates, and brightness values. I build an editor of this type at Bell Labs, called 'pico,' that has proven to be an irresistible toy. A portable version, that takes up only about 500 lines of C-code, is described in my book [1]. It will run on any system with a C-compiler, from a million dollar supercomputer to a hundred dollar PC.

The photo that accompanies this article, for instance, was produced with 'pico.' It is a combination of two separate photos. The photos were originally shot on Polaroid Type 52 film, digitized at 500 dots per inch, enhanced and combined. The left profile was mirrored to produce a right profile and the three photos were then lined up at very high precision, and merged with a smooth linear fade across four different cut lines. The photo was then reproduced with a digital film printer onto 4x5" sheet film and printed. The result is startling, and can be enlarged to any size without giving away the fact that the photo was computer manipulated.

In Conclusion

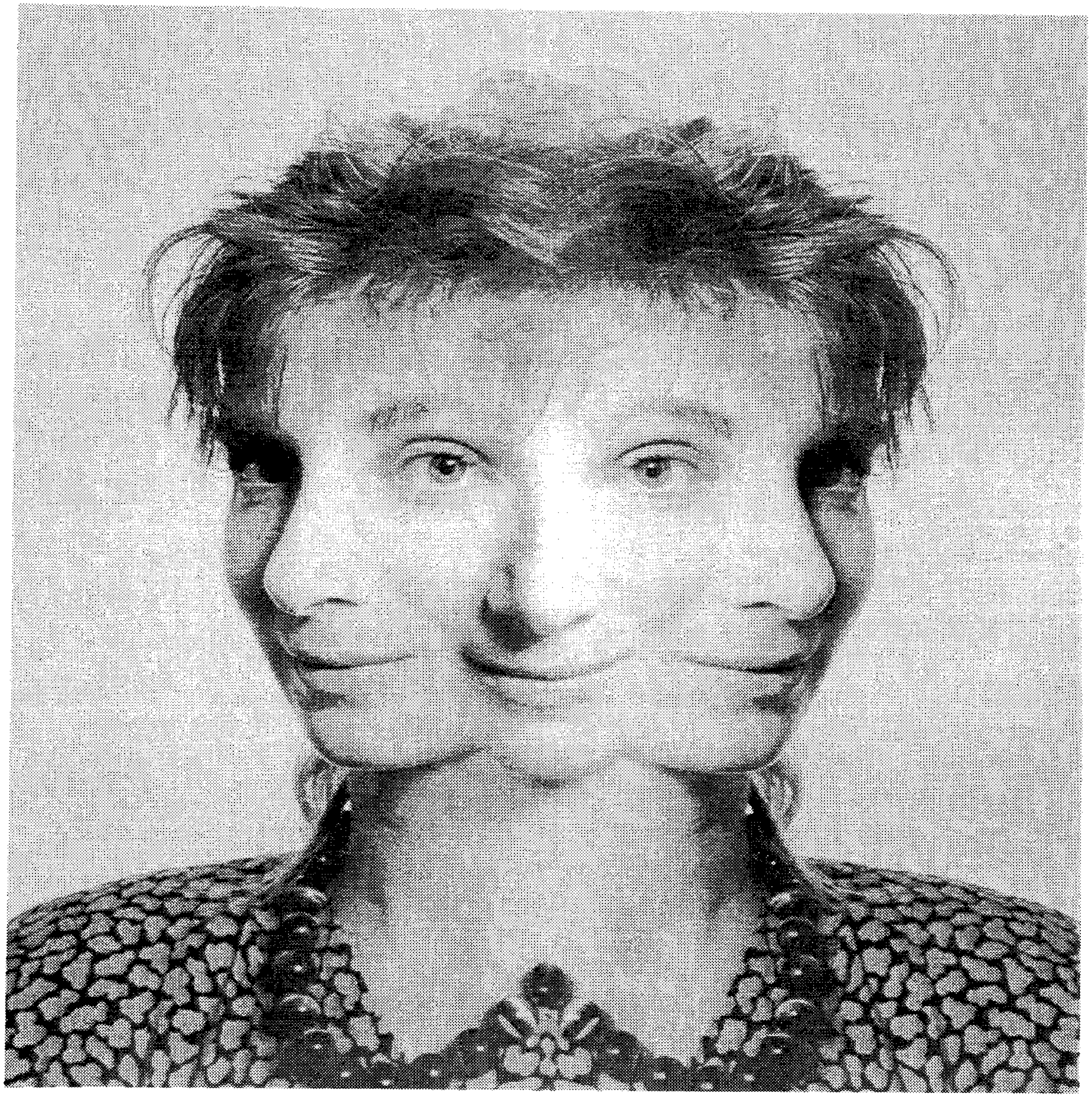
It is not unlikely that within ten years from now conventional photography, with films, chemicals, and darkrooms, will have been completely replaced by digital photography. The camera of the future is a digital camera, with a CCD array (a charged coupled device, invented at Bell Labs in the early seventies) to translate brightness into a digital signal, and stored onto floppy disks inside the camera.

Sounds unbelievable? Such cameras already exist, and are being marketed by Sony (the Mavica camera) and Canon (the RC-701 camera). They are 'standard' SLR (single lens reflex) cameras, from the outside almost indistinguishable from a conventional photo camera. The floppy disks of these cameras can hold 50 color photos each, at a resolution of about 500x500 dots per picture. The disks are produced and sold by Kodak (who else) and have already been standardized among all the major current, and potential future, manufacturers.

Now in all fairness: the resolution of the first digital cameras leaves something to be desired. The reason for this is an effort by the large companies to try and be compatible with video systems, so that you will be able to capture video images onto the floppy disks, or store the contents of a disk onto a video tape. That unnecessarily restricts the resolution to an unconvincing level. For the digital cameras to become competitive with conventional cameras the resolution of the images will have to go up by about a factor of five, and the price of the cameras will have to come down by about the same factor. There is every reason to believe that they can and will.

Reference

[1] G.J. Holzmann, *Beyond Photography — The Digital Darkroom*, Prentice-Hall, 1988, 128 p., ISBN 0-13-074410-7.



3D Design
and the Cartesian Coordinate System in the Computer

By Licio Isolani and Tim Brock

In fine arts, the student of 3D design learns that space is to be defined by width, height, and depth. Conceptually, these three basic lines cross in one single point positioned perpendicular.

In design, these lines are called axes: directional axis, dimensional axis, rotational axis, motion axis, and referential axis. In this basic position, these axes also represent the cartesian coordinates that we find in 3D computer design identified by the symbolic letters X - Y - Z (X = width, Y = height, Z = depth).

As a result, the computer as a tool shares with 3D design language a common spacial alpha set and through the computer we will be able to articulate many of the 3D design problems and ideas. Perhaps the most powerful use of the computer, as a tool, is as a recorder and animator. Because of its illusionary quality it is capable of creating phenomena impossible to obtain in reality. It can add both the elements of evolution and time to the 3D design language. With these elements we can study the dynamic transformation of shapes as they happen, controlling infinite combinations from beginning to end, charging the process with very specific data, and finally translating its ephemeral quality into a tangible reality.

Computer 3D Compositioning: The Process

3D Compositioning means to manipulate the reciprocal relationship of 3D shapes in space according to their axial position. It also means the modeling of volumes and contours and the definition of linearity and texture, their expressive visual energy and movement, whether kinetic or implicit.

3D Compositioning not only addresses design conceptually, but can also be a device to design functional objects, such as a chair, a house , or a car.

Modeling:

A basic 3D design pedagogy , (which is an analysis of forms within the Cartesian Coordinate System), is a foundation for the applied and fine arts and is traditionally taught through verbal dialogue and still diagrams resulting in maquettes, that are handmade by "trial and error". However, within the computer, actual 3D forms can be modeled and viewed with endless transformations. The various elements represented include: points, lines, planes, and volumes.

Within any polygonal 3D system all elements are represented (or drawn) with polygons or multisided planes. This means a point, for example, is represented by a very small four sided polygon, a line is represented by a long narrow polygon, a plane is easily represented by a single polygon, and a volume is represented by numerous polygons connected to suggest a solid. These polygons are the building blocks for any form and can be represented in wireframe or fully rendered. With the polygon being the fundamental building block, simple design elements such as points, lines, and planes can be represented singly or in combination to form very simple or complex forms within an X - Y - Z space.

Animation:

In addition to a shared X - Y - Z modeling vocabulary, the computer provides the time dimension that crystalizes 3D concepts in the mind of the viewer through animation. Simple or complex forms can transform through time to illustrate design principles of form and space. For instance, through interpolation, points can transform into lines, lines into planes. A single plane, while rotating, can transform into a curved plane; a curved plane can transform into a double curved plane and so on. A simple interpolation from a plane to a double curved plane, for instance, consists of two workspaces containing the same number of polygons. The computer then averages the inbetweens, articulating the transformation over time. Through this process, the plasticity of form and space can be represented as time becomes another axis for compositioning.

The language of 3D compositioning fits well into the transparent X - Y - Z environment of the computer. But perhaps even more important is the addition of time. Time as an axis provides design educators an invaluable tool for analysis of form and space promoting the evolution and development of 3D design pedagogy.

Animation #1

The first animation shows the evolutionary process of creating a cube from a point in space, extracting volumes oriented towards their basic 3D X - Y - Z axes and then reducing everything back to its single point of origin.

A point in space is the beginning of design. A point is a concept. It is an abstract entity imagined to exist in space and does not become real until given physical form and visual presence.

A point becomes a line, or a line is formed by the accumulation of many single points placed consecutively along the same directional axis. Similarily, a plane can be made by consecutive accumulating lines and a volume by consecutive accumulating planes.

If we control the directional accumulation of points along a specific axis, we control the movement of a line, plane, and volume in 3D space. As soon as we establish the position of one axis we have reference to the remaining two. In proceeding, we establish the choice to position them. This is called "3D Compositioning."

Animation #2

The second animation shows the creation of three-dimensional forms by manipulating planes to give illusion of volume. Why? A plane contains only two dimensions. It is flat; two dimensional. It is defined only through the combination of X - Y or X - Z or Y - Z. So, to gain the third dimension, a plane has to bend along one of its axis or coordinates. With it, we return to the mode of "3D Compositioning."

COMPUTER ART: A PERSONAL VIEW

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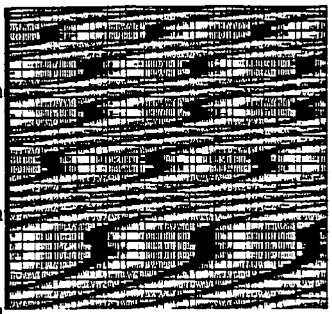
I WAS A "multi-media artist/experimental designer" three years ago when I first encountered an Apple II. My label did not survive the encounter. I am still an artist, but now I tell grandmother, Una, that I am a "computer artist." Grammie has always been able to catch me in a lie and she believes me, so that settles that.

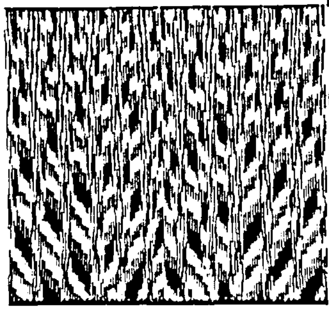
I work mostly with variations on a single algorithm that I stumbled onto shortly after my label changed. The algorithm makes endless patterns of beeps and dots. Their variety and integrity inspire me. As an artist, all media other than computers and people seem dull, so I program and teach.

We will get around to the algorithm, but the specifics of my work are not as important as this new label: "Computer Artist." This is a label worth writing about.

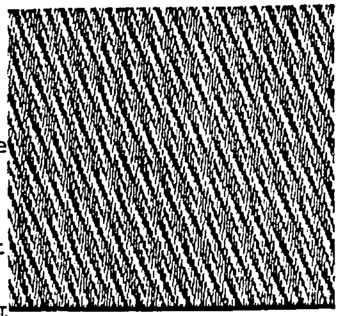
MAKING ART with a computer does not make one a computer artist anymore than making art with oil paint makes one an oil painter. It is possible to draw with oil paint. I suppose it is even possible to make music with oil paint. After all, it makes such nice smacking sounds on the palette when it is fresh and gooey. Of course, to be an oil painter one must paint with oil paint. Painting involves many things, most especially an appreciation of how the intrinsic qualities of paint lend themselves to making art.

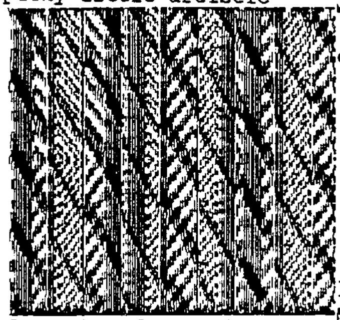


I decided early on that in my work with the computer I wished to be a computer artist and not a painter or musician whose paintings or music are computer-assisted. How the intrinsic qualities of the computer lend themselves to making art concerned me. I welcomed the adventure of exploring a new medium on its own terms and I have become ever more committed to this adventure.

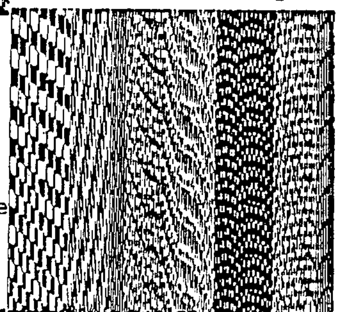


Working with the computer has convinced me that it is a mental machine. Art becomes "computer art" to the extent that the mental aspects of its production are performed or assisted by the computer. In the context of art the mental aspects that most concern us are decisions about aesthetics. The hallmark of the computer artist must be insight directing curiosity not craft in the service of sensibility. This is the essential point: To fit the label "computer artist" one must stop hogging all those picky little artistic decisions. Let the computer in on the action.

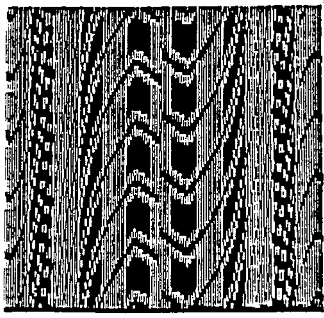




AS ANY programmer will insist craft is needed in computer art just as it is in every art form, but for artists craft is a small piece of a large puzzle: the development of a personal artistic style. I will now describe my personal process for conducting creative research with the computer.



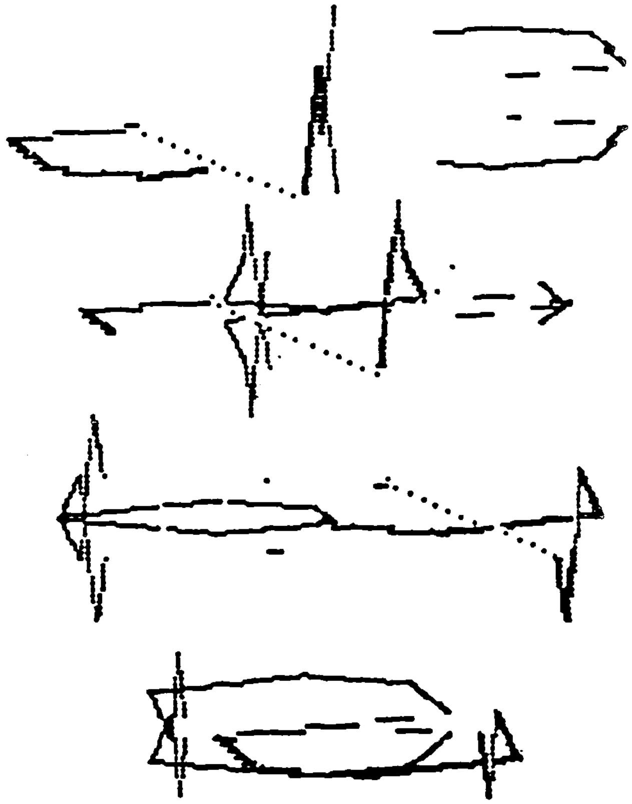
Often the first step in my creative process involves looking for a match between one of my aesthetic concerns and a rudimentary program structure. When I find such a match, I proceed by unfolding the intrinsic possibilities of that structure. I do not cavalierly combine it with other structures to get immediate results. The

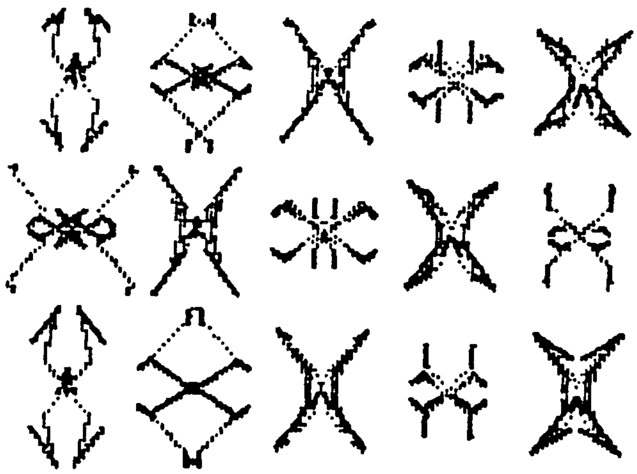


unfolding transforms the structure into an explicit model of my aesthetic concerns. The concerns become explicit program code.

At this point in my creative process, the computer and I enter into a cybernetic relationship: manipulating program code clarifies my aesthetic concerns, which no longer exist in their fullness except as code. Program code becomes a shorthand for my artistic feelings as well as my means of expression through the monitor. My creative process is a self-revealing and self-correcting feed-back loop.

Such man-machine intimacy exactly parallels



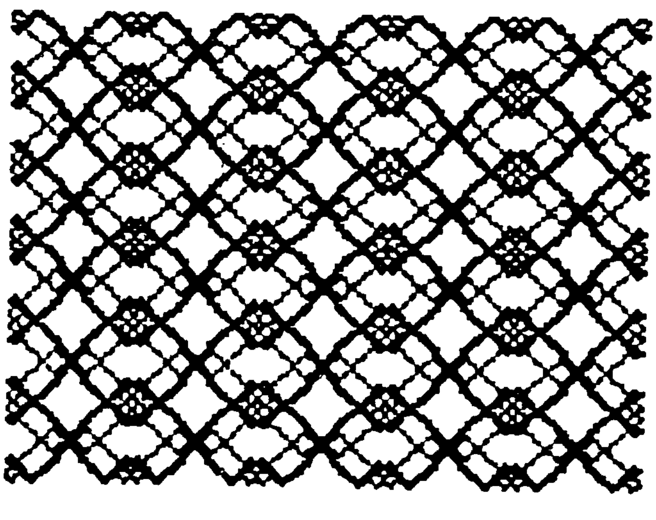


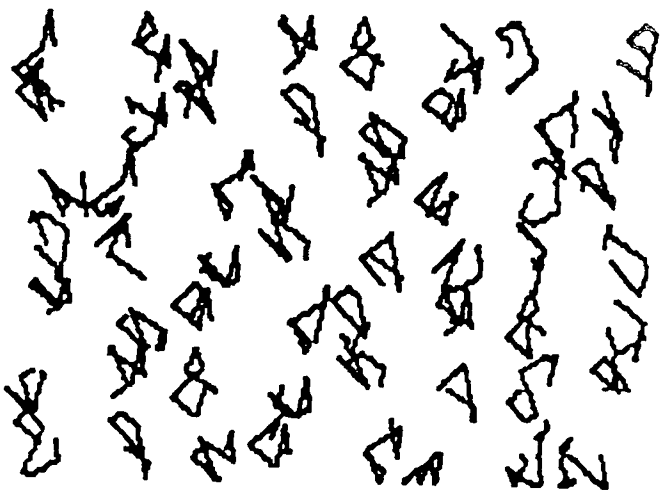
the intimacy that other artists feel with their media. Musicians, for example, often speak of "thinking in musical notation" and playing their otherwise inexpressible feelings through their instrument. At times I find myself thinking in source code, utterly oblivious to my surroundings, and saturated with a keen awareness of the aesthetic qualities I am investigating. Good times.

The computer is, perhaps, the most intimate of all the instruments that extend human capabilities other than natural languages. Rather than merely extending the eye or hand or voice or adding a specialized language which extends the mind in one dimension, the computer adds mental capacity in all dimensions. It frees the mind from lower order tasks; facilitates higher order tasks in innumerable ways; and even allows one to feel, desire, and imagine with greater freedom and efficacy.

This leads me to the question of artistic purpose: What do I value in my art? Answers to this question are often presented as a choice between product or process oriented art-making. Artists with a product orientation often see themselves as problem solvers. Process oriented artists, on the other hand, usually stress the expressive function of their art.

In my art I value aesthetic discovery and self-transcendence. These goals are sought by

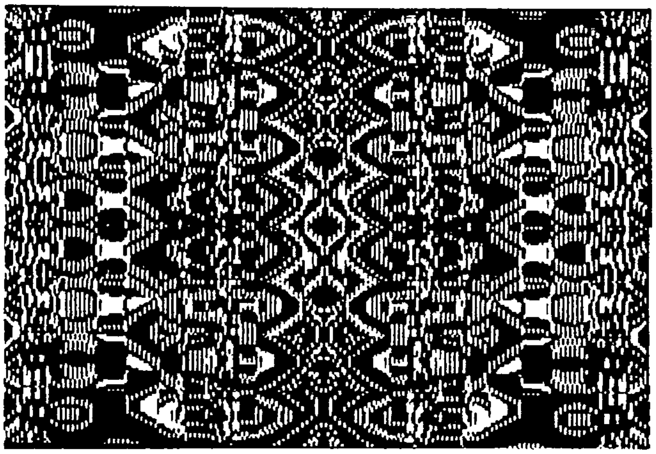




unfolding the possibilities and implications inherent in the materials (media) and techniques (processes) I am concerned with investigating. These materials and techniques need not be physical.

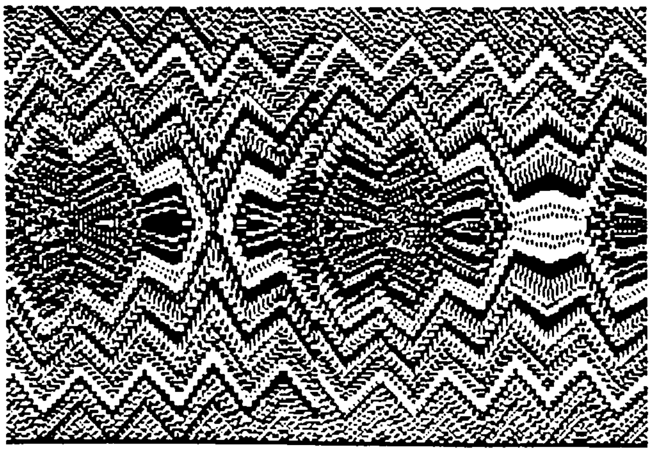
My goal is not to be a better problem solver. I prefer another mode of art-making which includes problem-solving as a sub-strategy. Neither do I wish to "find myself" so I can express that self-knowledge more honestly and thoroughly. I wish to outgrow the persistent impulse for that sort of expression.

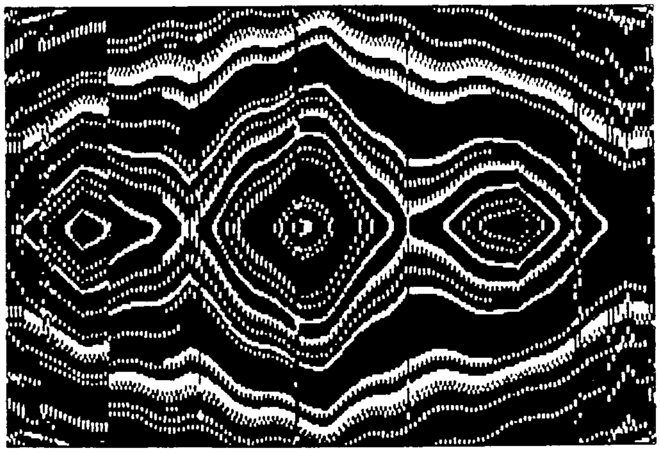
Rather than focusing on problems or feelings, I take a hermeneutical approach to the concerns, materials, and techniques of my experimental design and art-making. My goal is to



open a window to a larger aesthetic universe with them. I assume that each impulse to produce an image implies an entire class of related images. I attempt to produce a computer program which can produce that entire class of images and reveal the structural parameters of the class's aesthetic universe. The integrity and immeasurable variety of that universe should fill me with awe or the program is not complete. Very few programs even approach completion in this sense.

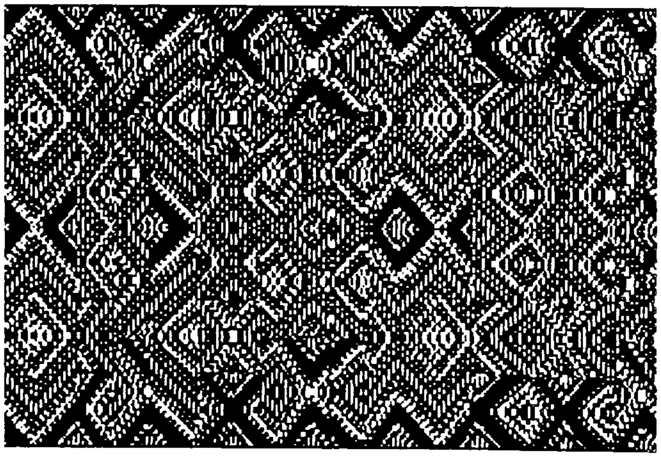
The moment that I sense the scope of a program's aesthetic universe I become an observer. The fun and the growth are over and I wish to move to a new area of investigation.





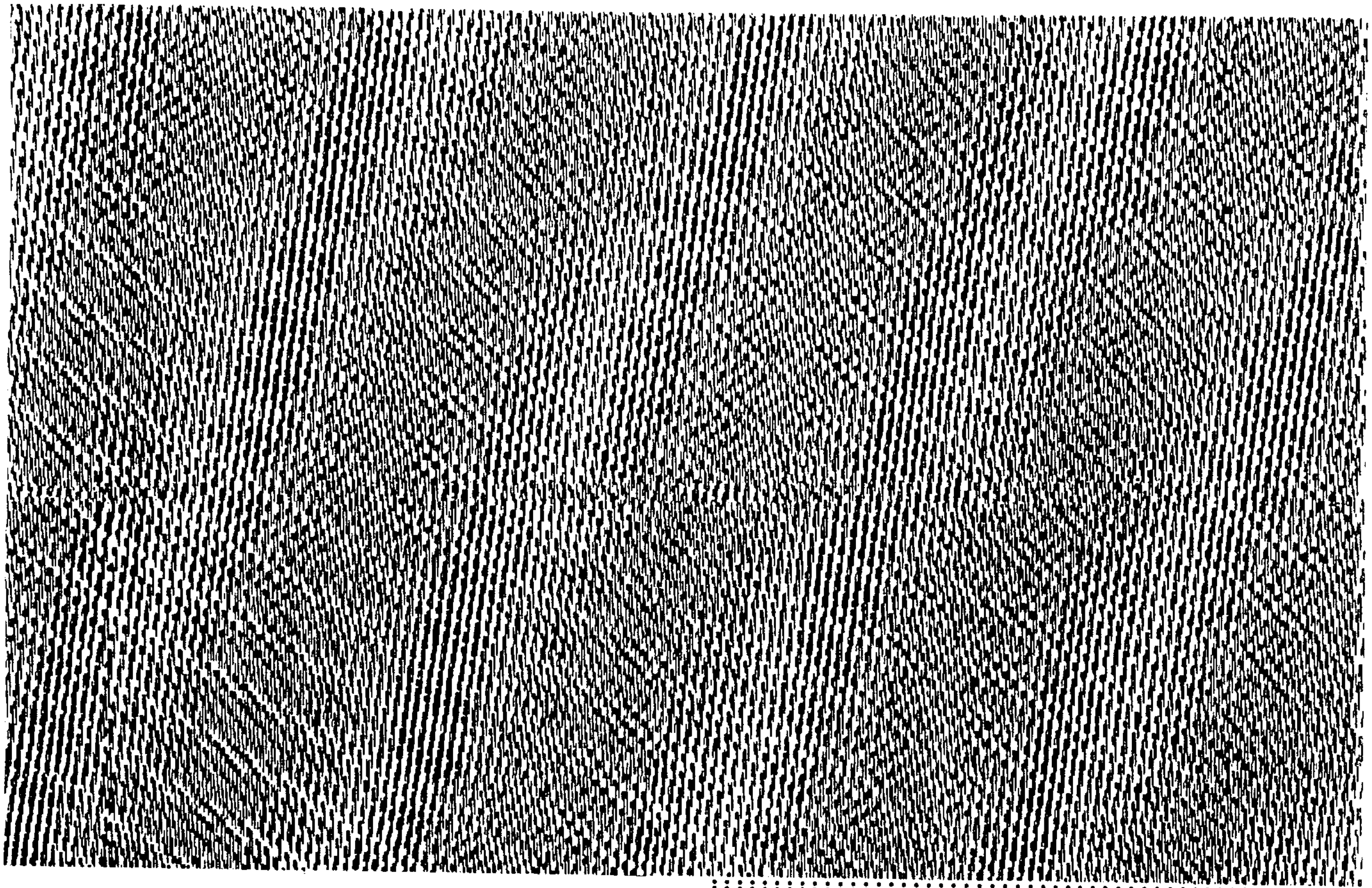
NONE-THE-LESS, pattern generation has held my attention through all my computer work. Perhaps this is because loops and variables are so well suited to producing repetition with variation which is what patterns are all about. Or perhaps it it something else.

I remember in my teens my mother told me of a recurring dream she had about "fascinating wallpaper" passing before her eyes for hours. And much earlier (I must have been 4 or 5) sitting quietly with grammie and watching her crochet. How do the patterns build so slowly from such tiny



repetitions? And how does she keep track of it all? I realized I would need a more powerful processor configured for multi-tasking to keep up with her.

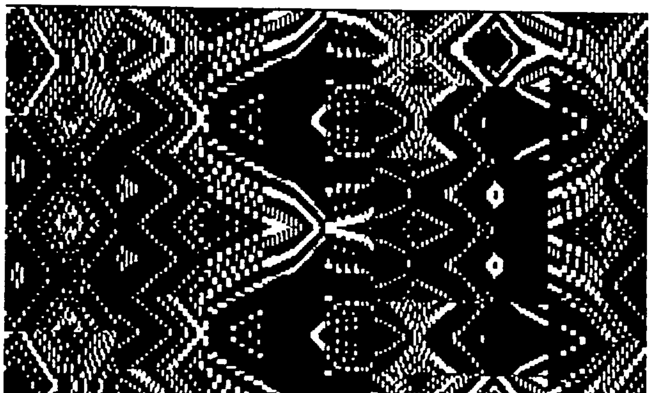
Last week in western North Carolina I spent an afternoon studying Cherokee designs. That evening I attended a local religious meeting. When I told them what I did for a living they asked to see my work. The response was fascinating. They said they already knew such animated patterns existed because they had seen them while praying and had wondered what they meant. I wonder if the responce would be much different in a village in India or Africa.

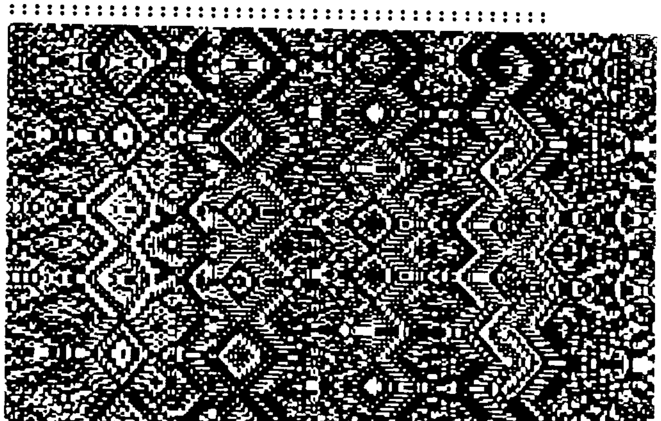


Program name:
P11G VARIABLES&COMPACT

```
10  DIM C(15): N = 0: CI = 0: I1 = 0
      : CL = 0: TN = 39: Y = 0: X = 0
      : Z = 0: ST = 16: T = 3: TT = 13
      : W = 1: HQ = .025: HF = .5
      : HOME: GR
20  CI = RND (1) * HF + HQ: I1 = W / CI
      : CL = RND (1) * TT + T
      : FOR N = Z TO CL: C(N)
      = RND (W) * ST: NEXT
      : FOR X = Z TO TN
      : FOR Y = Z TO TN STEP I1
      : N = N + CI: IF N > CL
    THEN N = N - CL
30  COLOR = C(N): VLIN TN, Y AT X
      : NEXT: NEXT: GOTO 20
```

HERE IS A listing of the rudimentary algorithm I stumbled on when I first began working with computers. Most of my subsequent computer art has consisted of variations on this algorithm. For example, all of the printouts in this article were designed by three such variations. If anyone wishes more information contact me. I will probably provide it; but if this sort of thing interests you, you would be far better off working it out for yourself.





Dance to Offset

Thomas Porett, Professor, Director of Electronic Media Program

The University of the Arts, Philadelphia, Pennsylvania

Abstract:

This paper will describe the process of creating a limited edition offset print based upon a dance piece choreographed by Judith Jamison. The project involved digitization of videotaped and photographic images, then constructing the print in an electronic paint environment. The process included use of image processing software to both enhance imagery, and to create separations directly on a color ink jet printer.

During the spring semester of 1988, I was commissioned by the University of the Arts to create a limited edition computer mediated offset print commemorating a new dance work choreographed by Judith Jamison. Ms. Jamison was formerly the lead dancer with the Alvin Ailey dance troupe, and a graduate of the Philadelphia Dance Academy, now part of the University. The image was to be printed as a limited edition on the Heidelberg press, located in the University's Borowsky Center for Publication Arts. This was to offer a unique opportunity for me as it would be my first experience with this print form, fulfilling a desire I had harbored for some time. My progress through the subtleties of the process was to be guided by the Center's master printer Chuck Gershwin, and two colleagues at the University, Patty Smith and Lois Johnson.

All was not to be ideal in this process as I was only to have one or at the most two short sessions with the dancers who were learning parts of the piece as it was being created. As a result, I determined that my best approach was to use a video camera, and still 35mm images to gather as much visual information as possible. This imagery would then be videodigitized in my studio and merged into the printed work in a paint program. After some preliminary tests before the actual dance session, I settled on the Amiga computer as the machine of choice for several reasons. It had good color capability, adequate resolution, a real time digitizer, and paint software that could be configured to extend beyond the conventional screen size. Further, I was attracted to the look of the dot matrix ink jet print and chose to use a Xerox 4020 color ink jet printer to print proofs, and eventually output the final separations.

The first opportunity in the dance studio proved to be somewhat disappointing as I was very restricted in my movements and the session was dedicated to rehearsing a very small section with just a few dancers. I was not allowed to light the scene, or control the background, restricting me from using two of the best tools that can control visual complexity. Although by the end of the session I had an hours worth of tape, I was disheartened to see the limited nature of the material. Many of the movements were quite static, interesting as singular images, but lacking the dynamic presence of dance motion.

I found one particularly sequence was interesting, a short motion in which a dancer spun while raising one leg. I had videotaped this movement framing it from shoulder to ankle, and the scale of the image gave it a dramatic presence. I digitized this and several other short motions using the Live! digitizer capture mode. In this mode, the software designates a chunk of ram for the capture, and a series of frames are stored in ram as fast as the unit can digitize. The number of frames that can be captured varies with the amount of ram the machine is equipped with, and the resolution desired. I settled upon the interlace resolution as the best compromise 320 x 400 with 32 colors. The 2.5 megabytes of ram in my machine enabled capture of up to 27 frames of video. This amounts to somewhat over one second of action, sufficient for my purposes. This chunk of data is then saved as a binary file that can be loaded at a later date. Its one major drawback is the near glacial time it takes to save the captured data to floppy disk.

Once saved to disk, I reviewed these motions, and selected individual frames that might be appropriate for the print. These were then saved as individual IFF picture files on another disk. Next I brought the images into Deluxe Paint II for reworking, eliminating unwanted background, and changing shapes to suit the multi-image format on the final print. The reworked pictures were saved on a separate disk for use as elements in the assemblage of the print.

The sequence of the dancer spinning was reduced to four frames, which if placed next to each other would convey a sense of time and space movement. Fortunately Deluxe Paint II allows the user to specify a frame that is larger than the actual screen size if the machine is equipped with enough memory. Unfortunately, a 'feature' of the Amiga restricts screen display to what is called chip memory, and that in turn is limited no matter how much memory is added as 'fast ram.' This ultimately means is the user is constrained to juggle back and forth between frames to construct the picture. After many frustrating attempts at cutting and pasting using the spare screen approach, I found it was best to make each element a brush rather than working with the full IFF file. These brushes could then brought into the oversized image (700 x 400) and pasted into place, and the new image is saved to disk. Some of this becomes quite frustrating if one is limited to a floppy disk as Deluxe Paint has a good/bad habit that seems to be part of the Electronic Arts software formula. They save a backup file of the original image automatically to disk, good for safety, but maddening if one is stuck with too little disk space and no extra initialized disks. Needless to say a hard disk is a boon for such work and a great time saver as well.

One powerful feature of Deluxe Paint is its color map editor, giving the artist control over each of the 32 colors of an image. One may set a color to any of 4096 using the editor (moving sliders for red, green and blue, or hue, saturation and value). While experimenting with changes in the color map I eventually figured out a way to save a lot of disk space and yet have a variety of different color maps to choose from by simply creating a small brush of each finalized color map, and naming it with its color characteristics. The color could then be restored by opening the appropriate brush and then selecting the Use Brush Palette option. Once the oversize image is complete, it can be printed directly in a variety of sizes for proofing, including prints measuring 8.5" x 27" on continuous roll paper. A print this size takes about 25 minutes.

Another step that some of the images were put through utilized image processing software to help delineate edges in the image, and exchange colors within the color the color map. The software package rather harshly titled "Butcher," proved to be most valuable for this exploration, and played an essential role in creating the final separations.

When I had the second opportunity to work with the dancers, I decided to dedicate at least half the session to using a still camera as well as the video camera to capture some frames in which the dancers were not blurred. The second session proved to be much more productive as the choreography was far more developed, and a full complement of the company was present for the session. External lighting was still out of the question, but enough light existed in the studio to photograph with the 35mm camera. I chose conventional color print film to assure quick processing and more importantly, an opportunity to work with the paper prints as collage.

I have always favored the process of what I term "electronic collage," in which torn or cut out parts of images are combined on the copy stand as a temporary collage, digitized and then subject to further collage treatment in the computer. For this piece, I proceeded to cut out figures from the color prints and assembled a collection of dance gestures that could be recombined in the final piece. These figures were organized into a group of about ten different frames constituting a separate body of work to integrate into the piece. In addition to the still collage pieces, I worked with the new video sequences in a manner similar to the way I worked with the first video group, generating many useful individual frames.

By this time I had created a number of interesting extended prints, but there was an uneasy feeling that the dynamics of dance were lost when printed separately. The simultaneity of the dance actions were missing even though the individual images were interesting. It was at this point that I decided to try to overprint sets of images, and increase the complexity of the image. My first combination was one with the spinning figure, and a series of assembled figures from the still photographs. Although the process was to go through seemingly countless iterations before it was finalized, the idea proved fruitful. The double print kept my attention with the tension of following the sequential motion and a visual counterpoint of the smaller figures moving in and out of the larger image in the opposite direction. A visual theme emerged centering on the idea of conflicting motions as well as near/far relationships in the figures.

At this point I felt that the simultaneous actions in the overprint signalled a motif for the whole print, and decided to carry the idea further by combining another two sets of actions as a counterpoint to the original set. I decided to make the print a dual image in which two images measuring 27" x 8.5" would be printed on one sheet of offset paper measuring 28.25" x 20.5" and each of these would be a complex overprint of two images.

The second of the overprinted images was divided in and interestingly related way to the first. There was a single sequential action from the videotape in which a dancer performed a jump, that was overprinted with an assemblage of actions derived from the two separate dance actions. As with the first print, the actions were placed into an active counterpoint to create and maintain as much tension as possible. The final combination of the two images together acted as further tension to the piece, bringing the print close to the desired feeling of both dance, and its electronic video translation.

I purposefully wanted to keep a dot matrix look, as well as a video presence to the final image and chose to make the Xerox 4020 printer the source for the offset plates. What I did not understand fully, was the difficulty and expense of making a color separation from the final overprinted ink jet print. It was at this point that I began to learn about the offset world from a master printer Chuck Gershwin who for a number of years, was the master printer for Aperture magazine, the world renowned fine art photography journal. Chuck explained the difficulty if not near impossibility of reproducing the actual overprinted dot matrix color print. He explained that two things would be lost; quality and control. Further, he made it clear that he would be much more interested in a process where all decisions were kept under our control, as opposed to one in which the Borowsky press would simply be reproducing a pre-existing print.

The final decision hinged upon whether the color separations could be made with the dot matrix printer as separated cyan, magenta, yellow and black prints. I knew it certainly was possible, but was not too sure how it would be implemented. Since, it had been my intention from the start to use the experience to learn as much as possible about the offset process, and certainly to learn from Chuck, I launched a series of tests to see if separations were feasible with existing Amiga software, and how effective such efforts would be.

Theoretically it was a rather direct matter, but when I started to implement the process it no longer seemed so simple. I first tried to accomplish the separation using Deluxe Paint's ability to print out colors as either gray or black versions. Unfortunately, the manner in which the color printer interpreted some of the colors as a monochrome left certain colors very weak or non-existent. I then turned to the previously mentioned "Butcher" program which has a color separation function. I brought a color test pattern into the program, and it did indeed produce a credible separation with one major limitation, the separations remained as colors. This of course seems only natural, but one major drawback occurs when intending to make plates for the offset process. The film used is orthochromatic (blue sensitive) and will not see red or variations of colors with red in them.

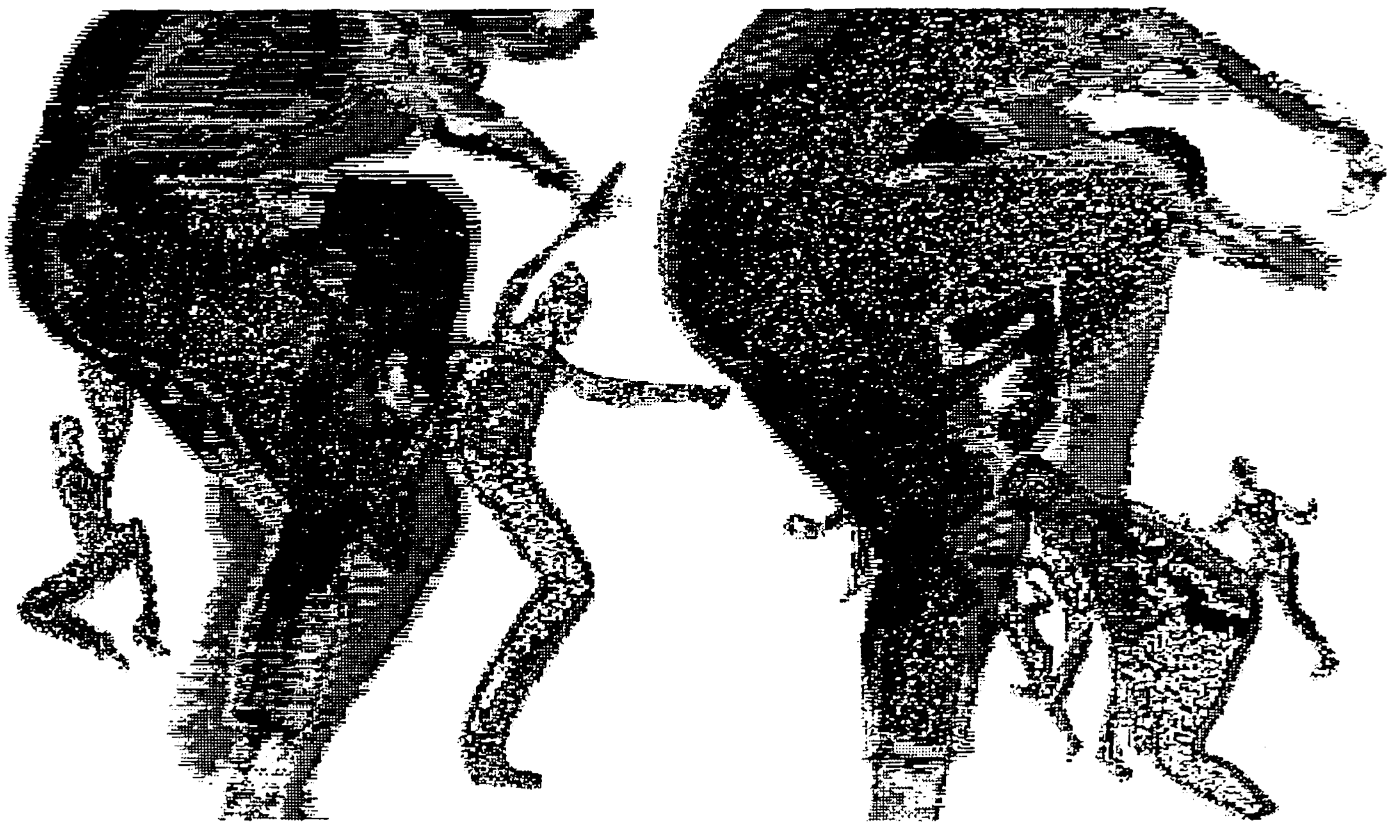
Ideally, this film wants to look only at black, presenting a considerable problem. The ink jet printer with its own dithering process does not always use black where it appears to put black dots. Rather it interprets colors as a collection of cyan, magenta and yellow dots superimposed over each other. So trying to print as black was not satisfactory. To make a long story short, I was forced to make each of the separations end up as a print in some version of cyan and black. I did this by making the separation and then putting that through a series of complementary reversals in the "Butcher" program to yield the final separation. Unfortunately the process was exceedingly drawn out as each section had to be printed with a registration mark (I made this too small but Chuck saved the day), and each separation had to be clearly labeled as C,M,Y or K (Black). Finally, because the overprint was too complex to use, I had to make separations of each of the individual elements, and was forced to divide each of these whole images into two halves since the copy film was too small to contain the full print. As a result, I ended up with 32 separate prints that were to be used to make the final separations.

The development of the separations went in a fairly straight forward manner, with each section being shot on the copy camera, creating a negative. We staged the process to check for accuracy using the 3M Color Key proofing material to get an accurate idea of how the print would look printed with process colors. Since my experience with this end of the process was nil, I learned to appreciate the degree of control that could be exercised by the printer at this stage. Through the manual stripping process we were able to precisely control the placement of the figures, and correct any element that had been overlooked in the original process. Further, it was at this proofing stage that we encountered an unexpected problem. There was a distinct weakness in the blacks causing a serious shift to much lighter colors than was acceptable, along with a distorted contrast range. After some thought we looked at the density of the cyan separation, and decided to shoot the cyan again as black to see if the range improved. To my delight, it worked although it also meant that the process was as yet not fully developed as a straight ink jet to final print proposition.

Once we were satisfied that the color was as close as possible to the original, Chuck proceeded to strip the negatives together, allowing freedom to adjust placement of figures, and the final plates were exposed. The plate making process allowed the figures which were overprinted in the ink jet prints to be combined as one composite plate for each color, reducing what had originally been 32 separate elements into four distinct plates.

The actual press run was printed with straight process colors, although there could actually be a nearly infinite range of variation if we chose to mix colors. I stayed with the process colors because the differences in the two images would unduly shift one of the two prints in the wrong direction. Further, I had spent so much time deciding upon the proper color maps with the computer, it seemed a questionable decision to change at this stage. I must admit it was quite tempting, but my lack of experience with inks made this too chancy, particularly considering the time it took re-run with the proper color should there be a bad choice. Further, I was under both a time and funding constraint that left little room for experimentation. This will certainly be a control that I will explore in my next venture with the offset medium.

In summation, I found the process of bringing the computer mediated image into the offset form very appealing from several standpoints. First, it allows formats that are not limited by the size of the computer printer, nor restricted to its color limitations and presence on paper. The selection of paper and ink is enormous and archival, something that cannot be said of ink jet materials, and freedom to make changes is available at each step of the operation. As yet there have been limited numbers of artists who have used the computer and are familiar with the offset process, but this circumstance will change quickly. It is natural to have the computer involved in image manipulation and pre press proofing, enhancing or in some cases supplanting more traditional procedures. I suspect that a major impetus for this kind of cross media involvement will come primarily from printmakers who begin to understand the potential of digital image processing, and learn to use these powerful tools.



Details from COUNTERPOINTS ©Thomas Porett 1988

MULTI-MEDIA

SYNCHRONIZING ANIMATION AND SOUND USING SMPTE AND MIDI IN VIDEO EDITING

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Abstract

Synchronization is the process of correlating two or more time-based image systems, such as the picture and sound track of a video tape. A theoretical model of the synchronization process is an aid to establishing simplified methodology for computer-controlled post-synchronous editing. Animation can be photographed directly to video tape using an inexpensive single frame controller. An accessible and affordable system is used at Northern Illinois University which records SMPTE Time Code onto a video tape master, then slaves a MIDI sequencer to its output.

Introduction

Artists working with today's personal computers have many processes available to them. Some of these processes had previously been the domain of experts who alone had access to specialized machinery and methodology. Although new technology provides us with this access, it does not instill us with an understanding of previously unfamiliar processes. This paper attempts to illuminate some generalized concepts about time-based art and to describe some specific experiences in the approach to the problem of synchronization.

Time-based Image Systems

A time-based image system is comprised of four parts: data, which is arranged in some configuration peculiar to the system; media, which holds the data and functions as transportation for it; a transceptual device, usually some form of machine which transports and processes the data and translates it into a sensory image; and a human, which perceives and interprets the image. There are often many complex versions of this kind of system, utilizing more than one form or arrangement of data or devices, but the general model holds true for the individual parts as well as the entire system.

An image is anything which may be perceived through the primary human senses. For this discussion, we will be referring to visual and aural images and their synchronism. Visual images depend on data which can be converted into focused light which falls on the retina. Aural images reach us as sound waves which stimulate the cochlea of the ear. Both the eye and the ear respond to stimulus in a specific range and have provisions for sensing the temporality of the stimulus. Thus we are able to perceive about any given image not only what it is but where and when it is. It is important to note that time art is dependant upon this human perceptual model of time/space.

An example of a simple time-based image system is the early 20th century invention, the zoetrope. The zoetrope was a cylindrical device which rotated around its central axis. Slits were cut into the rim of the device at evenly spaced intervals. By viewing sequential drawings through the slits as the zoetrope rotated, apparent motion could be perceived. The paper strip was the medium, the drawings were the data, and the zoetrope itself was the transceptual device.

The human part of the process which makes the zoetrope system work is the persistence of vision. All time-based visual images depend on persistence of vision, the tendency of the retina to produce an afterimage. The zoetrope is a machine which sequentially transports specific data to a specific place at a specific time, bringing each drawing into the perceptual time/space where it merges with previous afterimage and is interpreted as part of a real event. The movie projector and the video monitor are more sophisticated technically, but follow the same model as the zoetrope.

As the rate of rotation of the zoetrope increases, so does our sense of the speed of the apparent movement. This phenomenon suggests that there is an internal "clock" in our perceptual system. Variations in perceived speed are really fluctuations in the synchronism between our internal clock and the rotation rate of the zoetrope. An aural counter part of the zoetrope is the phonograph. As the rate of rotation of a record increases the pitch of the sounds it makes become higher. Thus we see and hear time by the effects of transceptual devices.

Synchronization

Synchronization is the process of correlating two or more time-based image systems, generally one visual system and one or more audio systems. Aspects of synchronization include interval, phase, start time, and time base. Methods of synchronization of sound and picture include wild, real-time, pre-synchronous, and post-synchronous methods. Each unique transceptual system has its own vocabulary but basically is concerned with transporting media and translating data.

Picture a train and an automobile racing toward a crossing. Both have left the station at precisely the same time and have accelerated to their top speed. The engineer looks at his speedometer and it indicates 60 miles per hour. The driver of the car looks at his speedometer and it too indicates 60 miles per hour. The car and the train are neck and neck. Will they crash at the crossing? Their start time is the same, their interval and phase (60 MPH) is the same, but what about their time bases, in this case, their speedometers?

Electric motors allow us to control the transportation mechanism of various transceptual devices such as projectors and tape and video recorders. The "clock" which governs the rate and consistency of these motors is generally related to electrical cycles and not is absolute. Any two motors, even so-called synchronous ones are only accurate within certain margins of error. Time base is affected by the relative accuracy of motors in the system.

Motion picture film is a medium which holds silver-based photographic image data in a special configuration called frames. The transportation rate of the film, its interval, is consistently 24 frames per second, give or take some margin of error. This error accumulates so that it may take different lengths of time to project the same number of frames even using the same projector. Simultaneously starting a film projector and a tape recorder is a good demonstration of wild synchronization. This is sometimes called "random sync".

Classic film and sound editing techniques place audio recordings onto magnetic media closely resembling that of the picture, that is, a long strip of celluloid edged with sprocket holes. The sprocket holes relate physically to the presence of one unit of film data: the frame. Because of the sprocket holes it is possible to move two or more strips of media in mechanical interlock, or synchronization. This is called double-system editing and is useful in pre-synchronous and post-synchronous editing where accents in a sound track need to be aligned with events in the picture.

Real-time synchronization in motion pictures is accomplished with by recording sound directly onto the film at the time of exposure in a single-system camera. The displacement of the sound track and the image makes editing impractical and so the sound is usually dubbed to another piece of media. The real time synchronization of the film camera and tape recorder is done by recording a sync pulse from the camera onto the audio tape. Thus, although no physical link exists, as it does in double-system, the time base of the picture can be resolved from the pulse in the audio track for post-sync.

The terms, pre-sync and post-sync, are used here to refer to the alignment of picture and sound in film or video which is not done in real time. Animation, for example, does not actually exist in real time, and has no real sounds. To pre-sync means to pre-record the sound track, then match the filming of animated frames to that track. This is done by analysis of the sound track, breaking it down temporally into intervals of frame time. Post-sync refers to matching the sound track to an existing picture.

Sprocket Holes for Video

Video tape holds a recording of the video signal, one or more audio recordings and a control track which governs the speed of of the video tape recorder. The video signal itself is very complex and contains information about individual fields (every other scan line of a video "frame"), line sync pulses and color information. The control track consists of pulses which represent the field sync pulse and are roughly analogous to the sprocket holes on film. Many different recording formats exist but most utilize this control track for synchronized editing.

The key to pre-sync or post-sync editing on video tape is the control track and a deck capable of insert editing. Most video decks will allow you to edit new scenes to existing ones in a mode called assembly editing. In this mode, the picture, sound tracks and control track are recorded simultaneously. This can result in a "glitch" at the edit-out point since the control track copied from the new scene will not fall in line with the existing one. In insert editing, the picture or sound track(s) may be recorded separately, without disturbing other signals on the tape, and without erasing the control track. The control track (CTL), is striped onto the tape before editing by recording the video from a color camera whose lens cap remains on, or from a black burst signal from a signal generator.

Making an edit at an exact place on a tape is difficult. Most editing controllers use the technique of pre-rolling (rewinding from a cut-in point) two video decks, synchronously running them and counting CTL pulses to find the edit point where the signal from one deck is switched to the record input of the other. The margin of error resulting from tape slippage is two to four frames. Creating an animated effect on video tape by conventional editing can be done only with the greatest of luck.

Animation on Video Tape

Traditional hand-drawn animation is still filmed on motion picture film then, if desired, transfered to video. The advantages of single frame photography, the superior resolution of film and the technical difficulties of recording on video tape make this the most practical route to follow. Computer animation on small systems tends to be designed to run in real time to facilitate video recording. Computer animation done on larger systems tends to be out-of-real-time frame buffer stuff that is dumped to large format video tape a frame at a time. Hence big system users get to make more eloborate individual frames than can small system users.

Small computer users can reap the benefits of working out of real time in two ways: the use of a film recorder for output to motion picture film in single frames, or the use of a single frame video controller. The benefits of working out of real time include the open-ended calculation time needed for complex, algorithmic images, and the possibility of increased color resolution by using multiple passes.

Good quality film recorders are expensive, but used motion picture cameras are becoming financially accessible. A system built by the author used a Dunn Instruments film recorder retrofitted with a Bolex 16mm camera controlled by a stepper motor. An Apple II computer with a high resolution graphics board generated RGB images, opened the shutter on the Bolex, fired the Dunn camera, closed the shutter, began the next frame and so forth, all from a simple program written in U.C.S.D. Pascal. The image quality which resulted from this film photography of RGB computer output was much better than video taped NTSC composite output from a comparable computer system.

Single frame recording on video tape is possible even on a shoestring budget. Video Media, a California manufacturer of video editing systems makes an inexpensive controller which uses a special control track to accurately position the edit point after pre-roll. It is accurate to within a single frame, it can be programmed to cut-in 1 to 15 frame long scenes, it can be run from a serial port and can be set up for a variety of different decks. It uses a CTL track containing numerical data, similar to SMPTE time code.

SMPTE Time Code

The initials, SMPTE, stand for the Society of Motion Picture and Television Engineers, a society which has determined many standards in the film and video industries. The time code standard discussed here is a digital code recorded as an audio signal. Its purpose is to identify each frame of video with a unique number and reads out in hours, minutes, seconds, and frames.

Since each video frame is composed of two sequential fields it is possible to mistakenly start the time code out of phase at the second field (the middle) of a given frame. Unless a sync generator is used in synchronizing the time code and the control track no actual relationship may exist between video frame rate and time code identification. SMPTE time code generators used primarily in constructing audio tracks may have no provisions for synchronizing to a video control track, but the code produced is still useful in post-synchronization and editing of sound.

Each place in the code is not just a pulse but a part of a list of sequential numbers which can be read and used to position a song pointer in a sequencing program. The relationship between the time code and the actual frames of video may not be one of absolute synchronization. However since the code is physically on the tape with the picture it will be an absolute reference to a point in time and may be used as the time base for recording sound tracks.

MIDI Sequencer

The initials, MIDI, stand for musical instrument digital interface. MIDI code is a data format used to represent hardware commands and data. Many modern instruments respond to MIDI signals and an excellent standard has evolved. It is important to realize that what passes between keyboards and computers through MIDI cables is not sound: it is a binary code, the data used to instruct the MIDI keyboard to produce sound. It is really a language consisting of messages to and from devices and is easily interpreted by a computer program.

A MIDI sequencer can be a stand-alone device or a hardware and software system which includes a computer, a MIDI interface and a program which sends and receives MIDI data. By using the system common message in the MIDI standard called "song position pointer", the sequencer is capable of holding the number of MIDI beats which have elapsed in an internal register. The software can create a list of messages and read these out according to some desired tempo based on MIDI beats. Thus the sequencer can control its own time base. Some sequencers can read SMPTE and synchronize the MIDI clock to it.

Post-sync Editing Using SMPTE and MIDI

The earliest sound cartoons made by Disney studios used a post-sync approach to sound recording. The animated drawings were filmed with an additional bit of drawing in the corner: a bouncing ball. When projected, the bouncing ball became a sort of metronome for the orchestra which recorded the sound track while watching the completed picture.

Our post-sync approach to editing sound starts with a video master tape. The tape has a final edit version of the picture and has SMPTE time code recorded on one of the audio tracks. As the tape is played, the SMPTE code can be read into a sequencer or sequencing program. Since the sequencer is locked onto the SMPTE code, any MIDI data input into the program will be synchronized to SMPTE.

The idea is similar to the method used by the Disney orchestra. You connect the output from the audio channel containing the SMPTE to the SMPTE sync input on your sequencer. Watching the tape, you play something on your MIDI instrument-- a rhythm track, a melody line, accents or beats which have a meaningful relationship to elements in the picture. What you have played will now play back exactly matching the visual cues you used when you used the video tape as the master time base.

You can edit your performance or even transfer it to a multitrack system, provided you make a copy (not a dub) of the SMPTE onto one of the tracks of your multitrack recorder. The MIDI coded song will always play back according to SMPTE, using the start point of the original take and moving its song pointer according to the SMPTE clock.

The final mix is made from the video master and the performance direct from MIDI code. The video picture is copied from the master to another deck. SMPTE time code from the video master is fed to the sequencer and its audio output goes to the audio input of the recording deck. Everything syncs up and the final video/audio mix is made.

Northern Illinois University

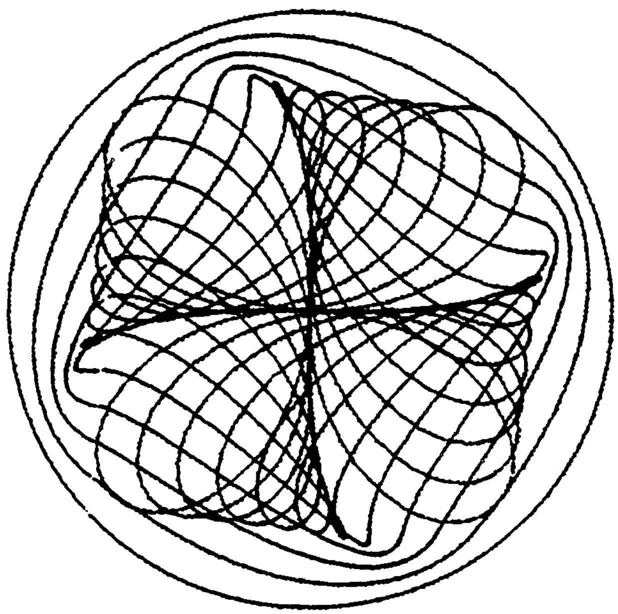
At the Northern Illinois University School of Art, students in our Electronic Media program have been using an inexpensive but very versatile system. The MIDI interface we use is a JamBox/4 made by Southworth Music Systems for the Apple Macintosh computer. The JamBox/4 is also a SMPTE time code generator and can synchronize MIDI to SMPTE. A software package called MidiPaint for the Mac allows recording and editing of MIDI tracks which are cued to the SMPTE played back from a video tape.

The time-based visual images our students create incorporate many elements, from live video to algorithmic art, image processing and "paint-box" drawings done on TruVision graphics boards. Often, software such as VVP or PC Carousel can be used for final editing of the picture. The use of SMPTE time code allows precise control of the MIDI-made music and sound effects. Some students collaborate with electronic music students from our School of Music while others work alone on both picture and sound.

the author

Conclusion

The relationships between the elements of sound and the elements of picture become more clear once the process of synchronization is understood. Time-based image systems may vary in their details but they have a common structure: data, media, transceptualization, and human perception. Alignment of independent time-bases, called synchronization, is often difficult, but standardization of data formats such as MIDI and SMPTE are making it possible to bring the personal computer into the process. Inexpensive systems are the key to access and understanding of this process.



References

The MIDI Specification can be obtained from MIDI Manufacturers Association, c/o RolandCorp US, 7200 Dominion Circle, Los Angeles, California 90040.

The SMPTE Time Code Specification can be obtained from Society of Motion Picture and Television Engineers.

[1] Craig Anderton, *MIDI for Musicians*, Amsco Publicans, New York, 1986.

[2] (No author given), *JamBox/4 Manual*, Southworth Music Systems, Inc., Harvard, Mass., 1987

[3] Byron Grush, *The Shoestring Animator*, Contemporary Books, Chicago, Ill.,1981

The Computer and Abstract Painting: The Monitor as a Picture Plane

Samia Halaby

PART ONE: The Picture Plane

We tend to assume that a new technology will cause a new form of art and that those artists using the newest technology are at the leading edge of formal development. It is important to question this assumption in our thinking and to ask if perhaps it was the development of new forms of thinking that brought forth the new technology. If we study historical precedents to help us answer our questions, what we find is that revolutionary changes in social and economic forms renewed both theoretical knowledge and technology. In fact in many cases we find that the new technology may have followed behind renewed theory and depended on it. We associate oil painting with the Renaissance and yet the first advances in Renaissance painting took place in tempra and drawing. We associate the book with movable type but all the principles of a book were in place before movable type.

Limiting ourselves to picture making we might trace backwards, in time, the sources of video pictures in film and of film in the camera and of the camera in the camera obscura and of the camera obscura in perspective and of the perspective theory in the early paintings of the Renaissance. Further, we can trace the sources of Renaissance perspective to ancient parallel projection in China and India and Greece. In fact we can, following this logic, understand raytracing as a further development on the theory of perspective. Alberti's theoretical investigations of pin-hole projection inside a box in Florence in the first years of the fifteenth century hold up as truely astounding.

Knowing history does not dilute the fact that in computers we as artists have a fantastic new technology that we must fearlessly exploit. Doing so we can imitate the spirit of scientific exploration set for us by Renaissance painters.

But have there not been any theoretical gains in the language of picture making that are more recent than Renaissance perspective and Renaissance shading? Those artists who are using the computer to make polished super-computer images and animations of surrealist subject with excessive foreshoretening, are they the leading edge of art? What have they contributed to the language of pictures.

This paper deals with picturing as a two dimensional formal language and investigates the implications of the cathode ray tube and of digital windowing environments as a new picture plane. Does this new surface demand a new form? How will we as artists use it to advance the language of painting or of picture making? How has the computer influenced picture making and what kinds of pictures have been made so far on the computer?

Today we call research in two dimensional picture making as painting. I prefer the word pictures because historically pictures have been of many different materials among them mural, pottery, rugs and weaving, bas-relief, photography, film and now electronic pictures. Out of our human investigations with pictures have grown many incredible technologies which went their separate ways to become new forms. It was out of picture making that writing first developed. I will not pursue this as we all know that writing began as pictographs intermixed with other pictures. And as I have allready described contemporary raytracing, photography, film, and perspective also grew out of picturing. Ideas and methods for color separation for color printing also grew out of painting. Picturing plays a significant role in providing science with the pictorial language with which to illustrate scientific ideas.

University Education in painting is burdenned with the responsibility of teaching mysticism. To preserve their positions professors often become high priests of ancient methods. As painters we suffer many contemporary prejudices on the role of painting is society. The artist and the art student are entrapped within notions of personal and emotional expression. We are made to feel that our work is useless and decorative and we are invited to be narcissistic and self-indulgent.

In fact the development of two dimentional picture making is an incredible history. Its evolution sheds light on what computer pictures are. It also gives us insights into how to use this incredible and exciting tool we have just, as a species, gotten for ourselves.

The first pictures we made were mostly pictures of animals on cave walls and ceilings. Generally they represented their objects from a simple broadside view and did not coordinate two or more animals. These animals were scattered in varying sizes and positions and often overwrote each other. The first principle which developed for the organization of objects in space was of a simple horizontal ground line. Representations of rows of trees or animals or stick figures on cave walls or around clay or metal pots are typical. This first step is important because pictures now could hint at a unified vertical gravitational direction and a unified scale. The horizontal scanning direction had a narrative potential.

From this one-dimensional space emerged the more sophisticated two dimensional space of ancient Egyptian, or of Shang, or of pre-Columbian pictures. Now things related to each other clearly and coherently over the entire pictorial surface. Vertical and horizontal dimensions were strongest but diagonal movements on the surface were possible and diagonal movements in space were hinted at through overlapp.

Pictures make illusions of multidimentional reality. But they themselves, however, are flat. The illusion of the third dimension, as a spatial direction that is perpendicular to the surface plane on which the picture resides, is the next step to develop. This started with the ancient Greeks and the ancient Han Dynasty of China as well as in northern India in the Ajanta caves approximately during the first few centuries before and after Christ. From this beginning through Renaissance perspective we have taken about two millennia to come to raytracing. But note, that raytracing remains a three-dimensional space and has not, like prallel projection, provided us with a new formal principle. It has not expanded the basic syntax of picture making.

The question suggested now is wheather one can say that film and raytracing animations have a fourth dimension of time and therefore a new principle in the making of pictures. Film gives us a picture plane which moves with us. We are stationary when we watch a film but we have an illusion of a moving window. Thus film gives us a movable picture plane and objects which move within it but it does not change the nature of the illusion behind the picture plane. This illusion remains three-dimensional.

In film, time is either actually passing or is manipulated through literary means. Pictorial means which stretch or compress or reverse time are possible with film. But there is not as yet in film a pictorial illusion of time. The language of picturing is about making illusions on a flat surface. Precisely in this fact lies its incredible usefulness. And so it is new theories and ideas on the nature of pictorial illusionism that we seek as picture making artists.

I caution my readers not to assume that I lack enthusiasm or respect for raytracing or fractals or any of the other magnificent things graphic artists and geometricians have shown us. Nor do I feel any superiority for being a painter. In fact I feel like the poor cousin. But, an enlightenned historical perspective and a scientific attitude of study will help us to make the clearest distinctions and the most productive work.

During the first two decades of the twentieth century Abstract painting developed first in Cubism and later in Constructivism. Abstraction rejects perspective and shading. It is as though painting split into two. Perspective and directional light became the domain of photography and film and video. Abstract painting, rejecting the static three dimensional space dependent on a viewing eye or lens, creates a relative space which might be described formally as four dimensional space.

The earliest Abstract painters declared that what they were doing is better describing reality in their new paintings. They did not think that they were exposing their inner self nor did they think of their art as emotional. Abstract painting is illusionistic of the world. The difference between it and pictures which use perspective is that Abstraction represents the general motion of things rather than a specific view of a thing or scene during a specific moment of time.

In Abstract painting light, rather than being directional, is a result of relative luminousity. Line, rather than describing contours and edges, is a path of motion or energy. Shape, rather than representing measurable distances, describes relative distances. For example a Rothko painting has neither directional light nor perspective but might give us an accurate understanding of the luminousity of colors at dawn. A Joseph Albers painting has no perspective but defines relative depth by allowing shapes to move freely back and forth in space, what Hans Hoffmann called push/pull. Abstract painting will develop and will give us yet more tools with which to represent our modern environment.

The picture plane for Abstract painting is no longer a clear window through which we see a finite three-dimensional world. In an Abstract picture the background, the negative space, is infinite. The first paintings to use such a new idea of a picture plane were those of Kasimir Malevich during the second decade of this century. Incredibly, the picture surface of Malevich's Suprematist paintings feels a great deal like the luminous surface of a computer moniter.

The computer moniter as picture surface has special potential when we manipulate it using digital information to create a multi-windowing environment. Since windowing is a software innovation it is important to give credit where it is due. Jerry Pournelle points out that ideas for this windowing environment were developed at Xerox's Palo Alto Research Center(PARC) many years ago, then partly perfected by Niclaus Wirth, and finally popularized by Apple's Macintosh.(1)

For Abstract painters to use the computer in place of the traditional media there has to be something new possible that can not be investigated in paints. What is it that is this new thing which attracts me. What I find to be very important and which renders this new medium significant is three-fold. One is the possibility to intuitively connect sounds and pictures. Two is the possibility of making Abstract movements and of developing shapes in time. And, three is the challenge the multiple windows provide as a picture plane.

That it is possible to have many different surfaces disolving, merging and intermixing with each other, of growing transparent and revealing a second surface is a challenge. This new picture plane seems to us to have a memory. Things which disappear can return. It psychologically connects to our experiences of other electric appliances like televisions. We can turn it on and off. We have been conditioned to expect a lot of information from a moniter. In short, the luminousity, the changeability, the seeming memory of the computer moniter as well as the rich complexity of the windowing environment have become an incredible challenge for Abstract painting. This picture surface clearly has the potential to be used to expand pictorial language and to give us more accurate illusions of our contemporary environment.

For example a few weeks ago I was walking down the corridor of the Amsterdam airport at dawn. One of the walls of the huge corridor was made of glass and covered with horizontal slats. Between the opaque horizontal slats were horizontal bands of clear glass through which I could see the view outside of airport buildings and equipment. Many lights of different colors were on against the dark blue of the dawn sky. The vertical bobbing motion of my stride with the horizontal slats created a visual experience of flickering lights and shifting picture. Could such a visual experience be better imitated by manipulating horizontal slices of screens and windows or with an oil painting? I think the former and I think the result would be far more exciting.

Computer graphics have to date been used in technical and industrial applications to great advantage. It has made the work of the designer easier and more fruitful. Techniques to input and output pictures into and from the computer, and to mix video and computer images and to manipulate them together are amazing. Amazing also are the techniques which create moving animations from satelite data; and so are raytracing techniques which create three-dimensional illusions with complex illumination and movement. Computer graphics have also been aiding scientists in visualizing their theories. The fine artist seems to be last at this feast and is the pauper picking up mini-computers from under the super-computer-man's table.

In computer graphics circles, at SIGGRAPH and at high powered symposia of computer graphics incredible misconceptions prevail about the art of painting and picture making and about what constitutes new form. Pictures are taken as a given and the fact that they rely on a pictorial syntax which has taken millennia to develope seems invisible even to the scientists.

For example at a recent conference in Utrecht, Holland, Donna Cox of SIGGRAPH compared an impressionist style painting of clouds to a computer animation (made for the Navy) of a cloud formation.(2) She said that the difference between them is that the computer knows what is behind the cloud while the painting does not know what the back of the cloud looks like. Cox implied that this difference demonstrates that computer pictures of scientific data are a new art form. The fact is that both pictures are flat and frontal.(3) They do not at any time show us the back of anything. Any illusion of three-dimensional space implies a frontal and single point of view at a single instant of time. For the impressionist picture, knowledge of the back of the cloud resides in drawings and writings on paper; while for the computer picture, knowledge of the back of the cloud resides in computer memory. What is new is technical ease and speed. The computer is a polished development based on the more primitive model. The material techniques are different but the pictorial principles are the same.

Others point to fractals and say that that is new.(4) It seems to me that what is new hear is the ability of mathematicians to visualize their ideas. The pictorial form used by fractals is that of mapping and Abstract painting. What is new is fractals as geometry, on the one hand, and the language of Abstract painting on the other. Fractals are not a new art form and the language of Abstract painting is not a new geometry. Fractal pictures are scientific illustrations which rely on the pictorial language developed by medeival Arabic wall patterns and by Abstract painting. The sciences have always been creative and beautiful.

Technical applications and scientific illustration do not investigate the language of picture making. Rather they apply that language for useful purposes. Significant research into pictorial form (language) in recent centuries has been made by painters. Wheather graphic designers and sceintists will now grab the lead because they have at their disposal very expensive multi-million dollar super-computers is uncertain. Their misconceptions aired at recent symposia makes me doubt their ability to do so. The prevalent opinion is that painting is a non-historical fancy, a pleasurable indulgence, and that it is a personal expression of the artist's emotions. Picture making is not seen as a knowledgeable and intuitive practice based on understanding history. They take three-dimensional illusionism as a non-historical given and seek nothing beyond it.

PART TWO: Why And How I Use The Computer

My prejudice and my education as a painter lead me to want to exploit a medium for what it might uniquely possess that other media do not. There would be little sense in using a computer if I intended only to imitate oil painting.

In making computer pictures the first question I had was about the material form the final art-work would take. What hard copy would I output my work to? The most appropriate and the most computer-like seemed to me to be magnetic memory, maybe a floppy disk. I reasoned that a disk is distributable like a print and can be played like a recording. However, incompatibilities between different brands of computers make this very difficult. Later I compromised and output my work onto video tape. This is satisfying because video is an electronic medium and because it makes the art-work much more widely available than a floppy disk would. (More people have access to VCRs than to computers). I can even accept the program itself as the work of art. As our small computers quickly become obsolete and as video is a fragile and inferior product, then writting clean portable programs is significant. Besides, it is more economical to save art-work in program form.

I chose to program rather than to use ready made painting or animation software because they both take for granted artistic principles which I have abandonned in favor of Abstraction. Using painting software we can create single static images like those possible with easel paintings but without the scale, texture, detail, or gesture that a painting or drawing can embody. Most animation software takes for granted that there is a single point of view and that objects move infront of or behind each other in relation to this viewing point. This imposes the notion of a lens and therefor of perspective on the art-work. There are no lenses in computers even though computers can be made to imitate lens-based image-making machines such as film and video cameras or projectors. And, since I am an Abstract painter whose thinking has developed beyond the need for either perspective or directional light, I found such software programs extremely limitting.

The result is that I chose to start programming. My very first explorations were with Logo on an Apple computer. Afterwards, when I bought my own computer, I used Basic and finally chose C. The Apple Logo which I was using was limitting but it gave me an easy entry into programming and it helped to build my excitement.

It seems to me that an understanding of a medium for purposes of pictorial investigation would lead the artist to intuitively reveal that medium in the art-work. I find that the logic of programming and the linearity of memory contribute to the pictures I make. As a very simple example, I have used two loops within a larger loop to control the rhythm of shape and sound. The nesting of loops contributes a structure that would not be there otherwise. I even find that there is an artistic difference between those programs which I wrote in Basic and those which I wrote in C. Like C itself the pieces I made with C are more coherent. than those made with Basic. On the other hand, those made with Basic have a rich unpredictability and bubbly enthusiasm.

My computer pieces and my paintings influence each other but each is an independent expression. Neither one is made as a sketch for the other. They simply enlighten one another. I do not sketch on paper for my computer work. Thinking for the computer begins with what programming allows me to try. Afterwards, I try to push its limits and those of my knowledge. The most obvious influence on my painting from the computer is that the colors of my paintings become brighter as a result of my staring for hours at the luminous colors of the moniter. There will be more interaction between the two as time goes by. The influence in the other direction, from painting to the computer pieces, is a large one in that I come to the computer as a mature painter having clear notions of the esthetic areas I will sepnd my time investigating and those I will not bother with.

often others will suggest to me that I enlarge and execute in paints one frame of my computer pieces, or at least to stop the flow of shifting shapes and allow them to stare at a stationary image. Both these ideas seem wrong to me. Single frames of one of my computer pieces is not as interesting as a painting. It is the sequencing in time and the shifting of shapes and colors and the intrusion of sounds into the quiet of painting that creates the total idea.

I am aware that the sounds which accompany my programs are primitive to the extreme. I am aften severely criticised on how I use sound. Mostly, I agree with these critics. But, I do not think of these sounds as music. The sound is incapable of standing up on its own. But like the noises of the street, the rhythm of which I often contemplate, these sounds are merely signals. They add a spatial dimension to the pictures. Some of my friends and critics have suggested that I use classical music to accompany the pictures. This seems as awful as putting a flowery gilded frame on an Abstract painting. Others suggest that I should not use sound. But, when the pictures are run without sound I feel as though I have gone deaf and that a whole dimension of reality was stolen from me. That I need to learn more in this area is obvious. Or, I need to find a musician whose work resembles mine and who might enjoy collaborating.

I do not have an ambition to make programs which run by themselves or have an artificial intelligence or posses some kind of magical automatism that will run away from me and become autonomous. I control through intuitive acts of will every fragment of my work. Just like my oil paintings these works are deliberate and carefully edited.

I use the keyboard exclusively for inputting information to the computer. I dont use digitizing pad and electronic pen. I do not miss brushes and paint. But I would miss painting if I had to give it up. There is much yet to investigate in painting and much yet to investigate in computer pictures.

My C programming environment is very simple. I have written functions which create the windows and screens that I want wnd which prepare the sounds and assigns them to the four channels of the computer's audio device. There are functions which open the libraries and prepare the timer device which is heavily used to create the delays that control the rhythm of things. The program starts by checking if a previous picture has left a window open, if so then it is wiped clean and the new picture begins. If not, a window is open and the picture begins.

Once the environment is set the program calls on a layered set of functions. At the lowest level there are some simple functions which are based on the operating system's primitives. These draw lines and shapes and play sounds. There is another layer of a few functions which push these basic shapes around or expand them or flip them. Above all these and relying on them is a top layer of less primitive functions which combine an auditory and a pictorial movement. These functions are specific to one moving picture and are usually not used for another picture.

At the recent First International Symposium on Electronic Art Harold Cohen, an invited speaker at the conference, declared that art on the computer can only be done by programming.(5) Until a couple of months ago I would have strongly agreed with him. But, seeing Roberto Matta's four video pieces at the present Venice Biennale changed my outlook.(6)

Matta's videos were made using ready made painting software and video recording techniques. The pieces were composed of drawn lines shown in rhythmic sequence. It seemed as though we were watching a master draw. It resembled many such attempts made with film of the process of development of a painting. This, however, was qualitatively different from these earlier examples of process. The artist and his hand and the unwanted gestures were not present. Nor was there an intention to present a process which led to a final picture. Rather it was the shifting and changing of the space, masterfully manipulated with lines and marks, that was the obvious subject. As we watched background spaces were turned into figures and figures into background. A cat's face became three figures. One figure in bed became two tumbling figures. Or, a figure might sprout an apendage which then evolved into a second figure. Subtractive marks, that is marks which erased earlier marks, were used just as creatively as additive markings. Until I saw these videos I had not imagined that it was possible to add anything to the language of three dimensional Illusionism.

NOTES

1. Jerry Pournelle, "Stick Shift or Automatic?" BYTE, October 1988, page 101.

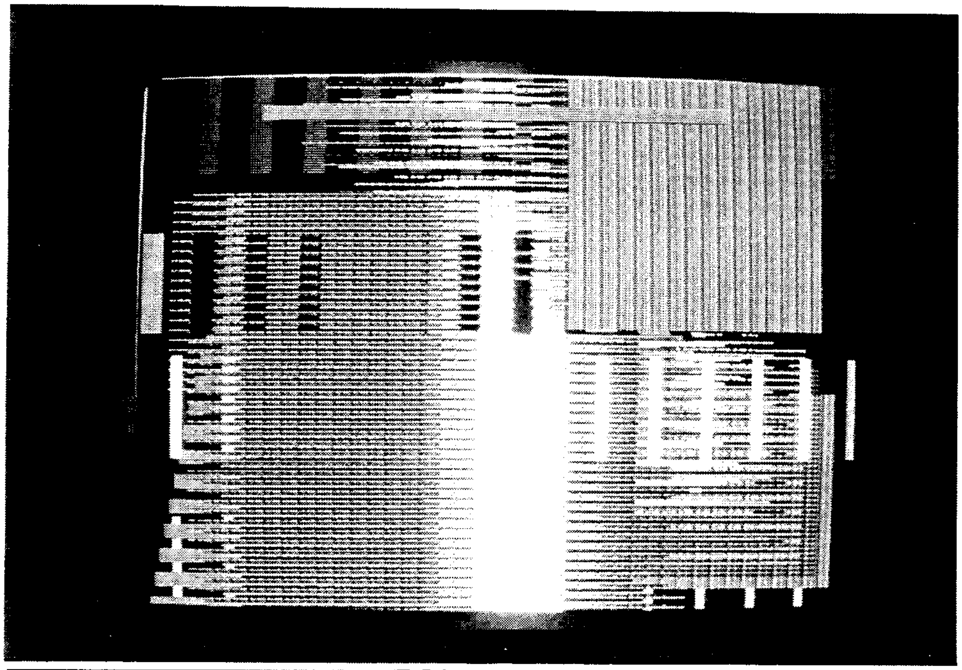
2. The first International Symposium on Electronic Art held from September 27 through 30 in Utrecht, Holland, was sponsored by the Foundation for Creative Computer Applications and by the Center for Art, Media and Technology. It was supportively attended by The International Society for the Arts, Sciences and Technology. A large number of the speakers had been published in the journal of the Society, the Supplemental Issue, 1988, of LEONARDO.

3. The idea that things are real in the computer is taken as a given in many statements one hears about computer pictures. It is as though some have forgotten that pictures are illusions. An ideological confusion between reality and computer imaging is backward. At best, it is a lazy intellectualism which breeds more science fiction than art.

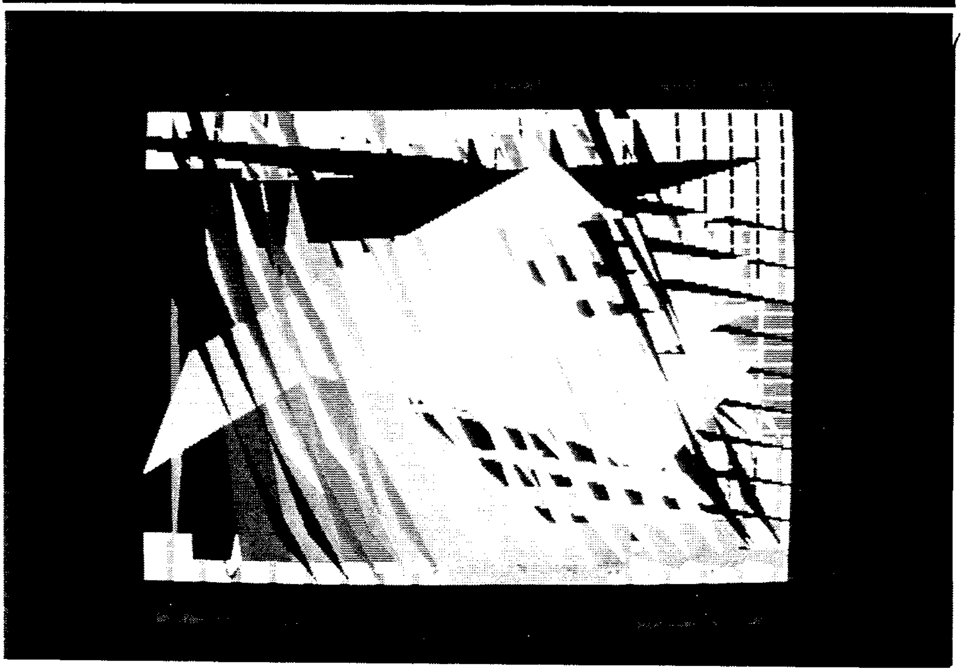
4. At the 1988 SIGGRAPH lecture series "computer Graphics in the Arts and Sciences", during discussion after Alvy Ray Smith's lecture on Formal Geometric Languages Mr. Smith implied that the complexity and speed possible with the computer was a new form in pictures. A participant in the audience then declared that fractals were a new art form. The series was co-sponsored by New York ACM SIGGRAPH and Pace University, The School of Computer Science and Information Systems and New York Academy of Sciences, The Computer Science Section.

5. See note 2 above.

6. The four video pieces were: "Auto-Elasto biographie",1988; "Oeramen",1988; "Passez-moi la guillotine",1988; "Passez-moi le souffle",1988; Video, paint-box, n.m. Shown at the XLIII Venice Biennale, 1988.



"Sine"
Samia A. Halaby
Computer Picture in Motion.
Programmed in C.
Hardware: Amiga 1000



"Kaleidescope" 1987
Samia Halaby

Computer painting program in BASIC for the Amiga
TOSSAN-TOSSAN Gallery

Motivations, Intentions, Meanings and Surprises

Thomas Porett, Professor, Director of Electronic Media Program

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Abstract:

In this paper, I am going to describe two projects in both the technical implementations, the conceptual, emotional origins, and how each evolved in their development. Both of these works involve the computer used as a device to display images, one intended for direct viewing on the computer screen, the other as a progression to be videotaped. Both pieces include digital sound, either voice synthesis or MIDI controlled sound track.

VICTIMS

The first project is actually an updated version of a piece done originally in 1985/86, titled VICTIMS. During 1985, a good deal of attention was focused upon the anniversary of the end of World War Two, and the liberation of prisoners in Nazi concentration camps. It also coincided with the visit by then President Ronald Reagan to the Bitburg cemetery, and his facile equation of the Nazi SS troops buried there with other victims of the conflagration. It also coincided with the release of previously unseen footage taken by the British forces of the Bergen-Belsen camp, also visited by the President.

These events impacted on me with considerable power, particularly the scenes from the camp. I was personally moved perhaps more that most because my grandfather had been incarcerated in a camp, and survived. As a child I knew him as an enormously warm, intelligent, and humorous man, and an important influence. My life without him would have been a very different kind of moulding, certainly lacking crucial depths of human insight.

I had a growing sense of unease that the images from these films were too factually cold, and detached. I had videotaped some of the footage off the air, and felt compelled to look at it until I began to more truly comprehend the visual sense of the calamity. This visual meaning began to emerge when I began to videodigitize some selected frames, generating images of individuals in a final tortured repose. These digitized still images intensified the mask like character of faces, and oddly enough brought to the image a more intimate sense of the individual. From these death portraits, I began to speculate on who these people were, and wrote some passages about many of them. I began to experience a sense of personal loss beyond the more usual one of generalized horror that is most often felt when seeing films of the holocaust.

It was at this point that I felt compelled to create an art work from these pictures, a decision that was to say the least conflicted. It was not easy deciding to work with images of victims, feeling that the work must be special enough to warrant using such pictures and not be exploitative. I felt that it was important enough to try the make the piece what ever it would end up being, and then judge the value of keeping it or destroying it.

One criteria that I felt essential to the work was that it not linger on the precise topic of the holocaust, but speak to the wider issue of victims of any tyranny. I edited the images with this in mind, even though several specific pictures do refer to the Nazi regime. The sequence in which the images are edited went through many variations before the final one, but I realized that no matter which structure I chose, some other element must be introduced to guide the way they are seen. I came to favor the notion of using the speech synthesizer that is built in Macintosh computer to narrate or comment about the images. I was particularly interested in trying to combine the short fictional biographies I had written into the piece, and tried this combination. To a degree it worked, but the limited intelligibility of the speech, and the slowness of the progression did not seem to be the right combination. I tried many different variations but none seemed to work. Finally the idea of writing a short poem to accompany the images emerged as most likely to succeed. The following poem is "spoken" at the beginning of the sequence, followed by silence as the images appear on the screen.

VICTIMS CANNOT WATCH
CANNOT HURT OR REST
CANNOT REVENGE
OR FEEL JOYS OF FLESH
NO CHILD CAN LEARN THEIR HOPES
NOW LOST TO VULGAR CERTAINTIES.

A CERTAINTY THAT SEETHES IN PLAIN MINDS
JUSTIFIED BY SELF SERVING LIES
PERFECT DECEPTIONS
THAT LIVE UNDAUNTED
OVER ONE'S SHOULDER
IT'S COLD BREATH YET
SEARCHING FOR PERFECT LOGIC
YOUR LOGIC, AND MINE.

A DANCE OF SOULS
TIRELESSLY WAITING
FOR A JUSTICE
THAT CANNOT
NOR WILL NOT
BE.

When the piece is performed in a gallery setting, the words are heard every three minutes, often startling those who have entered the room between cycles. I use a battery powered external speaker to make the sound louder and more intelligible than the rather underwhelming built in Macintosh speaker. In the installation configuration, the small computer is surrounded by four color prints each of which are made up of several frames from the sequence. These images were shot off the Macintosh screen and digitized into a Symtec PGS III system using custom software, and printed on an ink jet printer. Each of the four composite prints measures 15 X 40 inches. This configuration was selected to be part of the Siggraph 1986 Art Show, and was part of the traveling exhibition.

Although I had finished the piece and had exhibited it several times since the Siggraph show, I felt that the message and power of the piece was not accessible enough, especially in the art gallery venue. I had considered the notion of putting it into the public domain, but hesitated for two reasons. The original form was in the Slide Show Magician format, and required a special "projector" runtime software to make it work. Further, due to the unfortunate protection scheme built into this very useful software package, it required each and every copy to be duplicated with the original package or it would malfunction. I took up the issue with the manufacturer and got a very negative response. This was clearly untenable. In addition, I was not altogether comfortable with releasing an art work without some kind of commitment on the part of the audience. The notion of shareware occurred, but I felt that it was inappropriate for me to ask for personal gain with this piece.

The problem was resolved in 1988 when Apple Computer released the Hypercard software package, and encouraged a whole new wave of independent software to be created for the Mac. I was most interested in the "slide show" functions built into Hypercard, feeling this was an answer to distribution in the Stackware form. In addition, it would give me a project to learn and apply Hypertalk. Finally, I decided how to address the problem of commitment by treating the work as shareware, but asking for a ten dollar contribution to Amnesty International, an organization whose work I believe in deeply.

I won't go into a detailed explanation of how the final stack works, but will recommend that anyone who has an interest in Hypertalk buy <u>Hypertalk Programming</u> by Don Shafer, published by Hayden books. The most difficult problem I had to solve was how to get the computer to speak as there are no Macintalk functions built into Hypercard. This problem was solved by a public domain package called HyperMacintalk, a stack created by Dennis C. DeMars which creates an external command and function for use with Hypertalk.

The final public domain version of VICTIMS is available on GENIE, Compuserve and MacLink, and hopefully on many other smaller bulletin boards across the country. I do hope that a significant number of people will contribute to Amnesty International, and perhaps become members of this most worthwhile organization.

<u>DECEPTIONS</u>

I will briefly describe the genesis of this work from the standpoint of its emotional and conceptual origins, and the variations it went through. It began as a rather disturbing event, a simple domestic conflict between two good friends of mine. Conflict between couples married or not is of course not unusual, but this conflict was characterized by its cruelty, inflicted by both parties upon each other. One morning I had walked over to their home for a visit, and no sooner I had sat down at the table for a cup of coffee, an argument flared about nothing in particular. Its fury grew as each took turns at stripping away some element of each others nature that was "wrong."

The experience left me shaken for its intensity, rage, duration, and the fact that I was made an official participant by my presence. This feeling of upset stayed with me, and I determined that it would become the focus of a work. As I let this idea germinate, a structure developed in which characters would lash out at each other, tearing out strips of each others being.

As I set out to realize the images in digital form, a significant shift occurred. The original visual idea was altered, and a new and possibly more disturbing presence came into being. I was working with the technique of electronic collage, in this case tearing or cutting strips of faces. I worked with images of primarily female faces, as these are most prevalent in the popular media, but with a distinct intention of making them less gender specific. I aimed toward a more neuter persona that would symbolize generalized conflict, not necessarily sexual in nature.

As I have mentioned, the work shifted significantly, becoming a very different kind of work, one that somehow had a very different but related meaning. The images began to lead the work, they were powerful, and terrifying, they began to shake me in ways similar to the original event although they were not about that occurrence. This kind of shift is not unusual for my work, and I suspect it is not at all uncommon for works by other artists in any medium. The sense of discovery and working uncharted territory is most appealing. I gladly let the work continue in this direction.

In its initial form, I thought of the work as an installation piece that would utilize the images as fragments, combining elements of images to randomly form new mask like presences, with an internal rhythm of change. Using a custom slide show package that I helped design with friend and ace programmer David Turner, I worked out a progression in which a fixed series of images were combined differently in an infinite loop. The result was visually interesting, but there lay some doubt as to its success in conveying the same sense of meaning I had experienced in making the images.

This feeling of discontent was confirmed when I showed it to a friend Phillips Simkin, an artist whose work I respect, and a no nonsense tongue when given the opportunity to critique someone else's work. He felt that I was avoiding the issue of making a definitive statement, and certainly avoiding the meaning of the source imagery. I had to agree that the piece did not convey the power inherent in the images. I was torn between my interest in creating a changeable experience, and the need to clearly define this piece, even if it meant making a short tightly defined video presentation.

I set about the task of carefully editing the images in a manner similar to the way I had edited slides in my early multi-media presentations of the late sixties and early

seventies. I was fortunate enough to find a somewhat outmoded thermal videoprinter, and made paper "snapshots" of each screen. I then laid out all the images, and grouped them into visual "phrases" which would in turn be combined into "movements" of meaning. The use of musical or literary terms is based upon my earlier experience with photographic imagery in the multi-
media form. I had for some time thought that the power of the photograph was less as a totally self contained unit than it was as one that is relational. In a variety of circumstances, an image could mean different things, hinging on its spatial or temporal context. With the rapidly maturing of computer imaging, and expressive uses, these ideas were becoming as relevant as they had been with the photographic medium.

The piece went through several editions, each further distilling the meaning of the work. Once the actual sequence had been developed, the task of making an appropriate sound track grew in importance, particularly since the progression was to be limited to a rather short deliberate form. I had accumulated a number of music compositions with my newly reconstructed music studio. In the sixties and seventies, I had put together a solid analog system, but much of that hardware was marginal, and not MIDI capable. The new system is made up of a Yamaha DX7s, Casio CZ 101, Yamaha TX81Z, Casio RZ-1 drum machine, Yamaha RX21L Latin drum machine, and a Macintosh Plus computer with the Opcode Professional Plus Midi interface. I have stuck with the simple and affordable software, Deluxe Music Construction Set, and the Opcode sequencer.

I tried to combine several of the pre-existing pieces with the image sequence, but found that none conveyed the emotional sense appropriate to the work. As with nearly any combination of music with visual material, each composition worked to a greater or lesser extent, all too often dominating the visual content, and at times creating an outright conflict in meaning. Music and sound are incredibly powerful tools that can easily dominate visual material in most any context and this was not exception.

The piece was as yet unresolved, it had not made that powerful impact I had felt from the images. My unease with the piece remained. I spent some time away from it, thinking about the missing element. The sound track emerged as the weak link that as yet did not contribute its potential to the work. The character of the images was as yet not realized in the musical content of the track. Finally a feeling about what the track should be began to take root, not as specifics, but an emotive plan. I wanted the track to be broken rhythmically, even 'crazed' and dissonantly tense, yet tied to a repetitive counter rhythm. I cannot clearly establish the exact sequence of composition that ended in the final track, but as I heard the piece evolve, I felt certain it would be appropriate to the image sequence.

As I viewed the final work the realization that a wholly different piece than I had intended to make was driven home to me. What actually had come into being was a piece about a very different kind of human emotion than anger or conflict. Many of the images contained faces that were contorted in ways that seemed to infer the message of spite through expressions of a kind of evil intent, as though delighting in causing pain through deceit. The title DECEPTIONS seemed very right even though it was only tangentially related to the origins of the piece. I was not displeased as this process of discovery is in some ways more rewarding than merely following a straight path of realizing a work in its totality from initial concept. Indeed, I suspect that most works of art are arrived at in this manner, an unclear journey leading to some new revelation on its own terms.

From VICTIMS ©Thomas Porett 1988

From VICTIMS ©Thomas Porett 1988

From DECEPTIONS ©Thomas Porett 1988

The Importance of Interactive Computer Graphics in Education

Diane L. Schwartz

The following paper begins by giving a brief definition of interactive computer graphics. I then explain VOILA - Vasarely inspired OptIcaL Art - an interactive computer graphics installation that I have developed. Next I then relate the importance of interactive computer graphics in today's educational system.

Before discussing the importance of interactive computer graphics in education, it is extremely important to understand what is meant by interactive computer graphics in this context. So, what does it mean? Let's start with defining interactive first. The definition I use is as follows: interaction between man and machine means that a user can use some sort of computer graphics software in a non-threatening way. No experience by the user is needed. Now for the definition of computer graphics. That's a hard one because everyone uses their own. I will go for the most basic definition which is creating images on a computer.

For the past two and one half years I have been working on interactive computer graphics. In that time, I have created two interactive computer graphic installations that are learning tools and entertaining pieces (i.e. they are fun and actually teach something). The most recent piece that I have developed is called VOILA - Vasarely inspired OptIcaL Art. This teaches users about the principals of Victor Vasarely's optical art work (Vasarely is an optical artist from France) and the mathematics that these principals are based upon.

The game (please note that the word game is used for lack of a better word but that I am referring to VOILA which is actually a learning tool - I am open to any suggestions for better phraseology) has two main sections; a learn section and a play section. The play section is divided up into three levels which range from easy to hard. These levels not only increase in difficulty but also in complexity of the image created. In the first level, a pattern is chosen (see figure 1) and then shapes are reversed out menu, onto this pattern (see figure 2). The second level again begins with choosing a pattern. Then a menu containing twenty-two choices for manipulating the image comes up. The user can now create to their hearts content. When moving up to the third and most complex level, the user can pick two patterns, a way in which they mix, and then move on to the menu with the twenty-two transformation options (see figure 3).

The learn section consists of six subjects from which to choose. These subjects all reflect what the user has done (or will do) in the play sections. For example, one can learn the basics of Boolean Algebra, about color theory, the importance of the grid structure, etc. Each of these subjects then has several pages of information teaching about that chosen topic. Graphic examples of these are displayed as will as verbal descriptions given.

Figure 1.

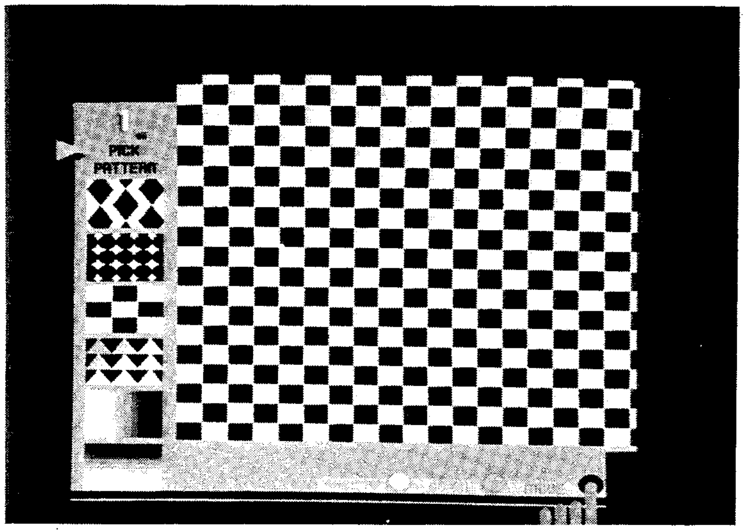


Figure 2.

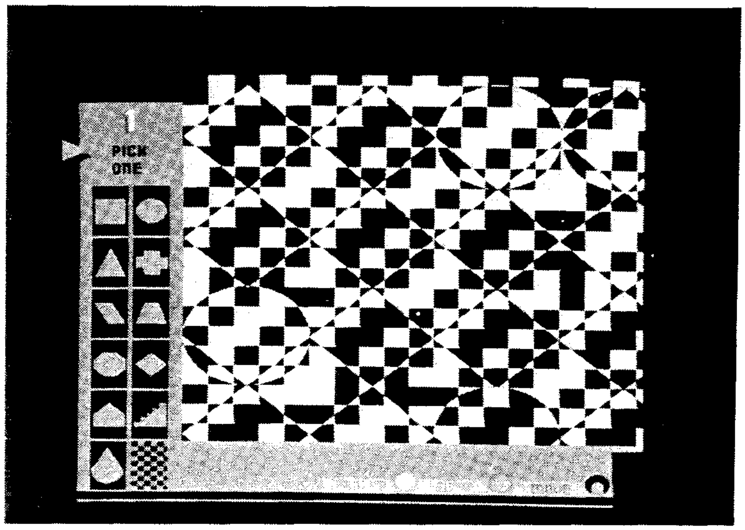
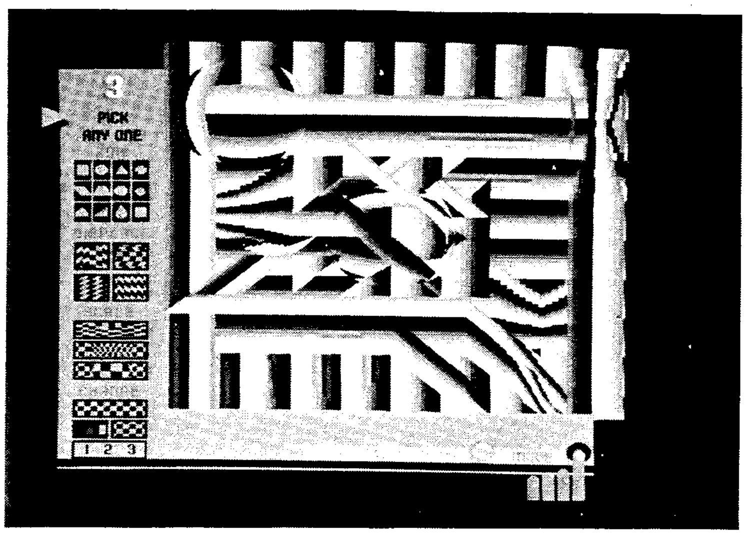


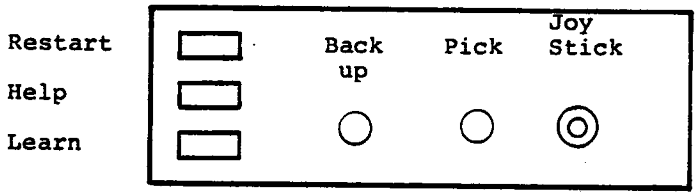
Figure 3.



The user interface consists of a panel with five buttons and a joystick (see figure 4). The buttons on the left hand side are as labeled - Restart, Help, and Learn. The Restart button will restart the game from any point. The Help button will give additional clues to the user as to how to continue. This Help button can be pushed also at any point in the game and will explain how to use the buttons in that particular instance. The Learn button allows the user to stop "playing" and go into the Learn part of the game. The remaining two buttons do the following - back up to the previous menu and pick the item that the user wishes. The joystick has different functions in different parts of the game. The most basic of these is to move flashing boxes to choose menu items. Other functions of the joystick include changing the size of a shape, moving a shape around the screen, or moving colors throughout the image. It is important to note that these buttons are different colors, light up, and flash for clarity.

Figure 4.

THE USER INTERFACE



The kinds of controls that were picked for this installation are the same kinds of controls that video games use. The most significant reasons for choosing these is that video game controls are universal. Five year old children to forty year old adults feel very comfortable in a video arcade. The goal here is to insure that same kind of security.

Now that I have described VOILA, I will get down to the nitty-gritty of why this kind of work is important and valuable in education. One of the most important reasons of educating through this nonconventional way is that the information flow is highly increased. The old saying "A picture says a thousand words" is quite applicable here. More information can be expressed pictorially than in a text The user can therefore absorb more information. We, as people, remember 30 percent more of what we see than what we hear or read. So in this situation, the user benefits by seeing things in an image format.

Secondly, everyone learns by doing. Because this game is highly interactive, the user is not an innocent bystander who pushes a button just to go on to the next page. Instead, the user creates themselves and therefore learns by doing. The boredom level in this type of situation is extremely low for two main reasons. One, this installation (VOILA) is fun and exciting to do. Two, the user is encouraged to challenge themselves and this maintains their interest.

Another important as well as unconventional aspect, is that the user works at their own pace. In a typical classroom there is pressure to be as good as the teacher's pet. People do not need additional intimidation. Teaching by means of interactive computer graphics, such as VOILA, allows the user to move at a pace that they are comfortable with. One can take time to understand the concepts, and move ahead when they feel confident. Therefore, there is no discouragement involved.

For the same reasons mentioned above, these types of installations are especially good for slow learners or people with Learning Disabilities. These people are especially intimidated by teachers that push for more results. That is the exact opposite kind of reinforcement that these people require. Therefore, installations like VOILA are suited to their needs as well.

VOILA encourages individual choice. Often times, with interactive methods, be it by computer graphics, videodisk, or other methods, the user is still inhibited because there is only one correct answer. That is not the case here. There is no right or wrong answer with VOILA. Instead, the user is encouraged to use their own personality and opinions in created imagery. They tell themselves when the image is complete and when their own resources are exhausted.

Another advantage to this type of installation is that as the technology grows the program can be changed. In other words, the software can be updated to meet the demands of a changing society.

The last point that I will make is that of subject matter. This type of learning tool can be used to teach any subject from art to physics. There are presently six other pieces like VOILA that teach different things. Any subject can be taught using this technology.

As the educational system becomes more open to new kinds of teaching methods, I believe there will be more and more kinds of interactive installations in schools around the country. Learning tools like VOILA are geared toward grammar, junior high, and high schools but colleges as well can benefit from these new types of educational instruction. I am working towards making this the trend of the future.

For further information or comments, Diane Schwartz can be reached at 4818 Jarvis, Skokie, Illinois 60077. VOILA will be installed at the Computer Museum in Boston on November 6, 1988.

INTERMEDIARY: A COMPUTER-GENERATED VISUAL COMMUNICATION ENVIRONMENT

Pamela Taylor

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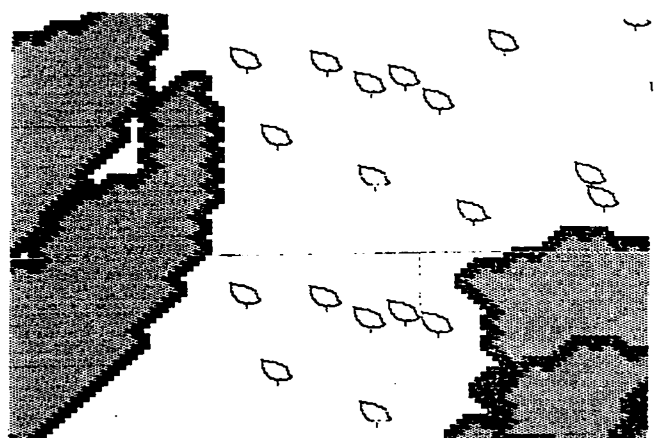
Intermediary was a computer-generated environment designed to encourage viewers to exercise their visual vocabulary. Random sequences of simple images were programmed to run on four monitors that were placed in a rectangular arrangement. Transparent screens with computer imagery printed on them hung in front of the computer monitors, altering and influencing how the images were interpreted. The images on the monitors were different and changed at different intervals, allowing various combinations. The interaction between these images, the images on the hanging screens, sounds that were designed to accompany the exhibit and the viewer's own visual repertoire were the real subject of this environment.

Intermediary physically consisted of four Apple II computers and monitors with two disk drives at each computer. These were displayed on gallery pedestals in height from thirty-four to fourty-eight inches placed in a rectangular arrangement approximately twelve by fifteen feet. Thirty inches in front of these were hung black line positive screens printed with computer graphics so that the viewer looked through these to see the sequence of images on the monitors. These screens were forty inches wide by fifty inches high. The final component was a two-track recording of sounds created by a Yamaha DX27 synthesizer mixed with spoken words.

The environment was designed to draw viewers into the center of the space where they could view more than one monitor at a time only if they turned their head or body; room was allowed for the more inquisitive viewers to walk out of the rectangular inner space and stand between the hanging screens and the monitors. In walking around the individual viewer could see an image through more than one screen or without a screen, and could also see reflections of images on the screen from the monitors. This viewing flexibility allowed a somewhat random layering of images.

All images used in Intermediary were computer-generated either through programming or digitizing. The images on the positive film screens were derived from interactive programs designed to create a variety of visual arrangements. Three of the screens were based on shape table patterns -- two were organic, inspired by leaves, and the third was comprised of geometric shapes that I personally refer to as "puzzle pieces". These shape table patterns were programmed to continuously draw in a random position, size and angle and when a preferred arrangement was drawn it could be saved by hitting the S key on the computer keyboard. Once saved, the program would resume its drawing. In this way a series of images was saved and collected, then one was chosen from each of the three and enlarged to become a screen design.

The fourth screen was arrived at in a similar way, but instead of a shape table a line drawing program was used that randomly drew lines in all of the eight high-resolution colors. Again, the program was interactive so that at any time the image could be cleared and a new one started, or an image could be saved onto a diskette. One of this series was used as a screen and the program itself was altered and used as a subroutine on two of the four computers in the actual exhibition.



This program was included in the monitor sequence to add an infrequent moment of color and movement as most of the other images were still, digitized images that were primarily black and white. An occasional frame of solid color was also included as a color visual relief-point. The only other movement on the monitor, besides the change of one image to the next, was used with two of the leaf shape table images. These were moved from left to right making the image wrap around, disappearing off of the right side and reappearing on the left.

Other images that appeared in the sequences were chosen for their simplicity and were not intended to relate to each other in content. They were digitized and then simplified so that they began acting as generic visual symbols. They were not images of things happening, they were images of things. These images ranged from a child's toy dog to the "Venus" of Willendorf, and were interspersed with text images such as the word "bird", "knowledge" and "black". In this context the text images had no specific meaning except what the viewer attached to them. The words were initially collected by paging through magazines and picking words that could have many associations to different people. A few words, such as "experience" and "idea" were included because they were strongly related to my concept.

Once these words and images were collected the problem of arranging them within four programs that would run consecutively had to be addressed. Part of this problem was purely organizational as I had almost one hundred images to choose from. Even though they were selected randomly, it was hard not to start relating the images to one another in various ways and putting them in some sort of order within the program. In order to maintain randomness I decided to write down the name of every image, put all of the names in a box and then draw the names, one at a time, from the box. The order that they were pulled from the box became the order that they appeared within the program. To add some variety in form, several slips of paper with the name of a color written on it were put into the box, along with some pieces of paper that had the word "repeat" and a number written on them. If "repeat 13" was pulled from the box to be image twenty-one in one of the programs, then the twenty-first image would be a repeat of the thirteenth image in that sequence. This was the method used to compose the four separate programs, each having twenty-six images with pauses of four to eight seconds between each image. Because of the varied length of the pauses, and the inclusion of some images that had additional programming, at no time during the same day would the same group of four images be on the monitor more than once. Therefore,

someone who viewed the the exhibition in the morning would get a different juxtaposition of images from someone who viewed it in the afternoon.

Another component which influenced the viewing was sound. Sound was created by recording pre-programmed synthesizer voices that had been sequenced into a loop structure. The result was somewhere between sound effects and rhythmic soundtrack. There were ten separate sound pieces that played over a period of forty-five minutes, ranging from bird sounds to hand-clapping percussion, to a distorted, slowed-down version of "Holy, Holy, Holy". The sound was produced separately from the images and was in no way timed to match specific ones. Interspersed within the synthetic sound were spoken words, the same words that at some point appeared on the monitors. How one perceived the exhibition could be heavily influenced by what was heard playing during the time they were viewing the installation.

<u>Intermediary</u> was the result of several branches of thought that I was concerned with, the first being models of communication. All of the models that I knew of were based on science, psychology, and semiotics. These were valid and valuable models but not conclusive or really appropriate when applied to visual, rather than verbal, communication. This is possibly because they are concerned with hypotheses that can be tested so that specific facts can be asserted due to this testing. I'm not sure that is entirely possible with visual language and, for my purposes, it's not necessary.

The simplest, standard communication model would be sender -- message (through a medium, an intermediary) -- receiver. Most acknowledge the natural condition referred to as noise which can occur at any point between the sender and receiver to potentially confuse, or in some way change the message that is received. More encompassing models include the environment surrounding each of the elements in the model, the effect of the medium itself on the message, the culture within which it is sent and received, and the previous experience of the receiver. All of these things influence the perception of the message and are valid when applied to visual communications.

These I call "linear" models although there are more "circular" models that include feedback from the receiver to the sender. The type of communication I was interested in was circular but not in that it required the receiver to get a response back to the sender. The viewer reacts to an image with his own internal image which influences how he perceives the next given image, which effects the direction the next internal image takes and so on. Thus occurs visual daydreaming.

The "message" I was concerned with was, of course, visual, not verbal, and it was not a definite message -- ambiguity, which could be considered noise in other models, was welcome here. The communication consisted of the series of simple images which flashed on the computer screen. In this environment the sender is not concerned with sending a specific message, but more so in giving the audience, the receiver, visual "stimuli" and eliciting private responses. This visual stimuli is provided in a highly simplified version of "real life"; there are constantly changing images displayed simultaneously, viewed through other images, while different, layered sounds are heard. The way the image is interpreted, and/or the private thought it provokes, is influenced by the nature of the image seen and how it is seen in relation to what is heard.

Unlike most communication models, the sender here wants to create a response in the viewer but does not want to control what that response will be. The "message" is ambiguous. In order to decode it the viewer relates it to previous experiences, previous assumptions about the images seen, the medium they were seen in, and the context of the viewing.

Coinciding with my concerns with communication models was my interest in visual language itself. Being visual, it is harder to document and therefore not as much has been written about it except for scientific and psychological theories such as how the eye travels across a page. My interests lie more in the purely visual. My idea was to let the viewer use his own visual language and, in doing so, to become more aware of its existence and begin to learn how to employ this visual language as purposefully as he uses his verbal language.

My belief that verbal language and visual language operate very differently was influenced by Susanne K. Langer in her book, Philosophy in a New Key.

> Visual forms -- lines, colors, proportions, etc. -- are just as capable of articulation, i.e. of complex combination, as words. But the laws that govern this sort of articulation are altogether different from the laws of syntax that govern language. The most radical difference is that visual forms are not discursive. They do not present their constituents successively, but simultaneously, so the relations determining a visual structure are grasped in one act of vision.*

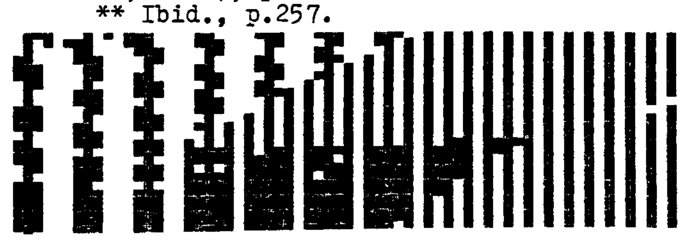
Also supporting this belief is, of course, my actual experience as a visual artist, especially working in electronic media with all the potential for the layering of media and meaning that it allows. Not only are are visual forms perceived simultaneously, but they may be conceived of and generated simultaneously as well. The process could not be described as linear.

Because of the differences in verbal and visual media (which isn't to say that they aren't compatible, they certainly are), it is important to realize which is appropriate to use in expressing, or sending, a message. Visual language exists because there are some things which are "verbally ineffable", as Langer points out: "... the import of artistic expression is broadly the same in all the arts as in music -- the verbally ineffable, yet not inexpressible law of vital experience, the pattern of effective and sentient being."**

A final and somewhat secondary concern was connected to the medium I was using. It was important that the computer be used effectively and appropriately. Much computer art that I have seen has more to say about computers than about art. In Intermediary it wasn't of the utmost importance that the images were on computers -- the technology wasn't the main attraction. Nevertheless, I feel that since the images were created on the computer it was important for the computer to be physically present in the environment. No other medium could do what I wanted better than a computer. It was a means of collecting, manipulating, organizing and showing the images. This, combined with the screen images and sound, I felt, was an appropriate means of reflecting the simultaneity and richness present in visual communication.

* 3rd ed.(Cambridge: Harvard University Press, 1956), p.93.

** Ibid., p.257.



SOUND AND IMAGE

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MR. WRIGHT: (WALTER!)
Sorry I didn't stop by last week (or call)
(I was bitten by a brown recluse spider & was sort-of "out of it")
Here's my schedule, I'll call (or you can call me 353-3401) for a weekly meeting time:

AUDIO AND VIDEO SYNTHESIZERS

One theory of composition for sound and image ? A number of people, especially in music, have explored non-traditional compositional systems. The one who comes to mind immediately is John Cage. He was able to apply his theories to both music and, just this past year, to a series of watercolors.

The hardware and software available for creating electronic music and for electronic imaging is similar. A number of people have thought about building a sound synthesizer in combination with an image synthesizer or, at least, an image synthesizer modelled after a sound synthesizer. Richard Monkhouse who designed the EML Synthi and Synthi A- the attache case music synthesizer from England, popular in the late '60s and early 70's and still used by Allen Ravenstine of Pere Ubu- also created a video synthesizer. Gary Hill constructed his own synthesizer which was capable of generating sound and processing images. He combined a number of modules designed by David Jones of the Experimental Television Center including colorizer modules and frame buffers, these were controlled by a Serge Modular Music System that Gary had purchased earlier. The Experimental Television Center's studio has equipment to create both sound and image. It's a large system containing a number of modules, the sound modules, image processing modules, and control voltage modules that can be shared by all the various systems.

A number of artists, both video artists and the electronic musicians, have merged sound and image, having a sound synthesizer control images or video control the sound- David Berman's cloud piece for example. It seems simple but a number of complications arise. There's really no easy way to do it. The video signal is not just image, a large part of the signal is devoted to timing information called sync, for synchronization. The sync information occurs at a regular interval just like sprocket holes in film. There is a sync pulse which seperates each frame, in fact each field. A new field occurs every 60th of a sec. If one listens to the video signal, one hears is a 60 cycle hum. There's also a sync pulse for each horizontal line on the TV screen. This pulse occurs every 15,750th of a sec, so it's a high pitched squeal. These waveforms are of the particularly nasty type, pulse waves, a sort of dentist drill sound, not nice smooth sine waves like those produced by a flute. In other words to transform the video signal directly into sound is not necessarily a pleasing thing to do. Similarly the other way around, to transform the sound signal into image often results in a color organ. A series of flashing lights responding to sound intensity in various frequency ranges which after a short period of time becomes tiresome.

Only a few artists have managed to successfully use sound to modify image and vice versa. Gary Hill with his system was able to share control voltage signals back and forth between sound generating modules and image processing modules. The Vasulkas have a number of experiments which indicate that it's possible to effectively move back and forth between sound and image. But, as the engineers like to say, "It's a non-trivial problem."

DIFFERENTION

Let's deal with composition in general. The commonality of equipment is a good indication that one theory of composition is possible. However, I think we need to look for something a little more abstract. In sound as well as in image we can begin the process of composition with a single step, differentiation, seperating this from that. There are a number of ways to do this.

We can seperate one thing from another. We can count similar things- the number of apples in a basket. This leads to the idea of repetition. Another way to differentiate is to seperate this from that, apples from oranges, two different things. Apples and oranges are of course both fruits but we can seperate things that differ even more- apples from bricks, something organic from something inorganic. This second type of differentiation leads to the identification of opposites, not only not alike but on two ends or poles of a continuum. In English it's easy to do this, we like to identify things in relation to each other- pairs of opposites or dyads such as organic vs inorganic, live vs dead, hot vs cold, rough vs smooth, loud vs soft, sharp vs dull. We can divide up space, left vs right, up vs down, front vs back- et voila 3-D space. Then there's fast vs slow- time- a third area for differentiation and quantification. But before we go on let's pause and look at this process in relation to our language.

We have definite names for the ends of the continuum- male vs female- and we think of these as opposites. This is not the only way to think about it, there are other languages which consider opposites as being two manifestations of the same thing, in this case humanness, male and female representing two aspects of a single thing. Hot and cold represent to different aspect of the same sensation. Fast and slow represent two aspects of the same thing, the flow of time.

The third type of differentiation which seems important to us is the idea of dividing up time- fast vs slow. Usually we measure in relation to ourselves, in my terms does it move fast (the hare) or slowly (the tortoise). We divide time into neat categories. The past is different from the present, the present is different from the future. Even though that's a leap of faith we are assured that it will be there. Through observation we note that the earth bears a certain relationship to the sun and that predictably the sun does rise every morning. We divide time into years, months, weeks, days, hours, minutes, and seconds. We wear watches, we maintain schedules, we make appointments and we'd better not be late. Time is money.

These examples cover several aspects of one process, differentiation, a basis for composition- breaking things down into parts, seperating them into opposites, counting things, and quantifying time. This is a first step in composition. Now here's a interesting twist of logic. Since we're into differentiation and opposites, what is the opposite of differentiation ? What is the opposite of seperating, breaking into parts, quantizing, analyzing ? The opposite is putting them back together, integration, looking at the whole instead of the parts, seeing relationships amongst things that might at first appear to be unrelated or dissimilar. Seeing the characteristics that might link them together, relate them as parts of a whole. We should keep this in mind because this is sometimes considered to be a final step in composition. The first step being differentiation, the last step the integration.

Let's look at what this means in terms of image making and music composition. We are all familiar with a number of opposites or dyads used in creating a visual image- light vs dark. black vs white, b&w vs color, hot vs cold, contrasting colors like red and green or red and cyan, left vs right, up vs down, close vs far, foreground vs background, focussed vs defocussed, active vs passive, horizontal vs vertical, angular vs rounded, regular vs irregular, pattern vs texture, random vs organized, bold vs finely detailed, large vs small, repetition vs singularity, and so on. These characteristics can all be related to visual design and the image. When we deal with moving images we run into even more- movement of an object such as left, right, up, down, forward, or backward. We can also concern ourselves with camera movement and characteristics of the lens- movement left, right, up, down, pan, tilt, tracking, closeup vs wide angle, zooming in or out. We can identify not only a direction of movement but the speed of the movement, the velocity. In film and video these characteristics relate to both space and time. Film and video come already quantified, broken into frames or fields. If we stick with frames video runs at 30 fps and film at 18 fps silent or 24 fps sound. The filmmaker and video artist deal with another group of compositional considerations- the shot and the rhythmic structures that can be produced by varying the length of the shot, by plotting the vectors of movement, by watching where the focal point moves shot to shot, edit to edit. Working with contrasting movement- left, right, left for example- one can produce a simple ABA rhythm. One can insert static shots to make this rhythm stand out. Rhythm are created in the editing process. There are a number of other variables used in structuring film and video, often called the cinematic codes, but...

In the interests of moving along let's jump to music and look for some of these things. In the case of visual design I identitified a number of opposites, pairs of properties that the image might have. We also find this in music, we find the tone colors of different instruments opposed to each other. We find a differentiation between percussive instruments and those with a sustained voice. Percussive instruments produce a single crack or explosion of sound whereas sustained instruments like a flute or violin are more like the human voice, capable of sustaining a tone. We can also quantize pitch into scales of various types. Instruments of the sustaining type can play notes, they can be designed and built to play a series of notes that fall on the scale. This series of notes played over time becomes the melody. We can compare melody to the kinds of things the percussion instruments do. They play out the rhythmic structure of the piece. They break the piece up in time, like the edit points in film. They set the rhythm. Again we have pairs of opposites such as rhythm vs melody, percussive vs sustained. I mentioned the acoustic "color" of an instrument. Quite often in a composition instruments of different colors are opposed to each other. An instrument like the flute which has a rounded mellow tone, might be juxtaposed with a harsher, brassier instrument like a trumpet. If you don't like a flute you can try something like a vibraphone which has a sustained note, well rounded, that might set off an instrument like a clarinet that has a harsher, reedier sound. We can consider pitch similar to the grey tones in an image. We can have dark or low instruments as opposed to higher, shriller instruments playing in the upper registers. The human voice seems to work in those upper octaves so that we often associate instruments like the flute or violin with the human voice. They are often accompanied by something in the lower registers like a bass violin, or a double bass violin. We juxtapose high register instruments with lower pitched instruments.

These ideas are also characteristic of still images and moving images, rhythm and proportion dividing up the surface or dividing up time. Music works in a similar way. We can position sound in 3-D space as in an orchestra, one type of instrument to one side of the orchestra and another type to the other side. Setting them in opposition. Putting an instrument on the left channel of a stereo "image" and something else on the right. We can establish a left to right relationship in recorded music, we can even set up a front to back relationship, placing a sound farther away from the listener by adding reverb, giving it "space", or moving it close by making it dry and distinct. We can create the illusion of 3-D space in sound and in film and video.

The simplest rhythmic structure, ABA, is used in visual design and music. In fact a number of compositional structures used in printed works and in moving images can be found in music- ABBA, ABA ACA ABA, verse chorus verse chorus break verse chorus. We see this tripartite structure in film and video- the rule of thirds, conflict crisis resolution. There already exist a number of parallel structures in the present compositional systems used in graphic design, film, video, and music. These flow from that initial idea of differentiation, seperation, juxtaposition of opposites, of playing one property against another which is most unlike it. We often see this at the center of interest in a 2-D image, at the height of tension or climax of a film, and at the point of climax in music. We have the point of most contrast where opposites are brought together. In film it's crisis, conflict, and resolution- we identify two opposing forces, put them in conflict, and then we neatly wrap up the plot. In music it's common to state a theme, then a counter-theme, put these in opposition (perhaps in different parts of the orchestra) and then in the final movement resolve theme and counter-theme. In printed material, at the point of most interest, we also find the most contrast- in a photograph this would be the area of the blackest blacks and whitest whites. These blacks and whites will balance and therefore the conflict, as it were, is resolved in the photograph as a whole.

So the overall structure is similar in all these media. There are similarities amongst compositional techniques in music and the visual arts, these must stem from culture and, I would guess, from basic human psychology. I think it's possible to identify structures that can be used back and forth between various media. John Cage introduced methods of composition using mathematical techniques based on indeterminancy or random numbers. In order to speed up the process he used a computer. However music tends to be very formal in its methods of composition but this is not quite as common in film and video, and maybe not so common in the visual arts. On the other hand, music has never been saddled with the problem of recreating audio pictures, that is representation (although some composers created sound pictures and Charles Ives used "real" sounds). Nonetheless, composition in music tends to be a formal process which deals with sound in an abstract way. This approach is perhaps less common in visual media with the exception of some of the newer experimental filmmakers and some of the work in video art. These works deal with the abstract qualities of the medium, don't rely on representation, and don't rely on narrative or story. Music, classical music in particular, doesn't tell a story, doesn't necessarily have a plot. It's music based on the abstract qualities of sound itself. Only a small number of filmmakers and video artists have pursued this direction in their respective media. But I think it's quite useful- in the area of commercial film and the area of television we have one compositional structure- crisis, conflict, resolution. The standard narrative, there are other possibilities that could be explored. For instance, one could

Sex fatigue
Fabulous night sketches
Certainly, the wrong dress surprises.

Miserable relationship recalls
Midday victim
Slinky time lives.

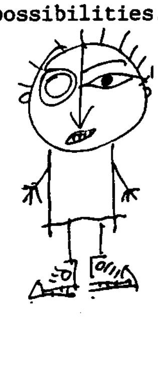
Kitten heart
Learning achieving
Willing and second-rate.

If love languishes, laugh back.

Vocabulary randomly selected from "Sex In The Office", Cosmopolitan, Nov '84 apply John Cage's techniques to the process of editing images together. One might even take a simpler approach. Hollis Frampton began with the alphabet, he found corresponding images for each of the letters and edited them together A through Z. This is a perfectly legitimate structure, it's an abstract structure of a formal nature. It's not narrative, it's not telling a story, there's no plot but it's a recognizable structure. Stan Brakhage calls this lyric filmmaking and although his film sometimes alludes to a story, a classical myth for example, he employs abstract structure in the sense that the intercutting and mixing up of the images often seems more related to music than it does to process of telling a story. In other words there's no dialogue, no storyline as such. There's often quite a flurry of images of all types, just like all the instruments in the orchestra playing at once. We can sense a number of different themes perhaps, in the same way that we hear themes or melodic lines in music. We sense these themes and watch them being woven together over time. Sometimes we identify opposing themes, variations on the themes, and resolution or suspension of the themes. There's a formalist tradition in filmmking. Eisenstein had quite a bit to say about the relationship between composition in music and putting together a film. In fact he proposed the idea of several themes, even themes at odds with each other, that would be first presented seperately then played against one another and finally resolved. This is very similar to a large scale musical composition.

For me the most interesting direction is to pursue the ideas of John Cage- to try and break out of the traditional structures and musical theories- to find new methods of composition that can encompass both sound and image. I think the places to look would be to mathematics and to psychology.

What are the characteristics of our senses and related mental processes ? What is this process of composition, structuring, ordering ? I mentioned differentiation, dividing things into groups, seperating things. I should now mention another process which has to do with perception. We see patterns in events- in phenomena of all kinds. Of course there is pattern in the real world. It's a given that the sun rises every morning. There's a certain regularity about things when looked at from our perspective. Things repeat over and over. In fact we observe quite pleasant results from the overlaying of several regular patterns. The rising and setting of the sun as played out against the phases of the moon, the solar vs the lunar calendar, yields a whole series of exciting relationships and possibilities.



Auto-dail adapters support
Complex outside integration
Her adapters scream, "convenient access"
Feel the link.

They interfaced and downloaded
Night family, day operation.

Telephone family, download & receive.

Vocabulary from an article on modems in A+, March '84

PATTERN

There are any number of recognizable patterns in the world. Human beings have a propensity for recognizing patterns and for trying to impose patterns on things in order to better understand them. It's characteristic of our mental processes that in order to make sense of something we relate it to something else. One of the simplest pattern is one of regular repetition ABABAB. We might think of it as in breathing in and out, the beat of one's heart, expansion and contraction, pumping blood through the body, a regular beat. Or on a larger scale the rotation of the earth around the sun, coupled with the fact that the earth rotates on a tilted axis producing the seasons, day and night, light and dark. A simple beat, this is the first pattern. One can elaborate on this basic pattern, the heart is an organ with a number of chambers working together. In order to pump blood in a particular direction we have a contraction in the first chamber an expansion in the second chamber, then the second chamber contracts followed by the first chamber opening up to receive more blood. Valves in the chambers that move the blood in a particular direction. We have ABAB going along with BABA. In the case of the earth and the sun, we have the rotation of the earth producing a sequence day to night and we have the movement of the earth around the sun which due the earth's tilted axis varies the relationship between the period of dark to light. It produces the seasons, the equinoxes, the solstices, the Tropics of Capricorn and Cancer which represent the furthest points north and south that the sun appears to travel. In music we recognize that simple beat in popular or commercial music, the pulse, hip hop, dance hall. One maintains the beat in primal ritual and dance. We feel the beat, just like the heart (disco runs at an excited 140 bpm). When we get into more complex forms of music, the beat is not necessarily overt or explicit, it may be implied. In fact the rhythm may be played around the beat. There's a regular beat in music, a time signature, which identifies the accent or where the beat falls in the measure. We see this pattern of repetition again in visual art- perhaps Escher springs to mind- the peculiar types of repetition in his work in which elements interlock with one another in the sense of the two parts becoming reintegrated. Black forms and white forms completely dependent on each other, yet existing in a relation of interdependance, seperate yet linked ABABAB across the 2-D surface. Sometimes there are three or four seperate figures interlocked, ABCDABCD. It's not just linear in time, but they happen in 2-D on a surface so that they can be scanned in a number of directions. Some of his drawings imply these things happening in 3-D space.

We can fill space with regular forms. In the simplest case, a solid and a void, one could consider this in making sculpture and in graphic design, any visual art. Inside and outside, moving from one room to another, all these are examples of simple patterns based on repetition. Moving through a series of room, moving from an open space through a door into another open space. Versailles and other castles were built in that way, where one moved from room to room, there weren't hallways just interconnecting rooms. Doorway room doorway room, through the whole building. As one moved along the fenestration might change, certainly the interior furnishings varied. So one got variation within repetition. This is something we talk about in music, a regular repetition and overtop variation. Or we have, as in the case of the rotation of the earth on it's axis and it's path around the sun, two repeating cycles working one against the other. If we add the moon to this we have cycles of different lengths that move in and out of phase. If we look at music again we can consider the structure of pitches and we can consider the way in which holes are bored in the shaft of a flute, strings are stopped on a stringed instrument, we can see that related vibrations are set up. When we talk about harmonics and pitch, something is vibrating in relation to another thing. One string or air column may be vibrating twice as fast as another, an octave apart. One may be twice as long as another.

That's the basic AB pattern, the pattern of regular repetition with variations. There are other kinds of pattern, that aren't necessarily as mechanical. But before we go on to those let's finish up the regular patterns. The division of 2-D space- I mentioned Escher- one can divide 2-D space with a grid. A grid is important in graphic design where one can repeat a grid- horizontal and vertical lines with a series of intervals between that maybe similar or varying, ABA or ABCBA- page after page. The grid becomes the basis for a rhythmic structure, overtop of the grid we place type and images. We use these elements to play with the grid or against the grid, variation within repetition. The grid is not always

Listless software heart
Bitter link fish, bed flesh
Differentiate & consume.

Dreaming lover, odd program
Satisfying desire, fast victim
Dream & delete.

Signing odd fire
The utility moves
Under the high candle.

Crave loose ambition ?
Bed the stiff artist
Sweaty thought suggests a loose mind.

The wrong password negates
The fish creature
Stimulated engines manufacture
Rotten money.

Languishing fun
Money drains endlessly
Rolled-up success.

Combined vocabulary, Cosmopolitan & A+

explicit, it's often implied. We may have the equivalent in graphic design of counterpoint, an off beat. This adds excitment and activity. In film we can have this same sort of thing and in television we have the "technical event". If we watch commercials closely we can see there's a visual beat set up in which shots change on a regular, predictable interval. In other words we have a cut to a new camera angle, a new shot every few seconds. It's exciting and involving. It's predictable but within that predictability we can build in variation. So we have repetition, a regular visual beat, with variation worked in overtop.

Now we go on to patterns that grow. A tree grows from a trunk which divides into large branches, which divide into smaller branches, these divide into twigs, leaves breakdown into spines and, finally, a membrane. We see a pattern which is the tree as a whole, branching to form branches and twigs. We see this pattern repeated in the spines of the leaf. If we were to yank the tree out of the ground we'd see a similar branching pattern in the root system. This is a natural pattern of growth. We see this pattern in our bodies, the nervous system, the cirulatory system. It divides down into finer and finer parts. Organic patterns have a number of characteristics which show up in music and in visual images. Quite often a larger pattern is repeated inside itself at a smaller scale. In music the larger structure of a composition is reflected internally within a movement, the large structure might be divided into 3 movements and within each movement we might find 3 subdivisions. We can see this in images where the surface is divided into units and each unit is subdivided in a similar manner.

Another thing we might notice, maybe not about a tree, but certainly about leaves is that they tend to be symmetrical- bilaterally symmetrical. They tend to divide up the middle, the left side being the mirror image of the right. We're also built that way. This is another form of repetition, AA'. In music we see this as a melodic theme that appears inverted- the whole thing played upside down or we might hear it backwards. Bach is prime example for this sort of thing- one voice might play a series of notes in the forward direction while against it a second voice plays the same series of notes in the reverse direction, back to front, a reflection, interlocked. This produces a complex result from a simple pattern or structure. And if we want to pursue symmetry, we find rotational symmetry as in a flower, the elements repeated in rotation. Another pattern we see in growth, beside dividing down into smaller and smaller elements, is a spiral type of growth, the head of a sunflower, seashells. Accumulated growth where things build up in a rotational form, the chambers of a shell move around themselves spiralling outwards, larger and larger. One characteristic of these patterns of growth- Corbusier's Modulor or Leonardo's drawing of the figure- is a specific ratio that shows up over and over, the golden mean. We find as well simple arithmetic progressions, geometric progressions, and various proportions that relate to growth. We find interesting mathematical oddities like the Fibonacci series which can be used to describe the growth of a natural spiral- this series approaches the golden mean. It is being used by a number of contemporary musicians to tune their instruments, Glenn Branca and Elliott Sharp to name two. These patterns exist in nature. Through observation we can identify and group these patterns together. I haven't discussed snowflakes, crystals and the patterns that they form. I haven't discussed some of the more interesting patterns that occur on the surface of things- that appear different from the standard definition of patterns because they lack a mechanical regularity. I'm thinking of tree bark and patterns on the surfaces of shells that seem to be highly indeterminate yet are still satisfying as patterns. We could study not only trees but all sorts of flowers which exhibit various symmetries, and combinations of these basic patterns. We can look at natural processes like erosion, turbulance in a river, and so on...

Two aspects of pattern are important in composition. First, there exist a number of patterns out there in the world and, second, one of our favourite things to do is to impose patterns on phenomena, to see them as a system of relationships. The simplest patterns result from our propensity, perhaps inspired by language, to see things as opposites- on vs off, black and white, this or that. That's on the simplest of levels. Let's think of some more complicated examples. One of the things I've observed as a video artist is that one can take an abstract video or film and couple it with almost any sound track. Randomly, I can select one of my electronic music tapes and play it along with the film or dub it onto the videotape. As long as I don't mention the fact that I chose the sound track randomly, in most cases, the audience thinks that the sound track belongs with the images. They sense correspondences, "You made that sound to go with the film, right ?" Certain things seem to work, the viewer senses that the sound and images work together. The mind imposes an organization, takes the structure from the sound track and is actively looking for correspondences in the video, seeing these as being intentional, as having meaning. This is one aspect of our propensity for imposing order on events. It's one way in which we imply intent and therefore a way in which we derive meaning- this relates to that.

I was raised with pets. I saw a cat as a system, a quadraped with fur, with the same sort of eyes, nose, and ears as me. A particular body type, a particular cat personality. This pattern was a cat. One day my grandparents took me to the big city zoo. I entered a large building and the first thing I saw was a mountain lion- did I see a mountain lion or did I see a large cat? The answer is obvious, I saw a big cat. As a child I know the pattern cat, I see the moutain lion as organized in a similar manner only larger. So I don't see it as a mountain lion, I see it as a large cat. Often we identify new things in relation to the patterns we know. If the pattern matches closely we consider it to be another one of those with some modification such as size.

How do we use pattern in composition. Patterns can be built up in a form a little more complicated than ABAB patterns such as ABA, ABA', ABCD. I mentioned that patterns can occur inside patterns ABA A'B'A' ABA. In that sort of pattern we've built up regularity, a certain expectation, the beat goes on. When we hear an unexpected accent or an off beat we pick that up immediately. It creates a certain amount of tension and at the same time a certain amount of pleasure. It's a variation on the basic rhythm. The purpose of the repetition is to build up that expectation- after a series of ABA ABA ABAs, a change to CDE grabs our attention. It focuses us on that moment in the composition. In relation to the pattern that was built up we tend to attach some importance to the variation, it stands out. We look to that event for meaning. So we can use it for purposes of emphasis, we can give things meaning. We can produce a sense of excitment and involvement by introducing these variations into the regularity or ground of a given pattern. Certainly we can find a number of examples in music, in graphics design, and even in film. Alfred Hitchcock was a master at building up the audience's expectations, at the very moment one expected one thing to happen he substituted something else. He altered the meaning, focused attention on that instant, the plot took a turn, for better or worse.

We've been dealing with abstract composition but if we think about language we can see that making something grammatical automatically implies that it makes sense. We can see this in poetry. I could create an example on the computer in which I mix adjectives, nouns, verbs, etc, provide a simple syntax and then randomly shuffle the words into their correct grammatical positions. We get what appears to be a meaningful sort of sentence. "My enraptured firearm functions exactly on theory/ With information & illusion/ With ammunition & the machine/ Animal matrix growth", in reading this poem we want to make sense of it. We recognize a pattern which indicates intent, we want to understand. We attach a meaning to it. This is a useful phenomenon especially in film. Eisenstein talked about the idea of putting things together, juxtaposing them in an organized way, and if these things were presented in a syntactically and grammatically correct way, one thing following on the other, then the audience will see a relationship between the parts. They will give meaning to the whole. Therefore the filmmaker can present ideas in an indirect sort of way, metaphorically. He or she can talk about things that are not easy to talk about directly. We can see the same thing in graphic design- in the sense that having established a grid, a regular pattern, in which blocks of type and images appear, any break with the pattern takes on meaning, if one turns the page and finds something unexpected that focuses attention on that page. We attach a greater significance to unexpected, resulting in a greater potential for meaning. It demands our attention.

I've discussed traditional ways of using pattern, structuring images and sound. So let's look at John Cage and indeterminancy. His methods of composition also play with the audience's desire to organize things. When things comes to us in a random manner we want to organize them, this can produce new and unexpected meanings. The composer is not predetermining the details of the piece and therefore its meaning. The elements are gathered together to produce an organization which is a natural organization- casting the I Ching according to modern physics is not an unnatural idea. This method allows the mind to get to work doing its job, organizing events. Things aren't always predictable. There is no way to predict the position of every blade of grass in a lawn. Even if we were to plant the seeds in a very regular way, the action of the rain and wind would effect their pattern of growth. The result would be unpredictable. Nor can we predict the exact way in which a tree will grow, what it will look like in a few years. Lightning may knock off a half the tree. This is the kind of situation that John Cage addressed. Eventually we'll have to incorporate fractals. Fractals indicate that in nature the number of regular and determinate patterns is very small indeed. They make pretty good models for some things but in no way do they actually model nature. John Cage's approach is much closer to the natural world than the traditional approaches to composition. If we were to extend Cage's approach, probably coupling it with the mathematics of Benoit Mandelbrot and Stephen Wolfram, we would have a more natural system on which people could exercise their propensity to derive meaning.

My nonverbal environment tends naturally to trash.
How do I study the paradox ?
How do I itch the virus ?
How do I process the matrix ?
With brain surgery & light,
With somnambulism & pharmacology.
My enraptured firearm functions exactly on theory,
My new brain functions completely by TV,
With information & illusion,
With ammunition & the machine,
Animal matrix growth.

I uses the personal bit extension,
I accelerates a small illusion icon,
Turning & discovering,
The previously classical scapegoat baseball,
Using & abusing,
Toxic anonymous consequences.

I shape the radical social disease computer,
Attitude amplify & relation speak,
Shock ask & form break,
Wisdom eliminate & nothing see.

Vocabulary from the first few pages of McLuhan's "Understanding Media"