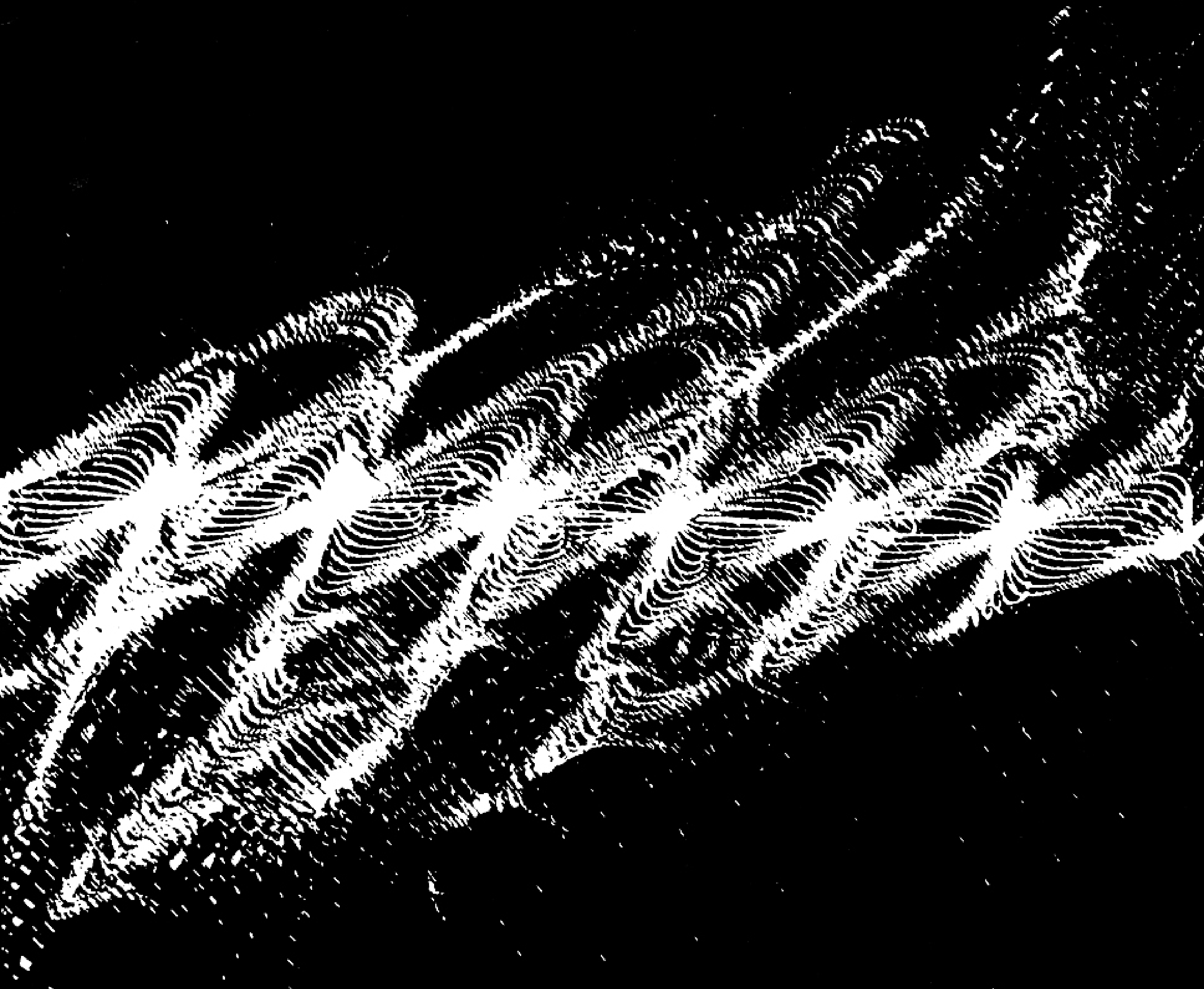
COMPUTER GRAPHICS AND ART



AUGUST, 1978

VOL. 3, NO. 3

MATERIALS SUBMITTED FOR PUBLICATION SHOULD BE IN ENGLISH. MANUSCRIPTS SHOULD BE TYPED DOUBLE-SPACED, WITH TWO COPIES OF THE MANUSCRIPT SENT TO:

Editor, COMPUTER GRAPHICS AND ART
Berkeley Enterprises, Inc., Chico Branch
555 Vallombrosa - #35
Chico, California 95926
PHONE: (916)343-2712

NOTE: Illustrations are REQUIRED with all manuscripts, 100% size preferred. Charts, sample programs are desired with work.

SUBSCRIPTION INFORMATION, ADVERTISING RATES, BILLING INFORMATION -- BUSINESS CORRESPONDENCE SHOULD BE ADDRESSED TO:

Business Office
COMPUTER GRAPHICS AND ART
Berkeley Enterprises, Inc.
815 Washington Street
Newtonville, Mass. 02160
PHONE: (617)332-5453

COMPUTER GRAPHICS AND ART is published quarterly, 4 issues per year. Printed in the U.S.A.

ANNUAL SUBSCRIPTION RATES

Personal, U.S. & Canada, $10 per year
Personal Foreign, $13 per year
Library, Departmental, $15 per year
Special Rates, $8 per year, U.S. & Canada
Special Foreign Rates, $11 per year

SPECIAL RATES apply to students and to members of computer graphics societies and art societies. Please attach membership number or evidence of same for these special rates. (See CG&A Ad for details of 2 year rates.)

PHOTOGRAPHY, LAYOUT DESIGN, Grace C. Hertlein

THE MAGAZINE OF INTERDISCIPLINARY COMPUTER GRAPHICS FOR PROFESSIONAL GRAPHICS PEOPLE AND COMPUTER ARTISTS

NOTE: Due to economic conditions, the November issue of CG&A may be delayed in printing.

EDITORIAL

GRAPHICS STANDARDS AND PRACTICES

The SIGGRAPH Graphics-Applications Subgroup will meet in Anaheim, California on July 19-20. At this work meeting, additional recommendations for graphics standards will be formulated, in preparation for presentation at the August SIGGRAPH Conference.

A National Graphics Network is being formed, under the leadership of Richard Schulman, Commander, U. S. Navy. Teams of graphics professionals will work together on the following project subcommittees at the Anaheim meeting:

1. *National Graphics Network;*
2. *Classification and Characteristics Projects;*
3. *Graphics Standards Team;*
4. *Standards Glossary Project;*
5. *Technology Impact on Standards Team;*
6. *Raster Graphics Project.*

Due to a prior commitment for the ACM/NSF Computers and Society/Computer Literacy Workshop, I will not attend this work session, but will participate in the project at a later date. From the meeting, we hope to have summaries of important decisions regarding graphics standards and practices in the November issue of CG&A.

In preparing materials to be sent to the meeting, I reviewed again the in-depth "Status Report of the Graphics Standards Planning Committee", published by ACM/SIGGRAPH last year. /1/ The report is superbly organized, is highly readable, and it reflects a great deal of excellent teamwork by participants of GSPC. Anyone interested in graphics standards and practices should get involved with this fine group. Their reports are also excellent materials for graphics software classes to study in depth.

WHY GRAPHICS STANDARDS?

As any discipline (or art) matures sufficiently, there is a need to assess techniques, approaches, and materials, to find the core of principles that are being utilized in the given art. In some areas (fine art for example), there has been a tendency for many practitioners to seek "pure" freedom -- to disregard principles and standards. However, even in such a free field as art, critics and scholars seek to analyze, synthesize and specifically state what is being accomplished by practitioners.

This is deliberately mentioned, because computer science is often considered to be an art/science. Many persons think of it as an applied science. Some individuals prefer to define it as a pure science. It is all three.

If computer graphics is to advance beyond present levels, it is mandatory that standards and practices are formulated, disseminated, and practiced.

The need for standards is precisely stated by the GSPC in a beautiful, brief paragraph:

"Workers in a given field seek a standard when they recognize the field to be maturing and that separate and duplicate efforts are expended to arrive at common goals. The field of computer graphics has now matured to that point." /2/

This concise, excellent statement says volumes! However, computer programmers too often consider programming to be a personal "art", and because of this, reject the need for graphics standards. But the trend is obvious -- and establishment of accepted (practiced) standards is inevitable.

FOUR METHODOLOGICAL THEMES

In the GSPC review, four important methodological themes are discussed in depth:

1. Portability of programs (and programmers) is the most significant purpose of a standard.
2. Those issues which affect portability are those which affect application program structure, and therefore deserve the most attention.
3. Methodology of both design and use of a standard per se is as important as its semantics (functional capability). Syntax and special calling sequences are much less important.
4. The functions of constructing and manipulating an object, and of producing a picture of the object, should be cleanly separated.../3/

Because of space, I will just briefly comment on a few items here. Anyone working in graphics over a period of time readily accepts the idea of portability. The GSPC group does not consider absolute portability to be realistic at this time (or in the near future), and would accept a small amount of routine alteration to the source program. /4/ I would regard the search for "absolute portability" as a source of ideal graphics principles and would hope that this could be achieved in the near future. I am perhaps a purist.

Two significant recommendations are for:

1. *Device-independent graphics systems;*
2. *Machine-independent graphics systems. /5/*

Noteworthy is the idea of "programmer portability", the need and ability for a programmer to be able to move from one installation to another without the need for extensive retraining. Let us hope that the manufacturers heed these excellent graphics standards and recommendations!

SUMMARY

In the next issue, we will publish a "wish-list" of standards, practices, and suggestions for computer graphics. SIGGRAPH is to be complemented on having a core group of cooperative professionals who are willing to work together to form needed standards and practices. For it is obvious that computer graphics has matured beyond its initial period of "free" experimentation, to have allowed the development of a body of knowledge and sensible practices to form adequate professional graphics standards.

Editor, CG&A

/1/ ACM/SIGGRAPH, "Status Report of the Graphic Standards Planning Committee of ACM/SIGGRAPH, ACM, Vol. 11, No. 3, Fall, 1977, 117 pages.
/2/ Ibid., p. i.
/3/ Ibid., p. ii.
/4/ Ibid., p. II-2.
/5/ Ibid., p. II-2.

COMPUTER ART SYSTEM: ART-3

by Mutsuko K. Sasaki and Tateaki Sasaki
Institute of Physical and Chemical Research
Wako-shi, Saitama 351, JAPAN

ABSTRACT

Hand-drawn figures are very useful for computer art, just as they are for conventional pictorial art. This article describes a picture-generating computer art system, ART-3. The main purpose of this system is to process hand-drawn figures. Art-3 is written in FORTRAN IV, and it can generate functional patterns as well. Two pictures generated by ART-3 are shown.

1. INTRODUCTION

The first process in making a picture by the conventional way is to sketch figures -- that is, to draw figures by hand. In this sense, hand-drawn figures are the principal components of most of the conventional art pictures, regardless of whether they are realistic or abstract. It is evident that hand-drawn figures are also very useful for computer art.

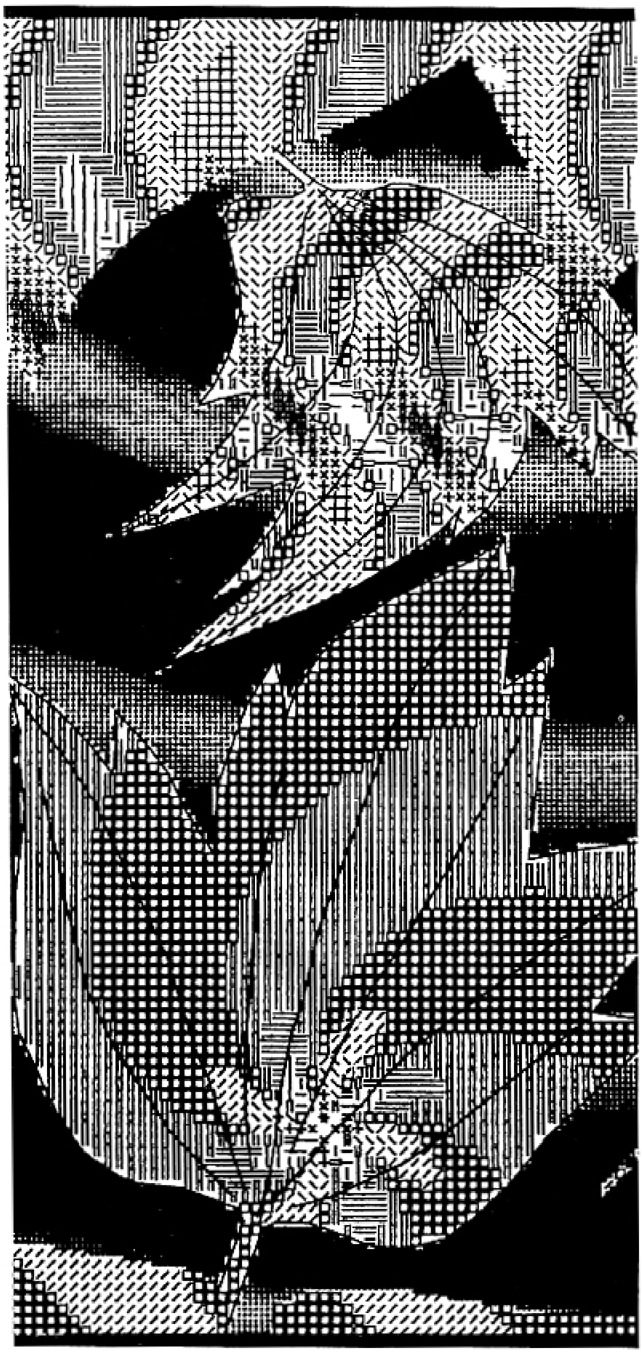
The majority of pictures generated by using computers so far are, however, composed of simple moire patterns or systematic patterns. The reason is clear: such patterns are easy to generate even for artists having poor backgrounds in programming, while processing of hand-drawn figures requires rather complicated programming techniques. Nevertheless, several computer artists have utilized hand-drawn figures and generated pictures transcending the conventional "wire cage" like pictures. Among others, Duane Palyka /1/ generated very elaborate and truly artistic pictures.

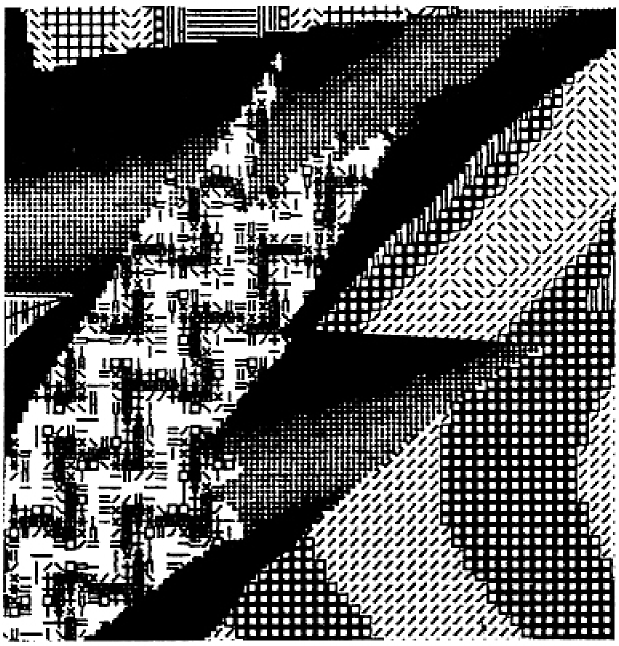
Some of the existing computer art systems can handle hand-drawn figures. The famous MINI-EXPLOR /2/ is one of such systems. MINI-EXPLOR is, however, a language-driven system, and it is not convenient for handling irregular figures. In order to handle hand-drawn figures, it is necessary to have facilities for hidden surface elimination, surface-painting, and so on.

We have constructed a picture-generating computer art system named ART-3 and have used it to generate art pictures for the past two years. /3/ ART-3 is equipped with elementary facilities for processing hand-drawn figures, and it can operate functional patterns as well. ART-3 is written in FORTRAN IV, and it assumes a plotter as an output device.

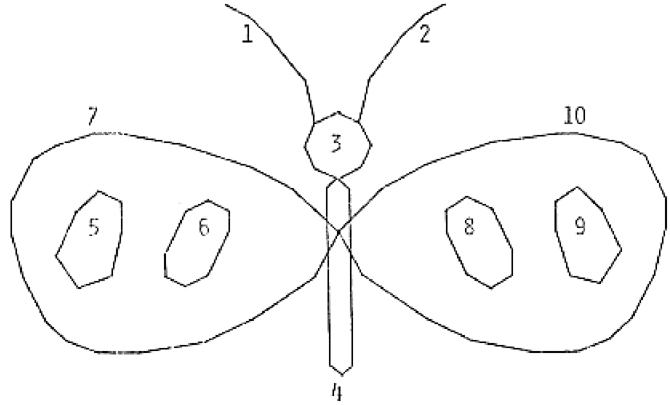
We describe in this article, most of the facilities of ART-3, which should be useful for the readers who are planning to construct such systems. We do not describe the algorithms employed in ART-3, because they are quite familiar to people in computer graphics.

BELOW: "Fire Maple I" by Mutsuko Sasaki, detail or portion of the cover from August, 1977 issue of "Computer Graphics & Art".





ABOVE: Another portion of the August, 1977 CG&A cover by Mutsuko Sasaki, revealing the unique textures painted by the ART-3 system.



ABOVE: Figure 1 - An example of the figure acceptable by ART-3. This figure was drawn by connecting lattice points, and it is composed of ten figure parts labeled by integers.

2. FIGURES AND THEIR REPRESENTATION IN ART-3

ART-3 accepts only linear and planar figures, and not cubic figures. That is, only two-dimensional representations of the figure are available. Three-dimensional representations of the figure are too tiresome and troublesome for the user to prepare, and in our case, they are never advantageous over two-dimensional representations, because the canvas is two-dimensional.

In ART-3, any acceptable figure must be drawn by connecting lattice points of a one hundred by one hundred square lattice. Every lattice point must be represented by a two-dimensional vector -- each component is one of the positive integers from 0 to 99. However, the null vector (0,0) is not allowed to be used, because it is interpreted as the end of the figure data (cf. subsection 3.2). Figure 1 shows an acceptable figure.

An acceptable figure is, in general, composed of a set of figure parts. Each figure part is a sequence of line segments joined with each other, one by one. Thus a planar figure part is nothing but a polygon. We assume that the polygon representing the figure part is simple; i.e., each line segment of the polygon does not intersect with any line segment of the polygon, except that it is connected with two neighboring line segments. This assumption imposes no restriction on us, because any planar polygon can be divided into a set of simple polygons. For example, the figure shown by Figure 1 is divided into ten figure parts.

Each figure part is therefore represented by a sequence of non-null two-dimensional vectors pointing the nodes of the figure part, and each figure is represented by a set of such sequences. A complete figure representation must include further information because there are different types of figure parts.

ART-3 accepts the following four types of figure parts:

Type 1 - Linear figures;

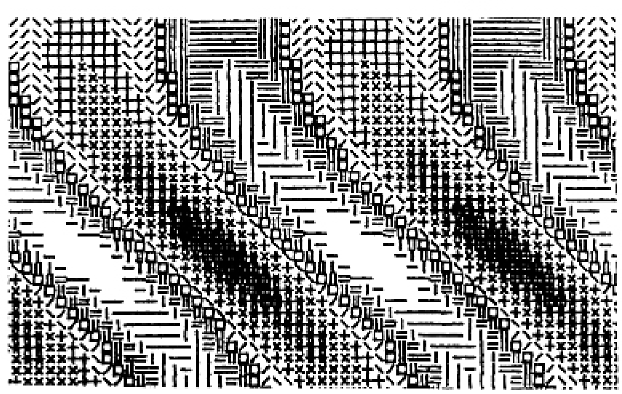
Type 2 - Contours of opaque objects with holes excluded;

Type 3 - Contours of holes in objects;

Type 4 - Contours of transparent objects with holes excluded.

For example, in Figure 1, figure parts of 1 and 2 and of Type 1; figure parts 3, 4, 7, and 10 are of Type 2, and figure parts 5, 6, 8, and 9 are of Type 3. The figure part of Type 4 is used to superpose different textures, as we shall explain later.

In order to indicate the type of each figure part, we add an extra two-dimensional vector at the head of the sequence of vectors representing the figure part. The first component of this extra vector has either the integer -1 or -2 or -3 or -4, depending on whether the figure part is of Type 1 or 2, or 3 or 4, respectively. The second component is a positive integer less than 100, and it can be used as a label of the figure part. For example, the representations of figure parts 1, 2, and 3 in Figure 1 are shown in Figure 2.

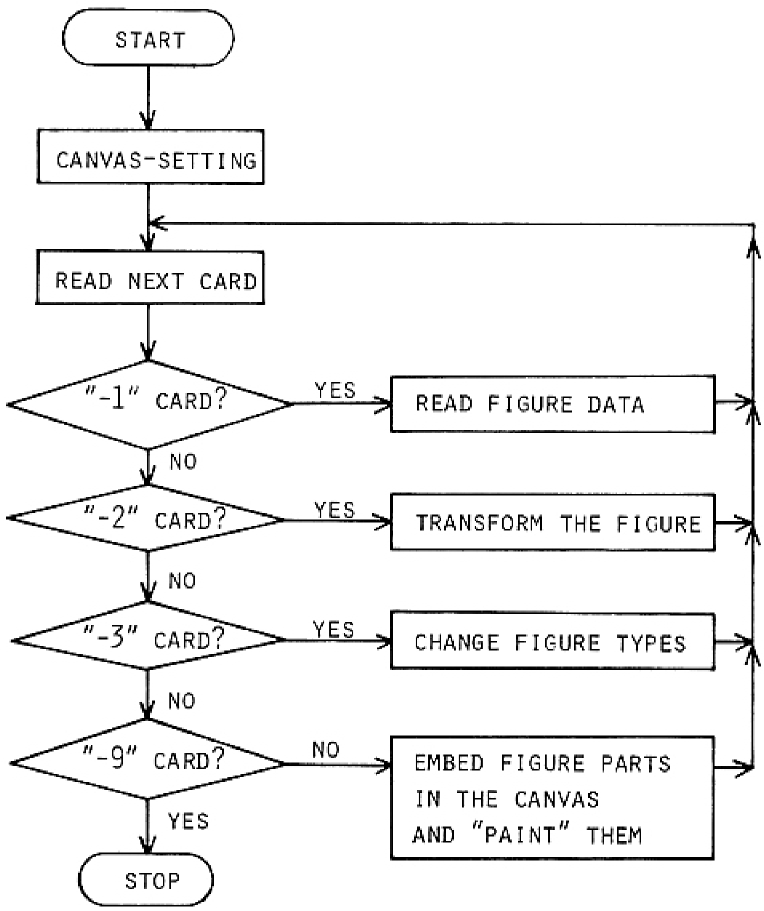


((-1, 1),(40,71),(42,70),(44,68),(47,64),(48,60))

((-1, 2),(60,71),(58,70),(56,68),(53,64),(52,60))

((-2, 3),(50,61),(48,60),(47,58),(48,56),(50,55),
(52,56),(53,58),(52,60),(50,61))

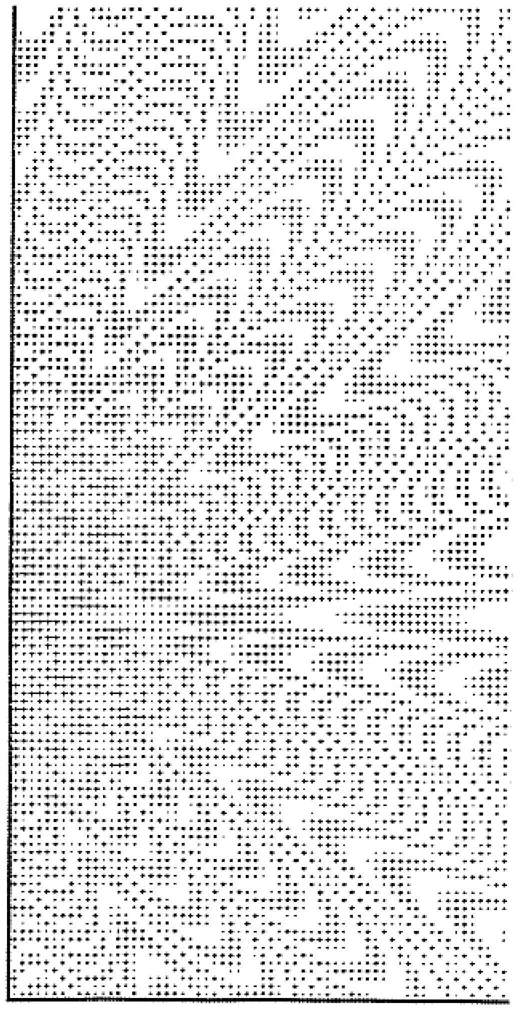
ABOVE: *Figure 2* *- Schematical representation of the figure parts 1, 2, and 3 shown in Figure 1. The first vector in each sequence represents the type and the label of the corresponding figure part. Other vectors represent the nodes of the figure parts.*



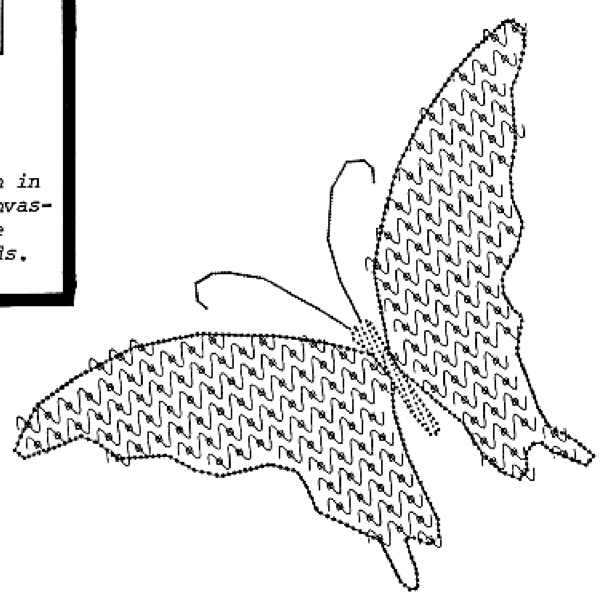
ABOVE: *Figure 3* *- The flow diagram of picture generation in ART-3. In the present version of ART-3, all data but canvas-setting parameters are input by cards. By "-I" cards, we mean the data cards containing the system-driving commands.*

One will notice that the first vector of a sequence of vectors representing a figure part is special, in that it contains the minus sign. Therefore, we can range all sequences of vectors representing the figure parts sequentially without any delimiters: one can detect the head of a sequence of vectors representing a figure part easily by searching for the minus sign. We think that our representation is simple enough to use even for non-expert users.

BELOW: Example of functional patterns generated by ART-3.



BELOW: Butterfly with textures by superposing different pattern elements. (See *Figure 7* *for another example.*



3. PICTURE-GENERATING FACILITIES

In the present version of ART-3, except for the canvas-setting parameters, all system-driving commands, as well as the figure data and the figure-processing data are input by cards.

Figure 3 sketches the job flow in ART-3. An "-I" card indicated in Figure 3 is a system-driving card, and it contains a negative integer in its first five columns and/or next five columns. Each procedure described in Figure 3 is programmed as a separate subroutine. When a data card is read in, a required subroutine is called, and a job step is executed. Therefore, the job flow is very simple, and the user can understand the performance of the system very easily. The "-9" card is a special card that ends the job. In the next section, we shall explain the picture-generating facilities in detail.

3.1 CANVAS-SETTING

The canvas is supposed to be covered by a uniform rectangular lattice, with LATICX vertical axes and LATICY horizontal axes. The interval of two neighboring axes is DX in the horizontal direction, and DY in the vertical direction. Usually, we set DX = DY = 1 mm. Many figure-processing operations, such as the hidden surface elimination or the texture generation, are prescribed only on these lattice points.

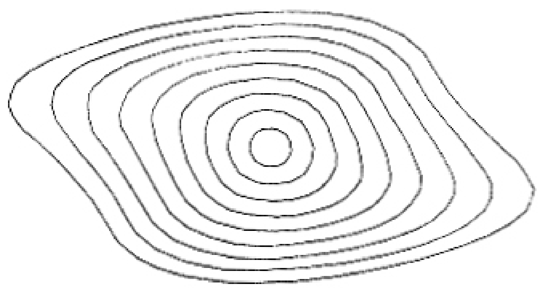
In this sense, we can regard the canvas as being quantized into LATICX, LATICY lattice points. The user can narrow the canvas area capable of being pictured by setting parameters MINLX, MAXLX, MINLY, and MAXLY to allow some integers such that 1 ≦ MINLX < MAXLX ≦ LATICX, and 1 ≦ MINLY < MAXLY ≦ LATICY. Then, only the lattice points {(i,j); MINLX ≦ i ≦ MAXLX, MINLY ≦ j ≦ MAXLY} are available.

3.2 INPUTTING THE FIGURE DATA

In the previous section, we have mentioned that a figure is represented by a sequence of two-dimensional non-null vectors, each having integers of at most two digits as its components. We, therefore, assign two columns of the data card for each integer. Thus the figure is input by a set of cards, with forty integers punched densely on each card with no delimiters. The end of the figure data is detected by finding the null vector (0,0). We need not punch any character at the end of the sequence of vectors. However, if the last vector ends at the 80th column of a data card, we must add another blank card to indicate the null vector.

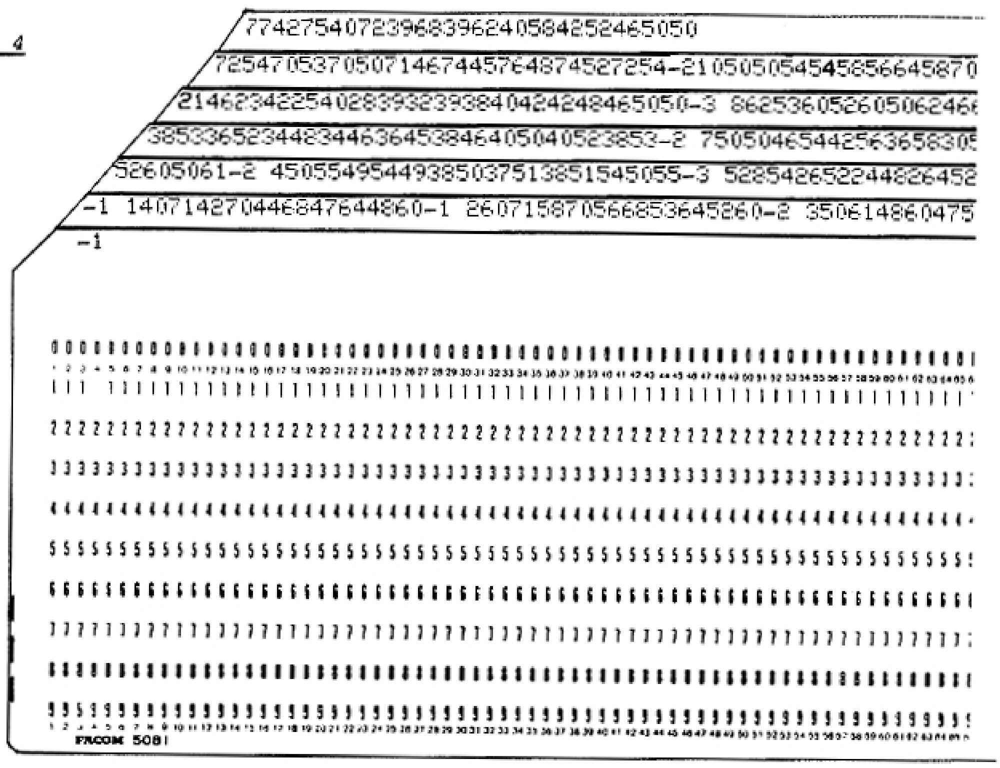
Figure 4 illustrates the data cards for the figure shown in Figure 1.

BELOW: Figure 4 - Data cards for inputting the pattern shown in Figure 1. The sequence of vectors must end with the null vector (i.e., four blank columns).



ABOVE: Figure 5 - Illustration of figure transformation. These figures are obtained by transforming concentric circles in the horizontal direction. (For another example, see the next page.)

FIGURE 4



If a new figure is input, the previous figure data are erased. That is, not more than one figure is existing in the computer memory. According to our experience, this restriction is useful for making system-driving easy for the users, and it does not inconvenience the user too much.

3.3 FIGURE TRANSFORMATION

The user can transform the shape of the figure by using simple mathematical functions prepared in the system. The transformation can be made many times for a figure, then the original figure is transformed each time. ART-3 stores about twenty functions for the figure transformation.

The transformation is performed in two mutually perpendicular directions successively and independently. For example, when such directions are horizontal and vertical directions, a vector (X,Y) of the figure data is transformed into a new vector (X',Y') as follows:

$$X' = a_x \cdot f(X-X_c;b_x) + X_c,$$

$$Y' = a_y \cdot g(Y-Y_c;b_y) + Y_c,$$

Where f and g are transformation functions, (X_c,Y_c) is a transformation center; a_x and b_y are magnitudes of transformation, and b_x and b_y are parameters characterizing f and g, respectively. Except for the numbers designating f and g, all other parameters are given default values. For example, (X_c,Y_c) is set to the figure center unless it is specified by the user.

Figure 5 shows two figures transformed from the concentric circles.

3.4 EMBEDDING FIGURE PARTS IN THE CANVAS

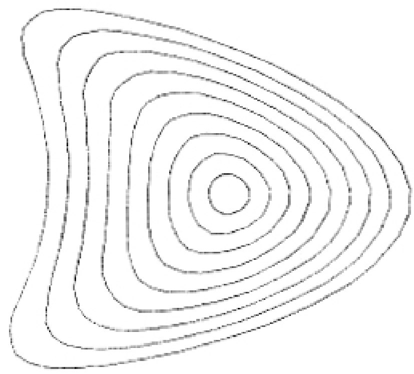
When a figure is input, all its figure parts are distinctively labeled with numbers 1, 2, ..., N (N is the number of the figure parts). The figure part appearing k-th in the figure data is labeled by k. Thus, it is convenient that the user labels each figure part in the same way.

In ART-3, the user must give two integers, say i and j, $1 \leqq i \leqq j \leqq N$, to designate figure parts to be embedded in the canvas. Then a set of figure parts with labels i, i+1, ..., j are called and processed in the same way. If the figure has been transformed, the transformed figure parts are processed. If i=j, the figure part with label i is processed. The user must specify further the location, the size, the rotation angle, the texture pattern and the gray scale of the figure part to be processed.

If the user does not specify the texture patterns, then only the contours of figure parts are drawn with no textures. We shall describe the texture generating facilities in the next section.

It should be noted that a figure of Type 3 is treated as a hole of the figure part of Type 2 or 4 to be drawn just after it. Furthermore, the user can change the type of any figure parts dynamically by using type-changing command cards, as is indicated in Figure 3.

BELOW: A second transformation, from Figure 5, the patterns are transformed in the horizontal direction.



If some figure parts are overlapped over each other, the overlapping surfaces of the later-embedded figure parts are eliminated unless the covering figure part is transparent. If a figure part is embedded outside the available canvas area, it is not drawn at all. If a figure part protrudes the available canvas, its protruding part is automatically eliminated. These are elementary facilities for processing hand-drawn figures.

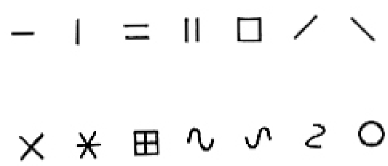
4. TEXTURE-GENERATING FACILITIES

In addition to the facilities described so far, the provision of various texture-generating facilities are indispensable for generating truly artistic pictures.

4.1 PATTERN ELEMENTS

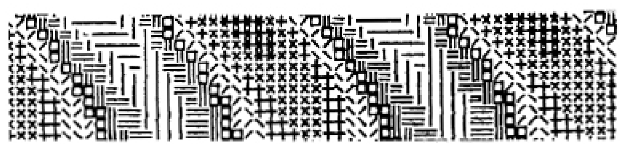
Figure 6 shows the pattern elements being prepared in ART-3. The size of these pattern elements are not fixed but are changeable. Thus, the gray scale of the texture is controlled by changing the pattern elements and/or their sizes.

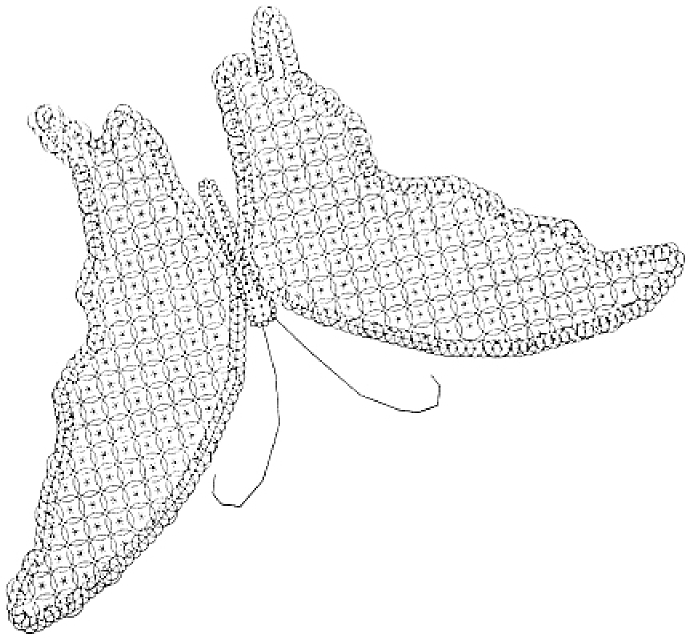
Although ART-3 provides the user only with the elements shown in Figure 6, the user can generate more complicated elements by superposing different elements: such superposition is possible because the transparent surface (i.e., the figure of Type 4) is allowed in ART-3. Figure 7 illustrates the superposition of different pattern elements.



ABOVE: Figure 6 - The pattern elements being prepared in ART-3.

BELOW: A detail of patterns from these elements.





ABOVE: Figure 7 - Textures generated by superposing different pattern elements.

4.2 BRUSHES FOR UNIFORM AND RANDOM TEXTURES

The uniform texture brush and the random texture brush are elementary brushes in ART-3. A uniform texture is generated by drawing a pattern element of a given size on lattice points at regular intervals. A random texture is generated by drawing randomly chosen pattern elements on lattice points at regular intervals. The size of the pattern element and the interval of lattice axes on which patterns are drawn are specified by the user.

Although the pattern elements are drawn only on lattice points for surface-painting, they are drawn on either horizontal or vertical lattice axes for contour-drawing (cf. Figure 7).

4.3 FUNCTIONAL PATTERNS

By functional patterns, we mean the patterns whose gray scales are spatially changed by simple mathematical functions. In addition to the uniform and random textures, ART-3 can generate three types of functional patterns:

1. The first type is such that the size the pattern element is changed;

2. The second type is such that the density of the pattern element is changed with the size fixed;

3. The third type is such that the pattern elements themselves are changed with the size fixed.

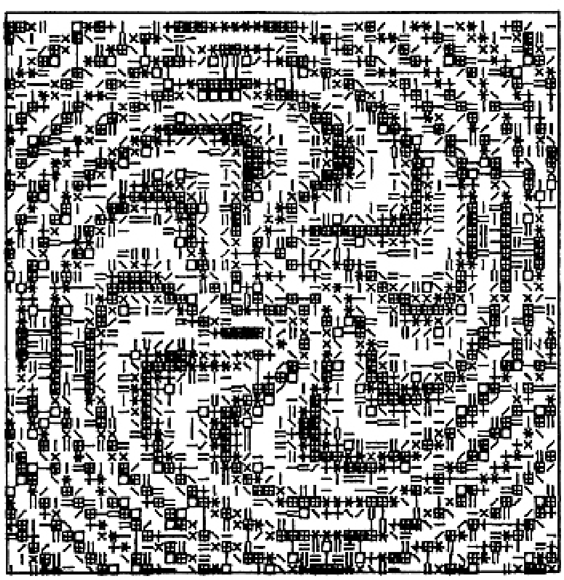
Figure 8 shows several functional patterns generated by ART-3.

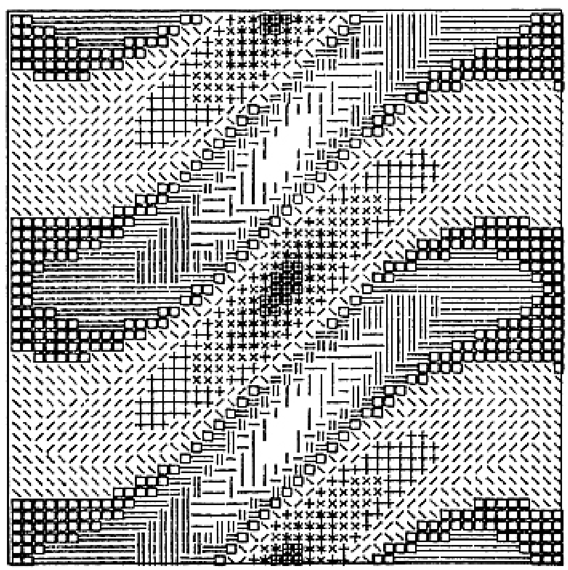
ART-3 provides the user with about forty pattern functions, and it allows the user to define his pattern functions. For a functional pattern, the pattern element to be drawn at the lattice point (X,Y) is determined by the value of

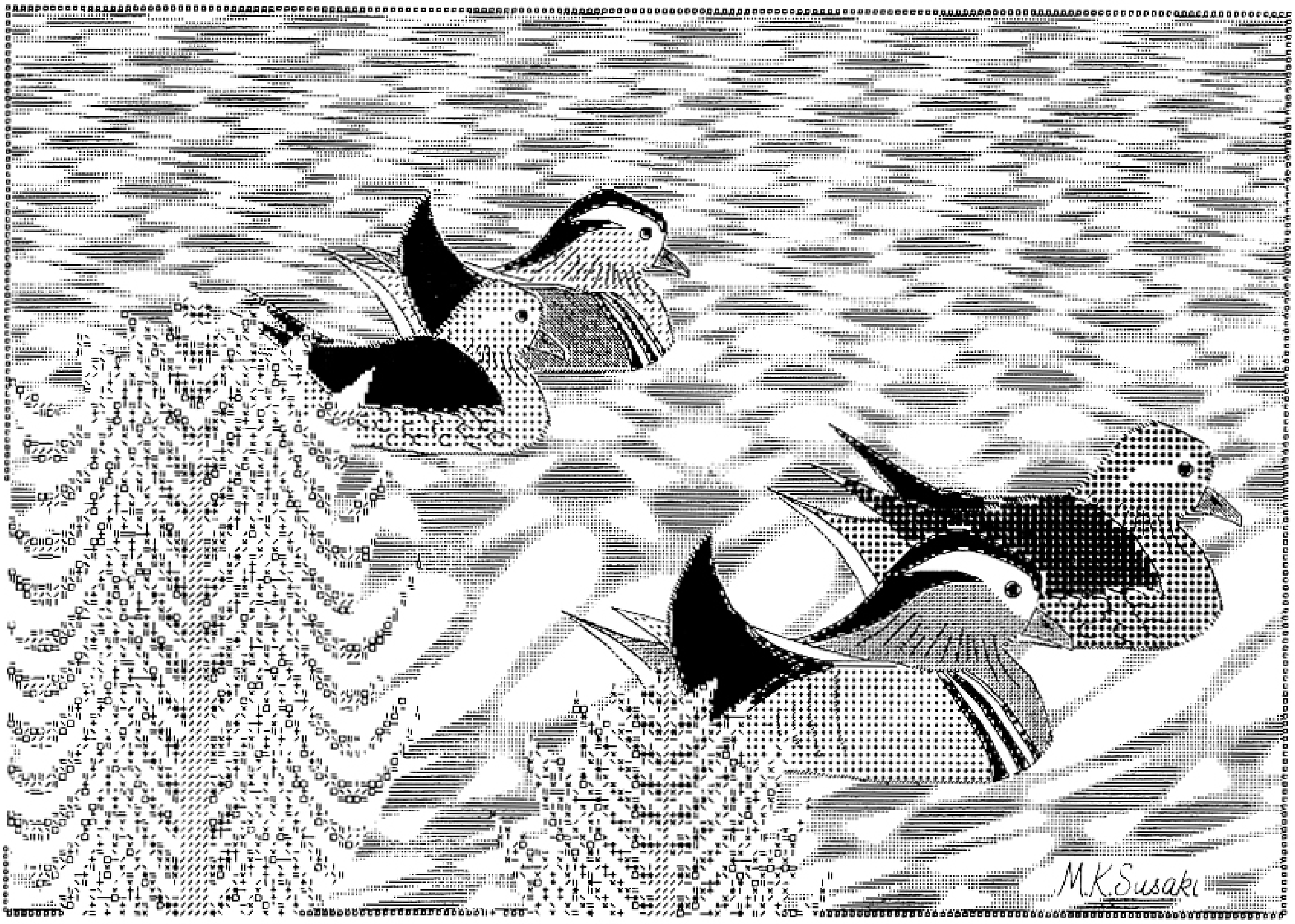
$$F = f_0 + c \cdot f(X-X_c, Y-Y_c ; a, b),$$

where f is a pattern function of two variables. Other symbols appearing in F are parameters defined by the user, and they have the following meanings: The vector (X_c,Y_c) is the pattern center; f_0 and c are, respectively, the average value and the magnitude of variation of F, and a and b are parameters characterizing f. All of these parameters are given default values. For example, (X_c,Y_c) is set to the center of the figure part to be processed unless it is specified by the user.

BELOW, LEFT AND RIGHT ILLUSTRATIONS: Figure 8 - Examples of functional patterns generated by ART-3. Notice the rhythmical quality of the painting accomplished by these functional patterns, eminently suited for textiles and decorative applications.







ABOVE: Figure 9 - A picture generated by ART-3. The title of this picture is "Mandarin Ducks I". The shapes of mandarin ducks and the tree were drawn by hand. The ducks were painted by the uniform texture brush, and the trees and the pond were painted by functional pattern brushes.

4.4 COLORED PICTURES

ART-3 is equipped with a facility for generating colored pictures. That is, it can generate three separate pictures, corresponding to three primary colors, which combine to make a color picture. However, the generation of colored pictures is considerably expensive, and the desired tint is not easy to attain. This is one of the faults of using plotters as output devices.

5. CONCLUDING REMARKS

We have always classified beauty expressed by pictures into three types: natural beauty, mathematical beauty, and creative beauty. /4/ By using ART-3, we have aimed at combining natural beauty with mathematical beauty to generate new types of pictures. We think our aim is accomplished to some extent by ART-3.

Figures 9 and 10 show our recent works generated by ART-3. Our system is, however, not a well-equipped system -- except for the elementary facilities for processing hand-drawn figures, it provides the user only with a facility for generating functional patterns. With ART-3, it is very hard to generate delicate patterns. We have many things to do to make the system more powerful, and we are planning to implement several art techniques.

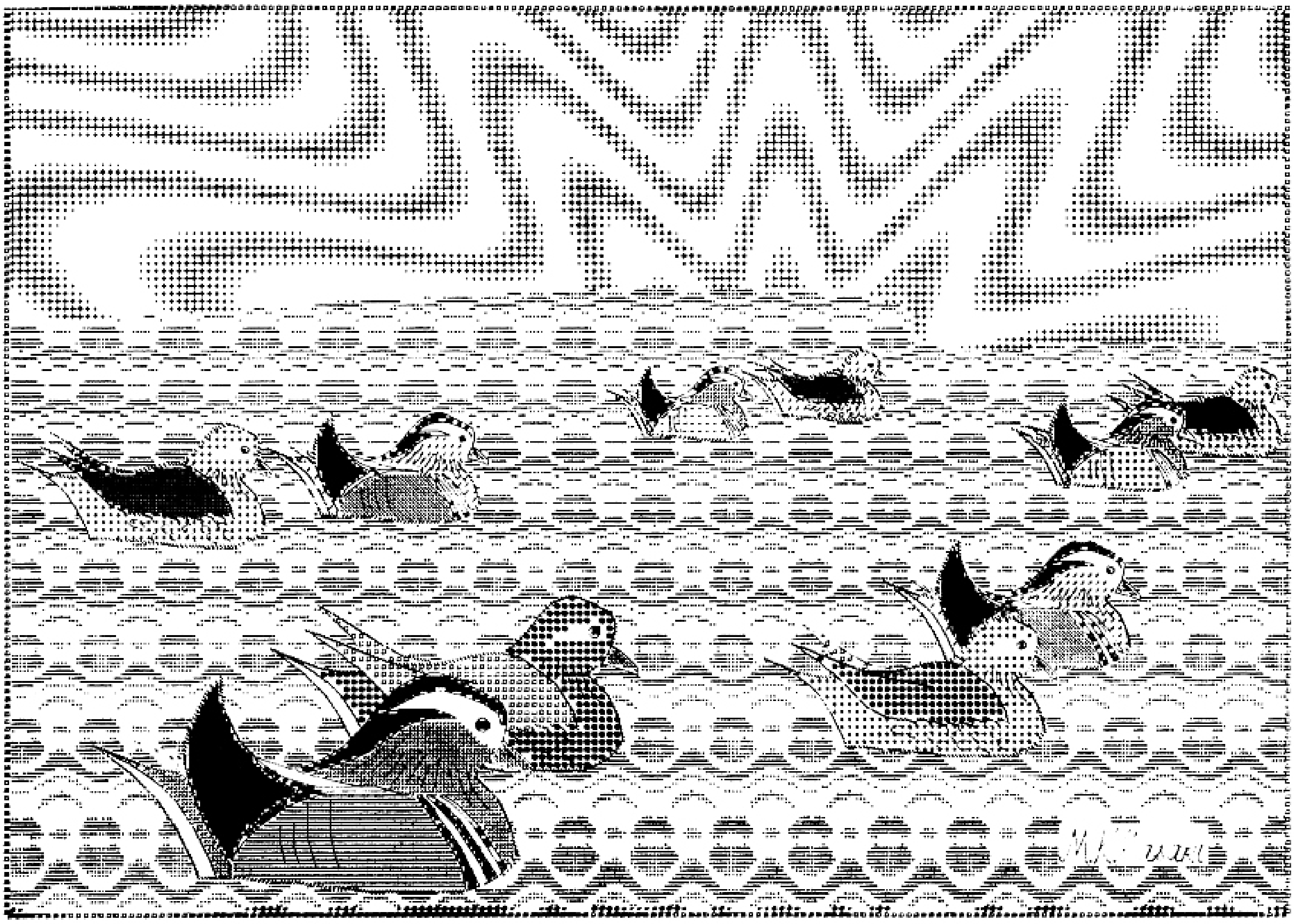
REFERENCES

/1/ Sasaki, Mutsuko K., "Featured Artist," in Personal Computing 1, #2, 1977, p. 140-141.

/2/ Knowlton, Kenneth, "MINI-EXPLOR - A FORTRAN-Coded Version of the EXPLOR Language for Minicomputers," Bell Laboratories, Murray Hill, New Jersey. (See also "EXPLOR - A Generator of Images from Explicit Patterns, Local Operations, and Randomness," in Proceedings, 9th Annual UAIDE Meeting, 1970, p. 543-583.

/3/ Several pictures generated by ART-3 can be seen in Computers and People, Volume 25, No. 4 and No. 8, 1976; Volume 26, No. 8, 1977.

/4/ Sasaki, M. K. and Sasaki, T., "Computers and Beauty," Creative Computing 2, #6, 1976, p. 48-51.



ABOVE: Figure 10 - The title of this picture is "Mandarin Ducks II". Using the ART-3 system, each duck is painted uniquely. The wave forms are painted in perspective. The ART-3 system affords works that are more painterly in quality than linear art systems, with greater textural richness.

ART OF THE SPACE ERA

INTERNATIONAL INVITATIONAL OF COMPUTER GRAPHICS

Huntsville Museum of Art, Huntsville, Alabama

PARTICIPATING ARTISTS

Manuel Barbadillo - SPAIN
Klaus Basset - GERMANY
Otto Beckmann - AUSTRIA
Jean Bevis - USA
Dan Cohen - USA
Roger Coqart - BELGIUM
Analivia Cordeiro - BRAZIL
Kenneth Dunker - USA
Herbert Franke - GERMANY
Charles Fritchie - USA
Aldo Giorgini - USA
Groupe Couleur de Belfort - FRANCE
Grace C. Hertlein - USA
Matjaz Hmeljak - ITALY
Sture Johannesson - SWEDEN
Kerry Jones - USA
Sten Kallin - SWEDEN
Kenneth Knowlton - USA
Bill Kolomyjec - USA
Richard Land - USA
Ben Laposky - USA
Frank Malina - FRANCE
Robert Mallary - USA
E. T. Manning - USA
Tomislav Mikulic - YUGOSLAVIA
Petar Milojevic - CANADA
Manfred Mohr,- FRANCE
Vera Molnar - FRANCE
Robert Morriss - USA
Katherine Nash - USA
C. B. Rubenstein - USA
Duane Palyka - USA
Mutsuko K. Sasaki - JAPAN
Lillian Schwartz - USA
Javier Segui - SPAIN
Paul Shao - USA
Keith Sonnier - USA
Stan Vanderbeek - USA
James Ver Hague - USA
Edvard Zajec - ITALY

NEW SYSTEMS FROM INDUSTRY

INTELLECT

by Micro Consultants, Inc.
P. O. Box 10057
Palo Alto, California 94303

Telephone (415)321-0832 TELEX 334420

WHY INTELLECT?

The manipulation of pictures by digital methods is finding increasing application in diverse areas -- ranging from broadcast television, infra-red imaging and military image processing, to medical electronics, sonogram displays and pattern generation equipment for commercial artists.

Although it has long been acknowledged that digital techniques have much to offer, particularly where flexibility is important -- the implementation and optimization of the appropriate function on anything but a theoretical basis is often a tedious, cumbersome task.

Even small changes in special purpose hardware are difficult and expensive to undertake, and although the digital computer has been available to make light work of the computational aspects, the peripheral equipment necessary for entering images as data into the computer, and for displaying the computed results, has not been so readily available. Those pieces of equipment that have been built tend to be slow or inflexible, and frequently, they limit the quality of the picture.

What has been needed is an interactive, intelligent system that has the ability to capture and process large quantities of data quickly, as well as display the results in real-time - as the computation proceeds. Further, these new media must perform their function without degrading the quality of the original image.

Such equipment can make a significant contribution to the interactive design function, since those users associated with image analysis or processing can enter a picture, choose an algorithm, and then observe the result in a matter of seconds. Those users associated with image synthesis can observe the picture at full resolution as it is created.

INTELLECT is an intelligent television system for the electronic generation and processing of pictures, which for the first time, gives the designer interaction with his machine. In real-time, a frame of video may now be captured, displayed, and interfaced to a computer. The resolution of this system, both spatial and gray tone, has been matched to that of conventional television -- ensuring no degradation of the picture. The operator is free to process the captured frame in many different ways by merely changing the computer program, while observing the picture on a flicker-free screen.

INTELLECT is equally applicable in the field of synthetic pictures. These may be drawn by the computer, as in the case of pattern generation and graphics applications, or derived from an alternative source of signal, as in the case of spectrum analysis or radar processing.

ABOVE: An image "captured" by the INTELLECT System.

This equipment has also been designed with the hardware engineer in mind, since facilities have been included for adding hardware processing to the video paths. Hybrid functions, simultaneously combining both hardware and software processing, are also possible.

Micro Consultants Limited have developed a new programming language to complement INTELLECT. This language, known as "ART", is a high level operating system capable of allowing users not familiar with programming to fully utilize the interactive capabilities of the system.

TECHNICAL DESCRIPTION

INTELLECT essentially comprises a digital video frame store, a high speed video input, a high speed video output, a mini computer, and a hardware interface. The video input can capture in real-time, a frame of incoming video while the video output is able to continually reproduce the contents of the store in raster format at standard television rates for display on a conventional monitor. The mini-computer can modify or analyze at will the contents of the store under software control and the hardware interface may ultimately replace the computer software with hardware.

The System - The system is centered around the video frame store, which is able to hold two fields of 256 lines, each line containing 512 picture points. The frame store is so arranged that it can accept video at up to 15 MHz sampling frequency and reproduce it for display at the same rate. The reading and writing processes for the store are independent, can operate simultaneously and may also be completely asynchronous. The mini-computer has direct access to any picture point in the store and may either read information from the frame store, write information to it, or alternatively remove data from the picture, modify it and replace it. The contents of the store may, at any time, be displayed on the TV monitor by the operator.

NOTE: For further information on the INTELLECT SYSTEM, write or call Microconsultants, Inc.

NEW SYSTEMS FROM INDUSTRY

RAMTEK COLORGRAPHICS TERMINAL AND LARGE SCREEN PROJECTION SYSTEM

by Ramtek Corporation
585 North Mary at Maude
Sunnyvale, California 94086

Telephone (408)735-8400 TWX:910-339-9379

ABOVE: The new Ramtek Colorgraphics Terminal in conjunction with a large screen projection system to present color computer graphics in the classroom. Part of the University's Visual Math Project, the Ramtek terminal permits graphic color representation of mathematical concepts in courses such as physics, engineering, chemistry, mathematics, and statistics. Above, Professor Ralph Abraham, Head of the University program, finds that the system is a very magnetic teaching tool. It commands instant attention and prolonged attention from students at all levels of study.

VISUAL MATHEMATICS - UNIVERSITY OF CALIFORNIA, SANTA CRUZ

A new color graphics display terminal system by Ramtek Corporation is enabling students to better understand the nature of advanced mathematical concepts at the University of California, Santa Cruz. This is one of the first student-interactive schemes to present large color computer graphics in the classroom.

The system, which includes a 6200 color graphics terminal, projects color representations of 3-D figures. In mathematics, a "dimension" can mean any additional parameter. Hence, the addition of color to the graphic presentation of a mathematical function can permit the student to easily visualize up to five dimensions.

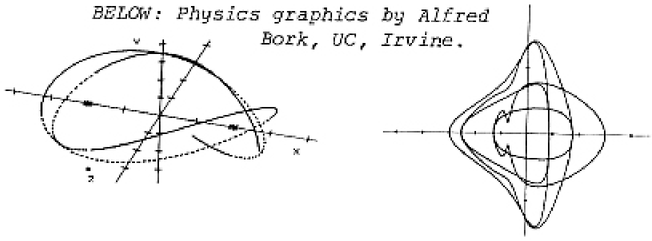
The color graphics terminal permits graphic color presentation of mathematics in these typical courses: mechanics, electricity, optics, thermodynamics, engineering structures, fluid dynamics, electronics, molecular structure, calculus, differential equations, geometry, linear algebra, and statistics.

The new system also offers control software with a wide variety of true graphic possibilities, such as conics, vectors, plots, bar charts, and a high-speed alphanumerics refresh feature with single-character addressability within a visible matrix of 25 rows of 80 characters. Selective erase, modification and update are also featured. Other options are available, such as extended RAM memory, interactive joystick and packaged software.

The staff of the UC Santa Cruz campus uses the system an average of 30 hours per week. Professor Abraham's project produces video tapes for specific lectures or lessons at the request of any professor. An extensive library of graphics software for visual mathematics has been created for these tasks. This means that if an instructor is giving a standard lecture on linear transformations or explaining binomial distributions, he or she can play this tape for the students and start and stop the display at will. The color video graphics can be displayed on a large screen by an RGB video projector for classes of up to 100 students.

NOTE: For further information, readers may contact Ramtek Corporation at the above address.

BELOW: Physics graphics by Alfred Bork, UC, Irvine.



PHYSICS DIALOGS FOR STUDENT USE

COMPUTER MAP OVERLAYS FOR LAND MANAGEMENT

The authors are Robert A. Johnston, Assistant Professor of Environmental Planning, Division of Environmental Studies, Davis; Michael J. Singer, Assistant Professor, Department of Land, Air and Water Resources, Davis; and Linda J. Thorpe, Senior EDP Analyst, Division of Environmental Studies, Davis.

This publication represents an equal effort on the part of the authors.

Land managers, land use planners, and other persons who need to make decisions about land use are faced with the formidable task of integrating a growing and poorly organized data base. Although large amounts of geographic data are desirable in planning for land use, an analyst can be overwhelmed by the number of diverse data sets available and the difficulty in manipulating them. The planner must choose the combination of variables that will help solve whatever planning or mangement problem is at hand. In general, the number of mapped variables that can be used is limited by the analyst's ability to combine these variables efficiently.

Examples of large and diverse geographic data bases are easy to find. The United States Census is a source of data for city planners. It contains, among other information, hundreds of characteristics of population and housing, listed by counties, cities, tracts, and block groups. Sources of physical resource data, such as soil survey reports or geologic maps, also contain a great many variables (table 1).

TABLE 1.
EXAMPLES OF SOIL SURVEY REPORT DATA.

SOIL PROPERTIES Physical	Chemical	INTERPRETATIONS
profile type	pH	potential crop yield
number of horizons	conductivity	capability classifications
kinds of horizons	salinity	suitability for road fill
bulk density	alkalinity	suitability for septic tanks
clay mineralogy	nutrient status	suitability for houses
soil depth		suitability for embankments
engineering properties		
slope		

One common method of assembling data is to prepare a clear plastic map of each variable. On each map, the state or level of each variable is assigned a color. Then pens with translucent ink are used to color the plastic by hand. Once the maps are produced, the analyst can superimpose them on one another and then peer through the stack, examining combinations of variables of interest. This method is fine if the problem is simple and does not require in-depth or long-term analysis. However, the use of plastic overlay maps has two main disadvantages: a large amount of expensive hand work is necessary; and the results are semi-quantitative at best.

Numerous computer mapping programs have been developed by universities and state and federal agencies to solve, in a practical way, the problems of analyzing geographic data and to offer planners and managers an alternative to the hand overlay technique. Many of these computer mapping systems have been reviewed by Tomlinson (1972).

Several states, including Virginia, Minnesota, and Illinois, maintain statewide data bases in digital form. These systems use computer programs that can put out data on a geographic basis. Sources of information about these systems include: a list of many of the systems (Johnston, Thorpe, and Long 1975); a summary of the systems available (Phillips 1974); an examination of resource information systems (Tom and Miller 1974); and a review of those analysis programs used in California (Miller 1975).

This publication discusses the advantages of computer mapping techniques, using, as examples, research projects completed by means of a computer mapping system available through the Division of Environmental Studies at the University of California, Davis.

Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

LAND USE MAPPING PROGRAMS (LUMP)

The system known as LUMP, Land Use Mapping Programs, was started in 1971. The system was developed to meet the needs of researchers in many disciplines on the campus and of land use planners in northern California. These two groups required a fast, relatively inexpensive, highly flexible system for handling and analyzing geographic data.

In 1971, several dozen computerized geographic information systems existed. There were several reasons for initiating a new system.

> The campus computer, a Burroughs B6700, is significantly different from its major counterparts. Since converted programs often do not run efficiently on the B6700, it was decided that it was as feasible to develop a new system as it was to convert available systems.
>
> In the University community, there is a rather unique set of user objectives, which were not fully served by any existing system. Some of these objectives are capability to combine natural and social data at a low cost and capability to enter data from a variety of media.
>
> A new system could incorporate good features from a number of existing systems.

CAPABILITIES

Input

Geographic information systems include options for modes of entry, analysis, and output. Do not confuse geographic information systems with programs that simply make maps.

In the LUMP system, data may be entered in one of several ways (figure 1). Data may be hand coded and keypunched on a grid or polygon basis (not illustrated). For each x-y cell in the grid, any number of variables may be entered. The number of variables depends on the complexity of the problem and the capacity of the computer. For large data sets, this procedure is cumbersome.

A less time-consuming procedure is to use the digitizer for semi-automatic input of geographic data. Maps, drawings, or aerial photos that represent any kind of geographic data may be entered by tracing the homogeneous areas of interest on an electronic digitizing device, usually a table. Maps are taped to the table, the origin (cell 0,0) is set electronically, and the electronic sensor is guided over the boundaries of the areas of interest. The data, together with their x and y coordinates, go directly to a computer and ultimately to a magnetic storage device, such as a tape or disc. Data entered in this manner may be at any scale and the choice of grid size for retrieval and output can be determined by the user. However, output maps cannot represent data with greater accuracy than was available on the input maps.

A third input procedure is GRID/BASE. By using interactive terminals on a time-sharing basis, it is possible to enter, directly into a computer, data that can be overlaid by a grid. This feature makes it possible to enter data cell by cell, but bypasses the coding of sheets and the punching of cards.

GRID/BASE and GRID/MASTER are computer programs that create files that represent a map as a matrix of grid cells. Initially, a background value is assigned to all cells for all variables entered. The user then addresses a cell by x and y coordinates and enters a list of values for the variables. To simplify the entry of identical data in a row of cells, the user may specify a repeat factor for the number of adjacent cells that have the same values.

If point data, such as precipitation measurements, exist for a small number of cells, values for the other grid cells can be generated by the use of contouring programs that fill in the missing data.

Optical distortion of aerial photos can be rectified and maps can be translated from one projection to another. For example, polyconic map data can be translated to UTM* grid data. Editing of input can be done on-line by using a time-sharing terminal or off-line by punching conventional cards.

*UTM stands for Universal Transverse Mercator.

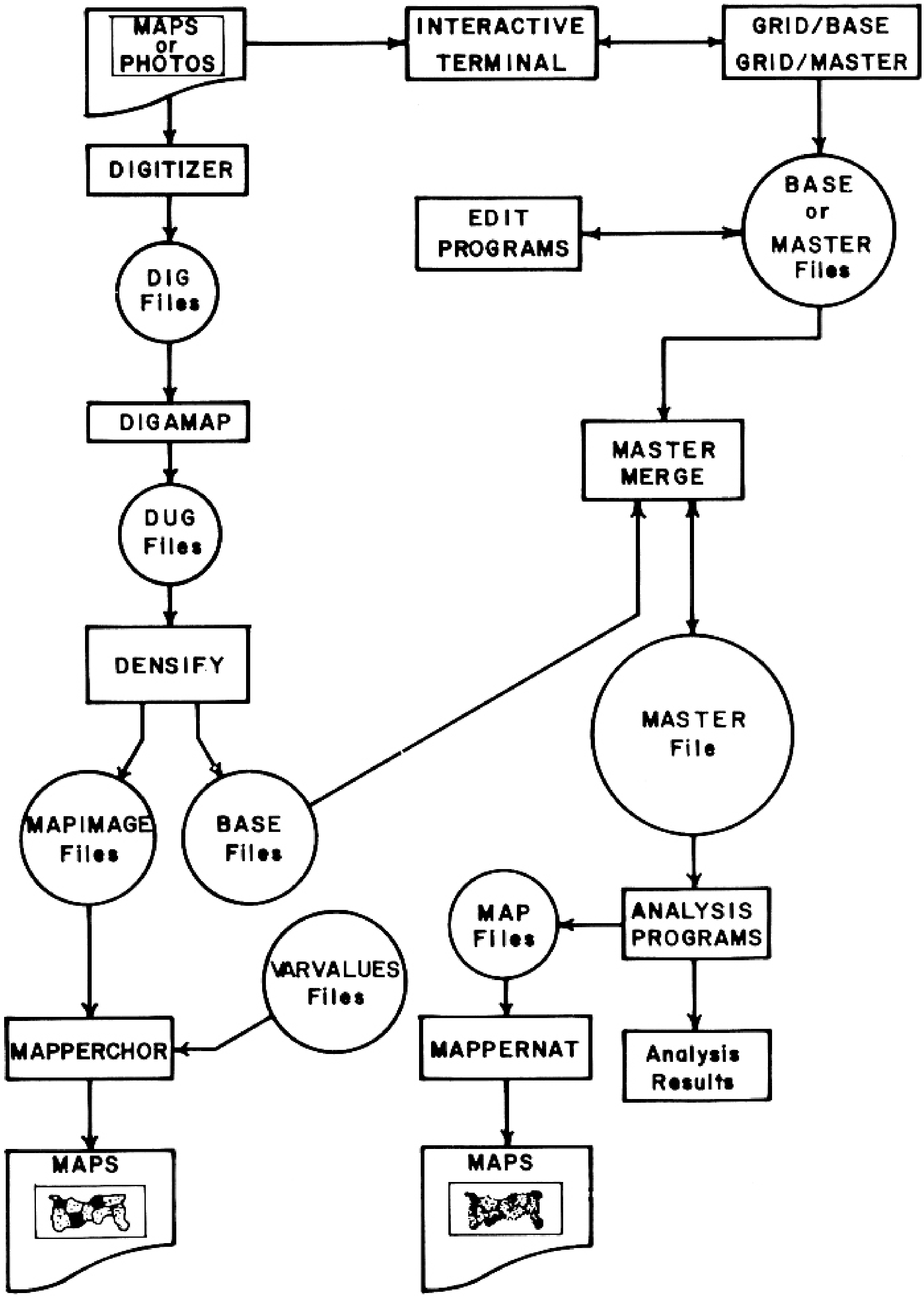


Figure 1. A flow chart showing the principal modes of input into the LUMP system.

These and other input capabilities provide considerable flexibility for users of mapping systems. Each system differs in cost, required equipment, and necessary labor. Ultimately, data entry leads to the creation of an information system.

In LUMP, this information system is the master file where base maps created by any combination of the above techniques are merged. This master file is the heart of the LUMP system. Each record in the master file corresponds to a unique x-y coordinate and contains a value for each of the variables entered. The LUMP master file has been designed so that it is easily used by a variety of specialized programs, including several written for LUMP as well as those in general use elsewhere.

This modular design concept has resulted in a system with great versatility. Although updates and corrections are possible, the file only needs to be created once. If new manipulations are needed, special programs can be devised to operate on the master file.

The line drawings are by Uy Thanh Ly.

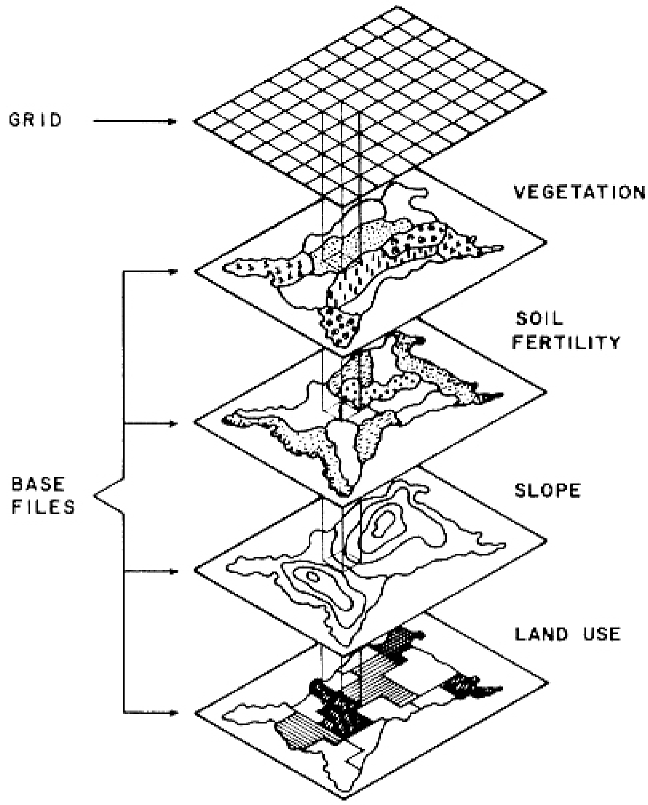


Figure 2. The concept of the master file

Analysis

The master file may be conceptualized as a stack of maps through which the user can see all the variable states for a given x-y grid cell (figure 2). In the analysis phase, which is distinct from data entry and mapping, computer programs analyze the map, cell by cell, and compute functions on the variables or look for particular combinations of variable states.

The result of the analysis may include statistics, areas, or tables of combinations, and a file that may be used to make a map showing the locations of various combinations or values of a function. For example, an analysis may result in a table of acreages of prime agricultural land in an area; the map shows where these lands are. (See figure 3. For a discussion of other aspects of these maps, refer to page 13.)

LUMP/COMBO is a program that uses the master files to find all possible combinations of a set of features that have a finite number of states. For example, this type of analysis requires that a variable, such as slope, be categorized as low, medium, or high, not given in degrees. For three variables, such as soil fertility, land use, and slope with three, two, and three variable states, respectively, there would be eighteen possible combinations of variable states.

The LUMP/COMBO program finds all the states that actually exist, the frequency (area) of each state, and then reports this result in a table sorted so that the most common combination of variable states is first. This table listing the combinations of variable states may be used to design a map. Figure 4 is an example of such a map where land use with two states—urban or nonurban and soil fertility measured as high, medium, or low—were used to create six combination categories. No key for this map is shown, but the darkest areas show where highly fertile land is put to an urban land use and the next darkest areas show nonfertile land in a nonurban use. The lightest areas show highly fertile land in a nonurban use.

The master file was designed to have a simple data structure to facilitate its use with standard analysis packages. The package most frequently used is *SPSS, Statistical Package for the Social Sciences*, a general and widely used computer program with a number of data modification features as well as statistical features (Nie et al. 1970). Among its many uses, SPSS can be used to compute functions, create correlation matrices, and produce cross tabulations among variables. The results of SPSS analyses may be output in a form convenient for LUMP mapping.

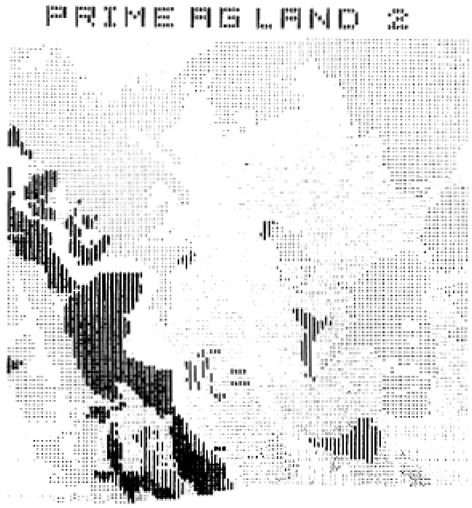
PRIME AGRICULTURAL LAND

RUMSEY MAP 1. AREAS ARE IN ACRES.

Level	Symbol	Class Limits		Frequency	Area	% Area
1		0.01	9.99	28	1516	12.02
2		10.00	19.99	32	4455	35.33
3		20.00	39.99	37	5223	41.42
4		40.00	59.99	15	344	2.73
5		60.00	79.99	18	476	3.77
6		80.00	100.00	19	596	4.73

RUMSEY MAP 2. AREAS ARE IN ACRES.

Level	Symbol	Class Limits		Frequency	Area	% Area
1		0.01	9.99	38	1516	12.02
2		10.00	19.99	32	4455	35.33
3		20.00	39.99	37	5223	41.42
4		40.00	59.99	15	344	2.73
5		60.00	100.00	37	1072	8.50



RUMSEY CONFLICT MAP AREAS ARE IN ACRES.

Level	Symbol	Class Limits		Frequency	Area	% Area
1		0.01	9.99	38	1516	12.02
2		10.00	19.99	32	4455	35.33
3		20.00	39.99	37	5223	41.42
4		40.00	59.99	15	344	2.73
5		60.00	79.99	18	476	3.77
6		80.00	100.00	19	596	4.73

Figure 3. Interpretation map of prime agricultural lands, as defined by the Storie Index, in Yolo County.

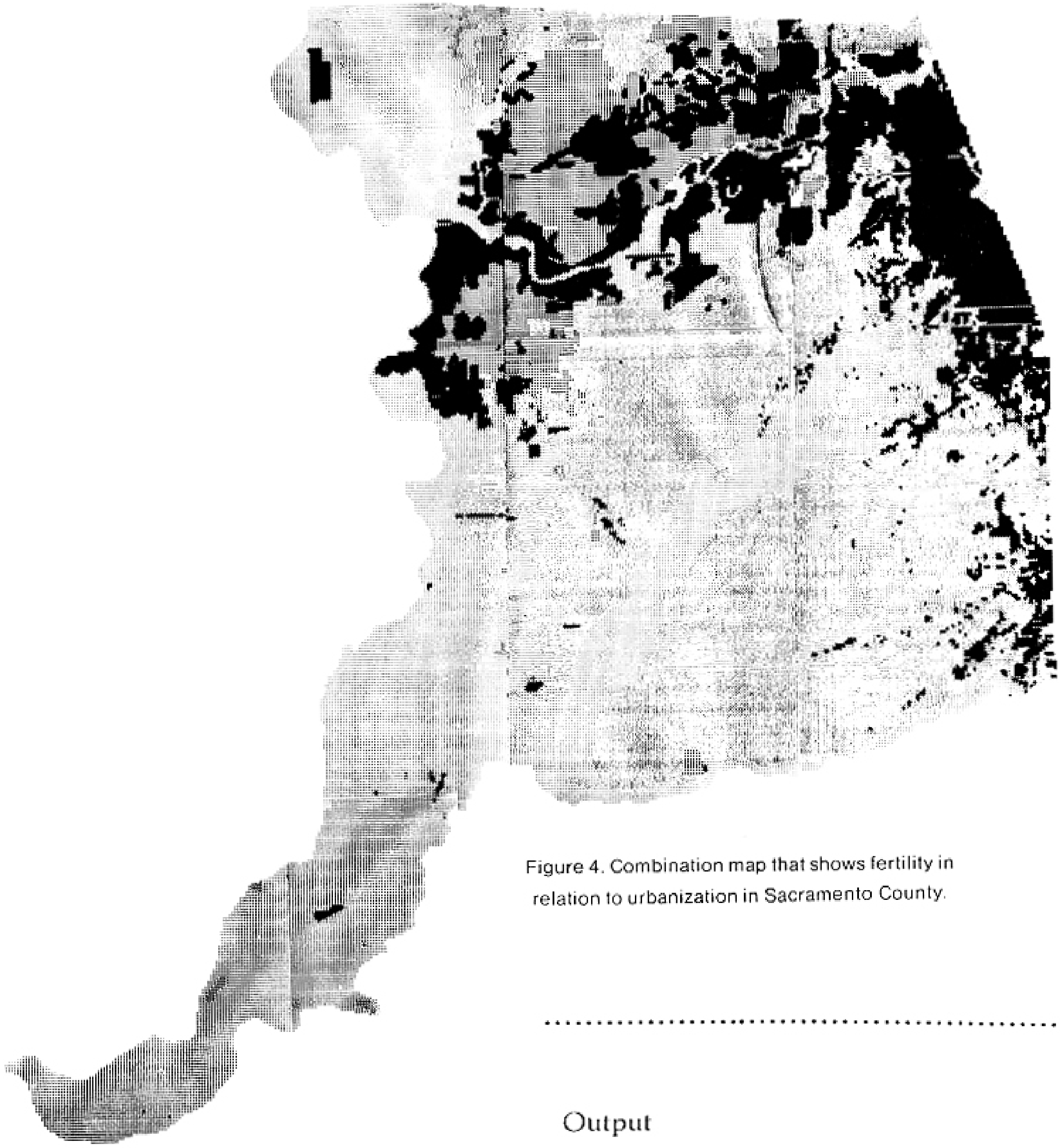


Figure 4. Combination map that shows fertility in relation to urbanization in Sacramento County.

In some cases, a user needs a unique analysis of geographic data, so special programs are written to handle just the analysis phase. Figure 5 shows a system where a LUMP master file was used as input for a program to calculate erosion potential for each cell where there are interdependencies among cells. LUMP analyses normally treat each cell independently. However, in this case, a special program was written to do the analysis because the interdependencies among cells were important.

Output

The LUMP system can produce, in mapped form, any combination or function of variables generated during the analysis phase. The maps are produced by standard line printers or by more specialized typewriter printers that use letters, numbers, or shaded characters. The types of maps that can be prepared include *inventory maps*, *interpretive maps*, *combination maps*, and *evaluation maps*.

An *inventory map* is merely a line printer depiction of the single variable input map. An example would be a printer image of a slope map.

A more interesting use of the system is the production of an *interpretive map*. This type of map is produced when a user defines a new variable as some function of the inventory variables in the master file. For example, different levels of seismic safety may be defined as a function of geologic, topographic, and population density variables. (See figure 3 for an illustration of an interpretive function map of prime agricultural lands.)

A *combination map* shows overlapping areas of given values of variables chosen by the user. In the LUMP system, one analysis program calculates the number of occurrences of all the possible combinations of the variable states chosen for the combination map. This information greatly enhances the ability of the user to sort through the large amount of data available in the master file. It is possible to print maps of all or any

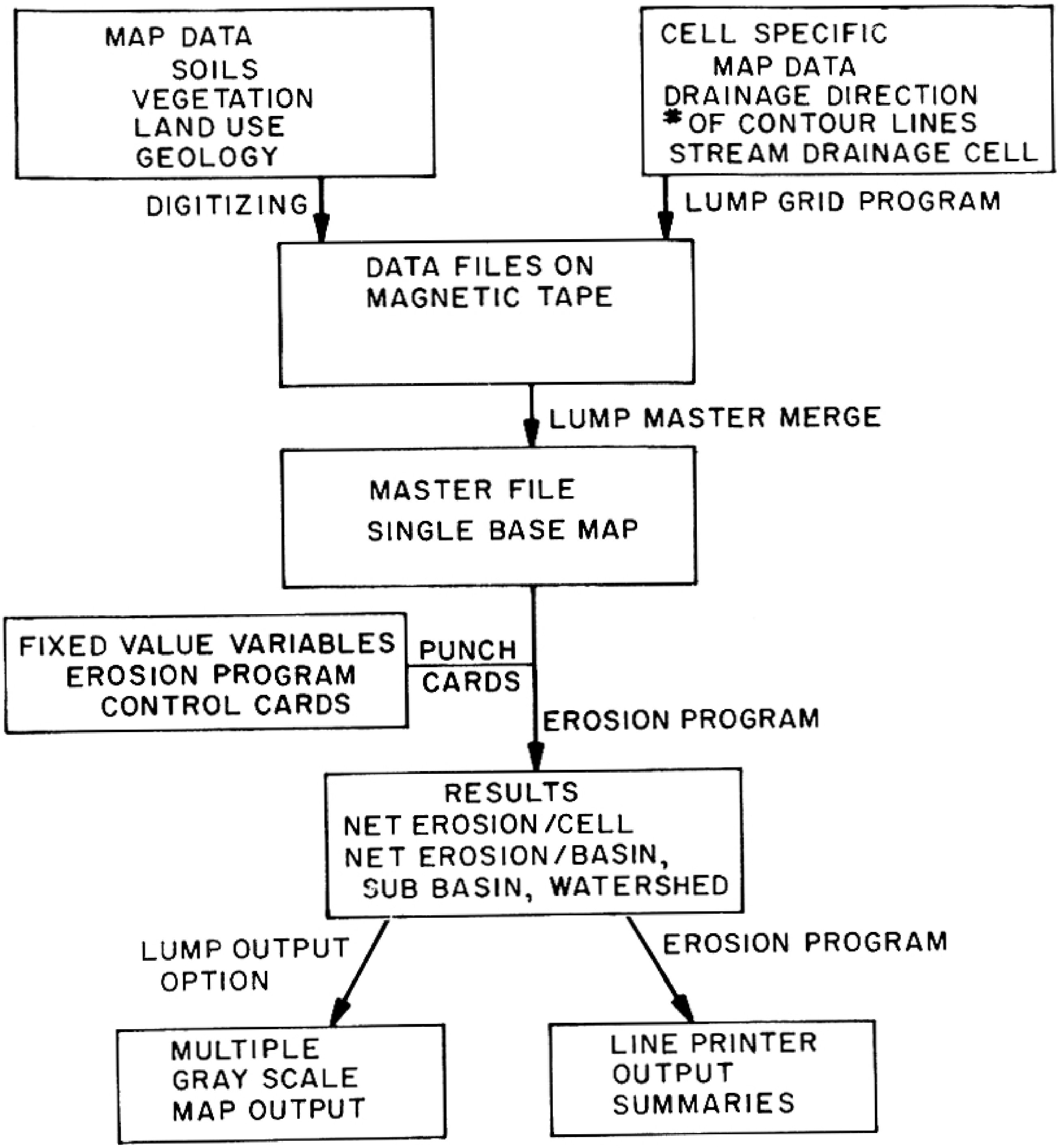
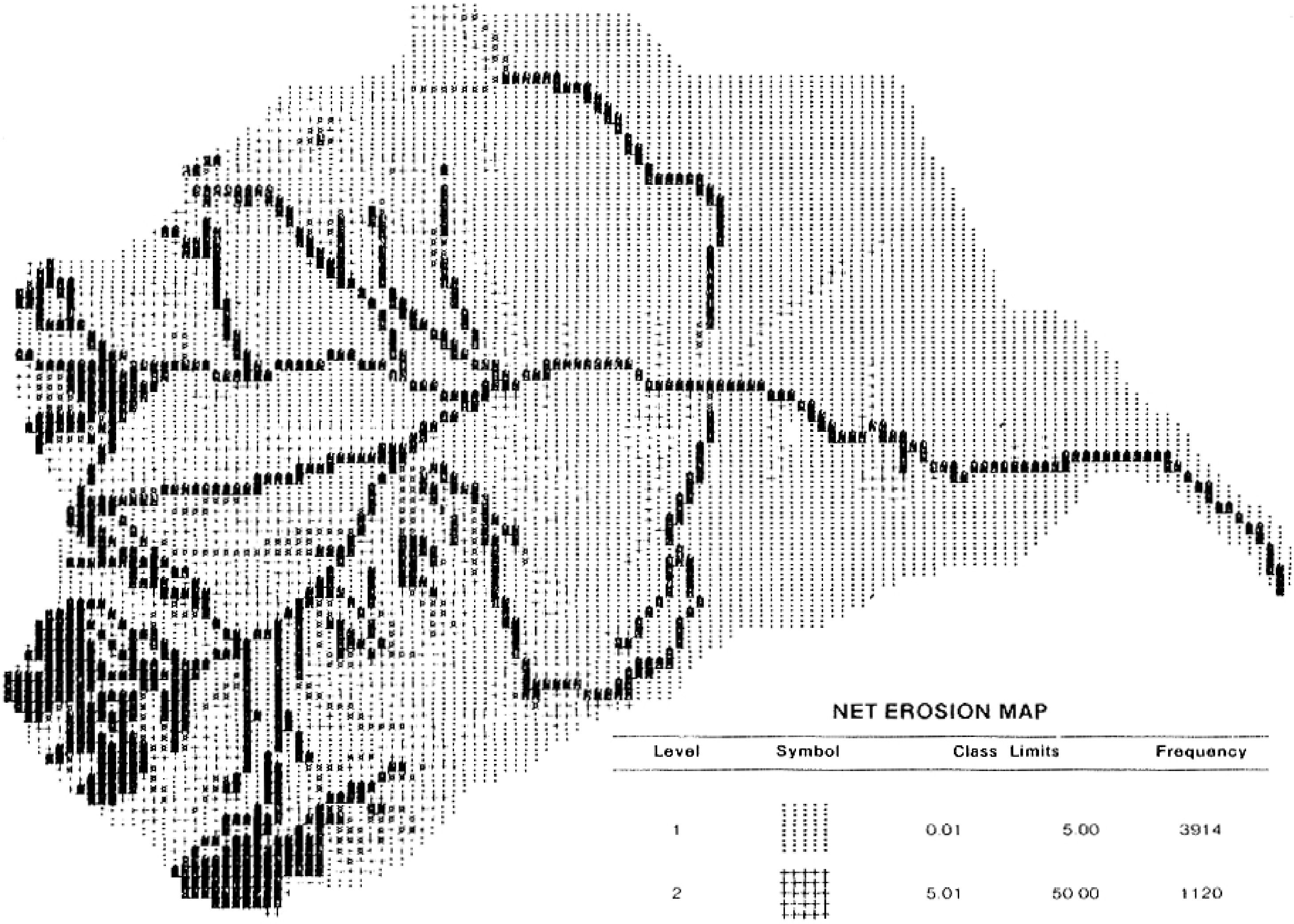


Figure 5. A flow chart of a system for calculating erosion.

subset of the combinations that occur. An example of a combination map would be a map that depicts potential problems in land use, such as prime agricultural land zoned for nonagricultural purposes. See figure 4 for an example of a combination map that shows urbanization and soil fertility.

The fourth general type of map is the *evaluation map*. This type of map is created when inventory and interpretive variables and states important to an analysis are chosen and given value weights. A total weighted value is calculated for each cell according to a selected equation. The values are then portrayed through a set of gray scale line printer characters. Evaluation maps are similar to interpretive function maps, except that the new variables created are more subjective. Examples of evaluation maps are maps of erosion hazard (figure 6) and neighborhood pedestrian dependency (figure 7).

Output for all options is in the form or square gray scale characters. Processor time and cost increase with the number of cells produced. Printer time and cost vary with the number of overprints required for dark shades and the number of categories the user wishes to depict. A key to the characters is printed as part of the output and may include a title and optional descriptive



NET EROSION MAP

Level	Symbol	Class Limits		Frequency
1	:::::	0.01	5.00	3914
2	+++++	5.01	50.00	1120
3	XXXXX	50.01	100.00	248
4	█████	100.01	3000.00	990

Figure 6. Evaluation map of erosion hazard in Ward Valley, Placer County.

Figure 7. Evaluation map of neighborhood pedestrian dependency for the central portion of Sacramento County.
(Deleted because of space.)

text supplied by the user. The key shows a block of the overprinted characters for each level of the function or combination of variable states on the map. Beside the block showing the gray scale are the lower and upper limits for values shown by the map and a cell frequency count (figure 6) or choroplethic area frequency count (figure 7). In some cases, the ground area covered by the value range is also shown. (See figure 3.)

The map in figure 7 is somewhat different from the other maps illustrated because the data are handled as choropleths rather than as cells. A choropleth is an area where all the information is uniform. Choroplethic mapping is less expensive than cell mapping because data are not stored cell by cell.

The output graphic characters are assigned value ranges, either manually or automatically. Maps can be accompanied by tables showing the frequency of distribution of output cells and, in the case of combination maps, by correlation matrices. Output map scales may be continuously varied by using a special printer. This allows the user to select an input grid size that is independent of output scale considerations. Another useful capability allows the "windowing" of different scale (and cell size) maps into specific portions of larger maps where greater accuracy is needed.

The choice of the number of variables to be interpreted and the number of shades of gray to be printed is critical in determining the clarity and usefulness of the product. If too many output categories are selected, it can result in a cluttered map that is difficult to interpret.

DISCUSSION

It is important to emphasize that LUMP can use data entered through boundary digitizing, the usual input mode, to produce grid maps of any desired cell size. This use of polygon (traced) input to produce inexpensive grid output is an important feature of LUMP. Polygon input is advantageous because it allows large numbers of crude, cheap (large cell) maps to be used during the experimentation phase of an analysis and more accurate, better looking (small cell) maps to be produced for display or publication.

The ability to produce inexpensive working maps permits trial-and-error testing of many different interpretive, combination, and evaluation maps. In this way, it is possible to develop an understanding of the relationships among geographic data. The use of small program modules for each task also keeps costs low. Finally, ALGOL, which uses pointers instead of formats, cuts computation expenses greatly over typical FORTRAN mapping programs.

LUMP was designed to be inexpensive and, at the same time, to allows lots of experimentation with working maps. The use of plotter (pen) output was rejected because it was extremely expensive and was not technically suited for the production of maps that combine a large number of variables. In general, computer maps produced on standard high-speed printers are not aesthetically pleasing because the intercharacter spaces are too great, the lines are not straight, and the ribbon quality varies from map to map. New special printer terminals are slower, but produce relatively high-quality maps. These maps are adequate for most uses and can be color enhanced by hand or transferred to traditional hand-colored transparent overlays, which can then be placed over typical cultural base maps for public presentations.

An image display system that produces a full-color image on a television monitor will be functional soon and will be used to produce full-color maps by using photographic techniques.

In 1976, Schwarzbart et al. evaluated seven computer mapping systems used by various United States Forest Service regions. The systems were classified into two broad categories—grid systems and line (or polygon) systems. When compared to polygon systems, it was found that grid systems were relatively inexpensive, but were quite limited in their capabilities.

LUMP exhibits the lower cost that is characteristic of grid systems and possesses capabilities found lacking in the systems discussed by Schwarzbart. If desired, LUMP can be interfaced with programs to produce plotter output. However, printer maps can be prepared in any desired cell size and at any scale because data are usually input and stored in polygons. Area calculations and statistical manipulations can be performed and scales can be changed internally. In output, polygon counts are feasible, overlays are not limited to two, plotter output is available, and shading can be done.

Schwarzbart's study found that the cost of a polygon system exceeded the cost of preparing manual overlays, regardless of the number of overlays desired. However, when six to seventeen overlays were needed, grid systems became more efficient in terms of cost than did manual production, depending on the details of the process. The LUMP system combines the advantages of both grid and polygon systems at or below the cost of typical grid systems.

SOME USES OF LUMP

Before describing some uses of LUMP for current projects, an important question needs to be considered: Does the work you are doing require or justify the use of a computer system? Only the individual user can completely answer this question, but several guidelines are helpful in making a decision.

The number of variables required to complete a specific project is the most critical factor in determining whether or not to use a computer graphics system. Only a few variables are easily represented by hand-drawn overlay maps. However, a computer graphics system can correlate large numbers of variables for analysis. For example, LUMP can "see" through dozens of overlaid variables for the purpose of evaluating data.

Another important consideration is whether the user anticipates a need for continued use of the data. Often, if the planning effort is small scale or on a one-time basis only, computer graphics systems have no advantages over hand-overlay methods because there is a large, fixed cost for input of data into the computer. In fact, there is the major disadvantage of having to train people to prepare data for input and in modes of input. However, modern electronics make computer data highly accessible on short notice once input has been prepared. Maps can be produced in a matter of hours, something that is not possible when maps are prepared by hand.

A third consideration is the complexity of the analysis desired. The number of variables, need for re-use, speed, analytical complexity, and cost are all factors that must be considered before selecting any computer system. If continuous use of the system is desirable or if complex maps are required, the use of a computer system is essential.

LUMP is currently used to analyze data for a wide variety of planning problems. These problems can be grouped into two broad categories: physical resource planning and socio-economic planning.

PHYSICAL RESOURCE PLANNING

In California, seismic safety is a major consideration in the design of structures. Numerous factors must be considered when determining potential loss from an earthquake or when determining necessary design elements for specific areas. This is true in the Santa Clara Valley, which lies near sea level between several major fault zones.

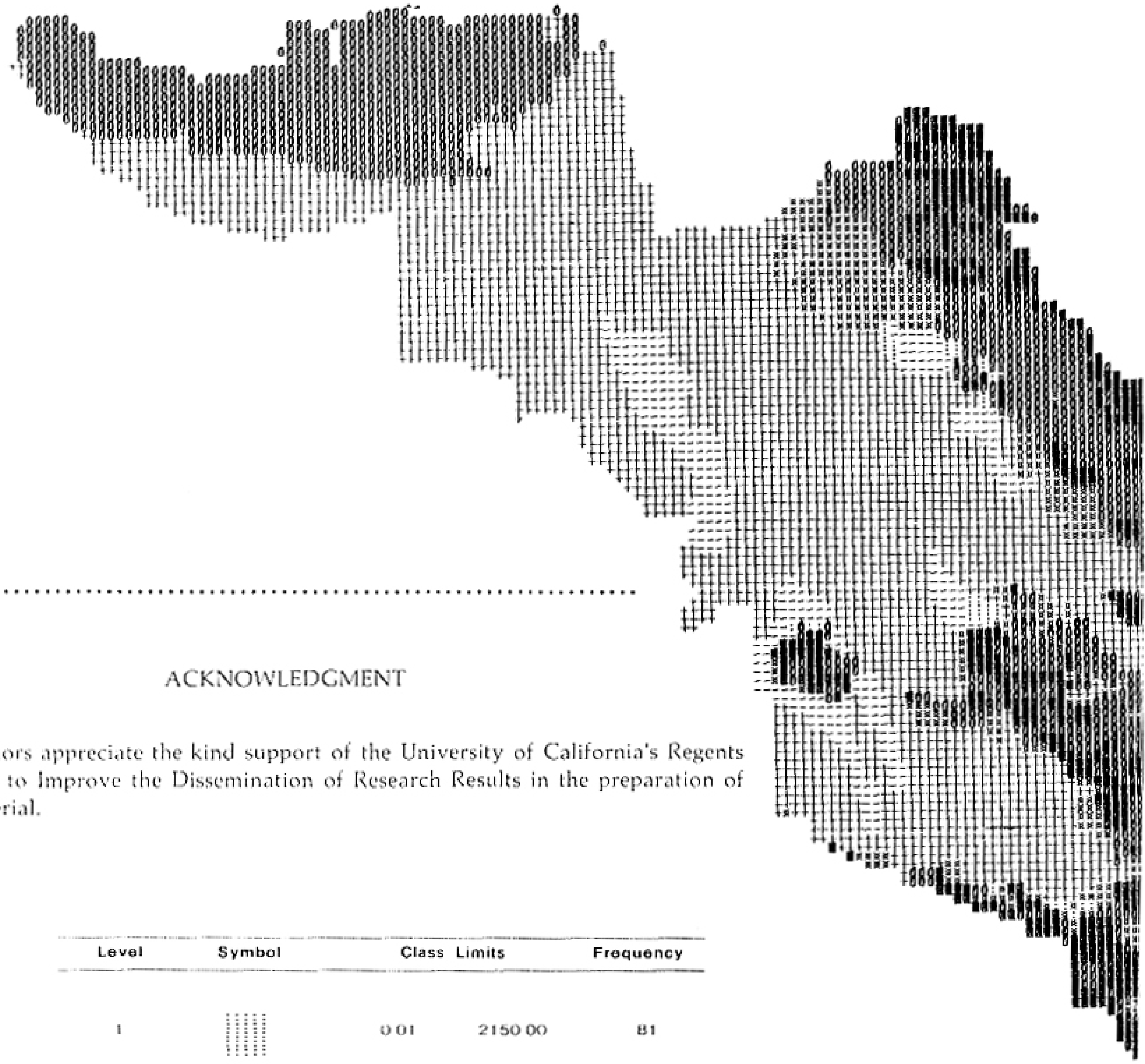
The Association of Bay Area Governments used LUMP to prepare maps of the potential cost of seismic hazards in the Santa Clara Valley. The costs of developing different areas of the Valley were estimated from ground cell calculations as a function of type of land use, level of geologic hazard, and value of mineral resources. The present value of future dollar costs was used in this example of an evaluation map (figure 8). The map depicts the future costs per acre of developing multifamily residential uses.

Another use of resource data is to determine if using land for urban purposes is in conflict with agriculture. See figure 4 for an example of a LUMP combination map showing urban and nonurban land uses combined with three levels of soil fertility in Sacramento County. The darkest shade shows where the most fertile agricultural land is being used for nonagricultural uses.

The map in figure 4 geographically displays areas that may be of future concern: agricultural lands that lie between urban areas. When a plastic overlay of cultural features is placed on the map, it shows that the dark area in the northwest corner, which is the Sacramento airport, is connected to downtown Sacramento by a major freeway. This corridor is well located for future development. It is also an area of excellent farmland. This conflict in potential uses is graphically shown by the computer map.

A third example of physical resource planning is the determination of prime agricultural lands for agricultural zoning. Prime land is land that can best be used for agriculture, but that can be defined in a number of ways. The use of different definitions can result in the inclusion or exclusion of areas of land from the prime category. Thus, the choice of definition plays a critical role in land use planning. Computer maps provide a useful mechanism for comparing different definitions of prime land. (See figure 3 for examples of such maps. In these examples, class limits are Storie Index ranges.)

In figure 3, map 1, prime agricultural land has been defined as Storie Index 80 to 100. Those areas considered prime agricultural land are printed in black. The other Storie classes are printed in various shades of gray. In figure 3, map 2, prime land is defined as Storie



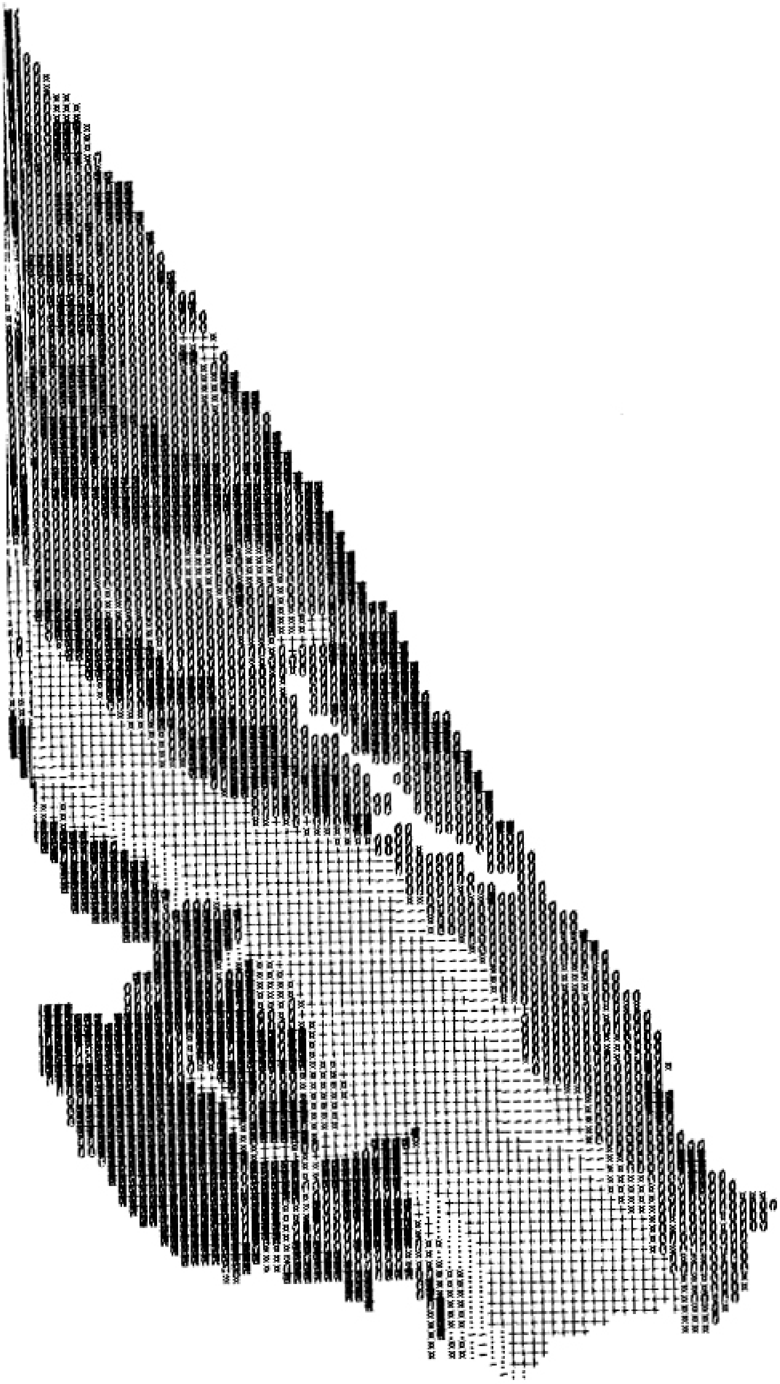
ACKNOWLEDGMENT

The authors appreciate the kind support of the University of California's Regents Program to Improve the Dissemination of Research Results in the preparation of this material.

Level	Symbol	Class Limits		Frequency
1		0 01	2150 00	81
2		2150 01	4630 00	337
3		4630 01	10000 00	3041
4		10000 01	21500 00	559
5		21500 01	46300 00	2230
6		46300 01	99999 00	1289

Figure 8. Evaluation map showing the costs of future development in relation to seismic safety in the Santa Clara Valley

Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA



Index 60 to 100. This class is printed in black. The lands treated differently by the two definitions are shown by the conflict map, figure 3. Computer analysis makes this difference obvious. The effects on this township (36 square miles) in Yolo County will be quite different, depending on which of the two definitions is used to define prime land. Both of these definitions are being considered in proposed legislation dealing with prime land in California.

The computer makes it easy to print maps using a wide variety of definitions, once the data needed for determining the classifications are entered into the master file. The advantage is that numerous definitions can be geographically displayed and the effect on particular locations, tax bases, and land use patterns can be readily determined.

LUMP was developed for use in planning and research problems and can be linked to resource models. One area of research uses geographically arrayed variables in various combinations to calculate new parameters. An example of this linking of geographic data to dynamic models is the use of mapped data to calculate erosion potential for watersheds. This type of mapping requires information about soil, topographic, climatic, hydrologic, and biological factors. To calculate erosion potential, these data must be known for each cell in a watershed. It is possible to make this type of calculation by creating a master file from maps and data files and then using the master file as input to an evaluation function. See figure 5 for an illustration of one system of handling these data.

Geographic data, such as soil and vegetation maps and land use, are digitized on an electronic digitizing table. Each digitized map is stored in a separate file on a magnetic tape or disc. Topographic information, water flow direction, and watershed basin and sub-basin identification are entered through the GRID/BASE program. These data are also on a separate magnetic tape or disc.

The information in all files is then merged into one master file so that each cell in the watershed is uniquely defined and each cell has all the information necessary for the erosion calculations. This master file is used as the data input mechanism for a special set of programs interfaced with the LUMP system. The results of the erosion program can be used to produce maps of different levels of erosion hazard. (See figure 6. The class limits in this figure are potential soil loss levels in tons per acre.)

SOCIO-ECONOMIC PLANNING

Among other questions, planners often ask how different zoning regulations will affect land values and soil erosion. Computer mapping can help answer this question. In the Nicasio Valley (Marin County), a 36-square-mile watershed was digitized in three zoning patterns—the existing zoning and two hypothetical schemes of ecologic zoning. Parcel boundary, scenic view areas, brush coverage, and land capability for urbanization maps were digitized. Data on assessed valuation, dwellings built, and Williamson Act status were also entered. Through evaluation maps based on economic models of land value and a model of soil loss, maps and tables were produced to estimate and display the effects of the three zoning patterns on land values, tax base, road view amenity, and soil erosion.

The source of much socio-economic information is the United States Census data stored on magnetic tapes. This information can be fed into LUMP software and computer maps can be used to show the geographic distribution of the data. Two examples are illustrated in figures 7 and 9 where tract data are handled as choropleths.

In a study of the level of neighborhood pedestrian dependency in a portion of Sacramento, this variable is defined as a function of the percentage of households without automobiles, the percentage of the population too young or too old to drive, and other variables taken from the housing and population census tapes. One or more census tracts are used to approximate neighborhoods. Freeway planners would try to avoid locating a route through neighborhoods that have a high degree of dependency on pedestrian travel.

Figure 9 shows the boundaries of minor traffic zones used in a multi-county transportation study performed by the Sacramento Regional Area Planning Commission in 1975. There are one or more of these minor traffic zones in a census tract and they have recently been used in crime analyses. Various crime data, reported by street address, are coded to census tract and minor traffic zones, analyzed, and mapped in an effort to make police services more responsive and efficient.

FUTURE NEEDS AND DEVELOPMENTS

LUMP serves a wide range of research needs within the University and land management agencies. As current projects expand or as new ones are started, LUMP capabilities will be added to meet new needs. Adding capabilities is a relatively simple and inexpensive procedure because current data files do not have to be rebuilt or re-designed. Instead, new software can be written to operate on existing or new master files. This will result in expanded flexibility of existing master files, since neither they nor existing programs will become inoperative due to new demands on the system.

The use of LUMP is expected to increase as the need for efficient handling and mapping of geographic data increases and documentation procedures improve. The system was not developed to compete with private industry systems, which are available on a contract basis to perform known production jobs. However, the development of LUMP will depend, to some degree, on the continuous presentation of new problems.

LUMP is in the public domain and program listings and manuals are available. If you wish more information about the applications of LUMP or other systems to planning programs, please contact the Division of Environmental Studies at the University of California, Davis.

REFERENCES

Johnston, R. A.; Thorpe, L. J.; and Long, T. H.
1975. "Land Use Mapping Programs." Unpublished report. Davis: University of California, Division of Environmental Studies.

Miller, William R.
1975. *A Survey of Geographically Based Information Systems in California.* Sacramento: California State Intergovernmental Board on Electronic Data Processing.

Nie, Norman; Hull, C. Hadlai; Jenkins, Jean C.; Steinbrenner, Karin; and Brent, Dale H.
1970. *SPSS, Statistical Package for the Social Sciences.* New York: McGraw-Hill.

Phillips, Richard L.
1974. "Computer Graphics in Urban and Environmental Systems." *Proceedings of the IEEE* 62(4):437-452.

Schwarzbart, Gideon; Hirsch, Ernest; Lennon, Thomas P.; Robertson, John R.; Rockey, Eugene R.; and Valjer, Ernst S.
1976. *Analysis of Computer Support Systems for Multi-functional Planning: Report III: Summary Report.* Berkeley, California: Pacific Southwest Forest and Range Experiment Station.

Thorpe, Linda J.
1977. *Land Use Mapping Programs: Users' Manual.* Davis: University of California, Institute of Ecology.

Tom, L., and Miller, L.
1974. *A Review of Computer-Based Resource Information Systems.* Fort Collins: Colorado State University, Department of Forestry and Wood Sciences.

Tomlinson, R. F., editor.
1972. *Geographic Data Handling.* Ottawa, Canada: UNESCO/IGU Second Symposium on Geographic Information Systems.

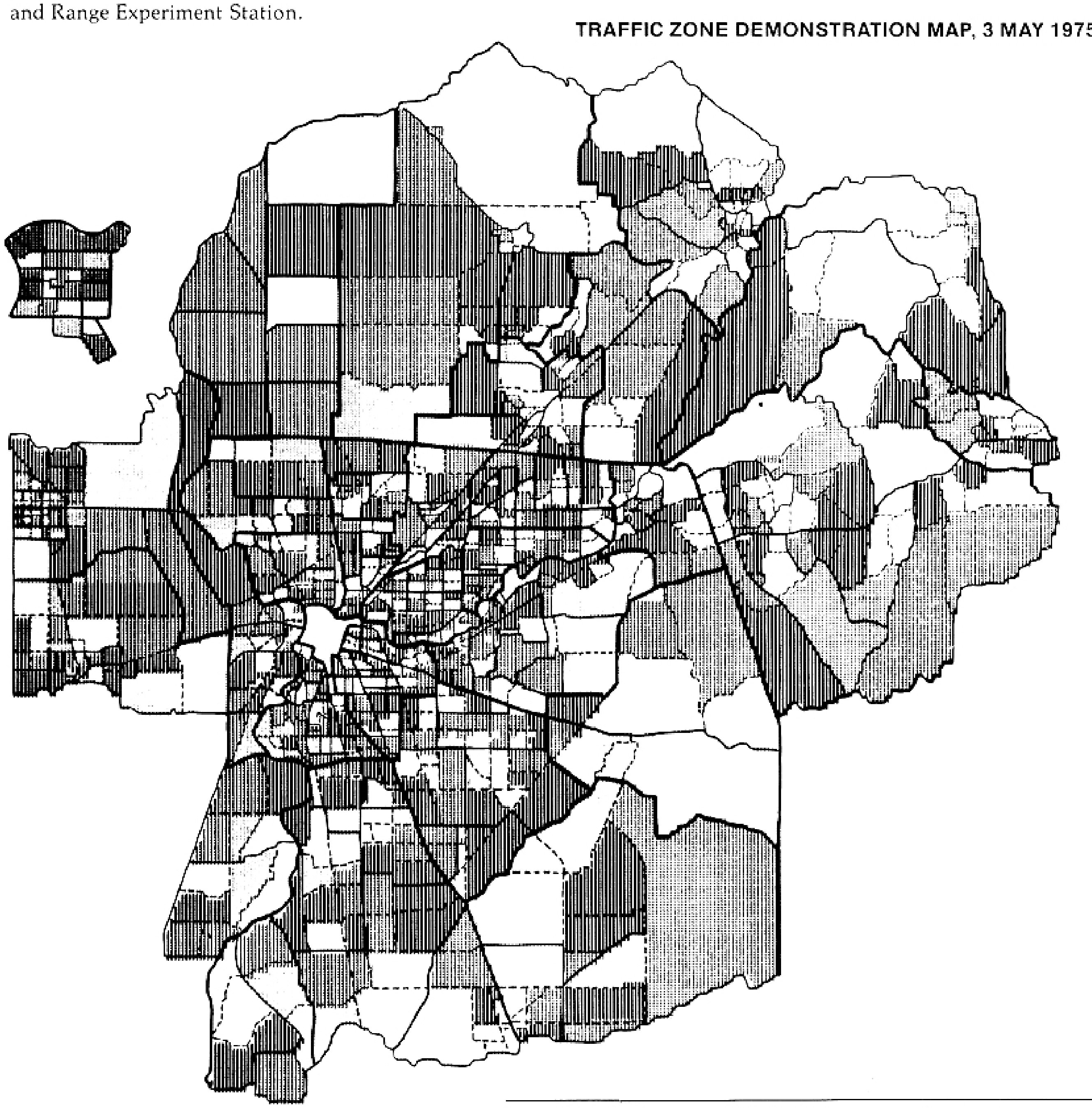


Figure 9. Inventory map of minor traffic zones in the Sacramento region.

UNIMAGINABLE IMAGES:
AN ART OF THE SPACE ERA

by Joseph P. Covington, III
Curator of Education
*Huntsville Museum of Art**
700 Monroe Street, S.W.
Huntsville, Alabama 35801

The Huntsville "International Exhibition of Computer Graphics" is a companion exhibition to "Art of the Space Era," which features artistic documentation of the exploration of space and the kinetic art that utilizes space age technology. Neither the space effort nor the advances in technology would have been possible without computers. These "thinking" machines are assuming a greater role in the existence of humankind. The current exhibition explores the relationship between computer technology and aesthetic exploration.

HISTORY

Computer-generated and computer-assisted art is still in its infancy. To attempt definitive judgment in this new field in 1978 would be as foolhardy as the condemnation of Impressionism a century ago before the experiments of individual artists had run their course and had begun to influence a new generation.

It was only a quarter-century ago that computers became commercially available. Less than a decade later, in the early 1960's, equipment was developed to allow graphic displays of the information retrievable from computers. Computer specialists and other scientists almost immediately realized the potential of computer graphics for science and industry.

The Bell Telephone Laboratories in New Jersey produced some of the earliest practical applications of computer graphics in industrial research. Dr. E. E. Zajac used a computer-generated film in 1963 to simulate the motion of a communications satellite. Bell computer specialists are responsible for many past and present experiments with computer visuals.

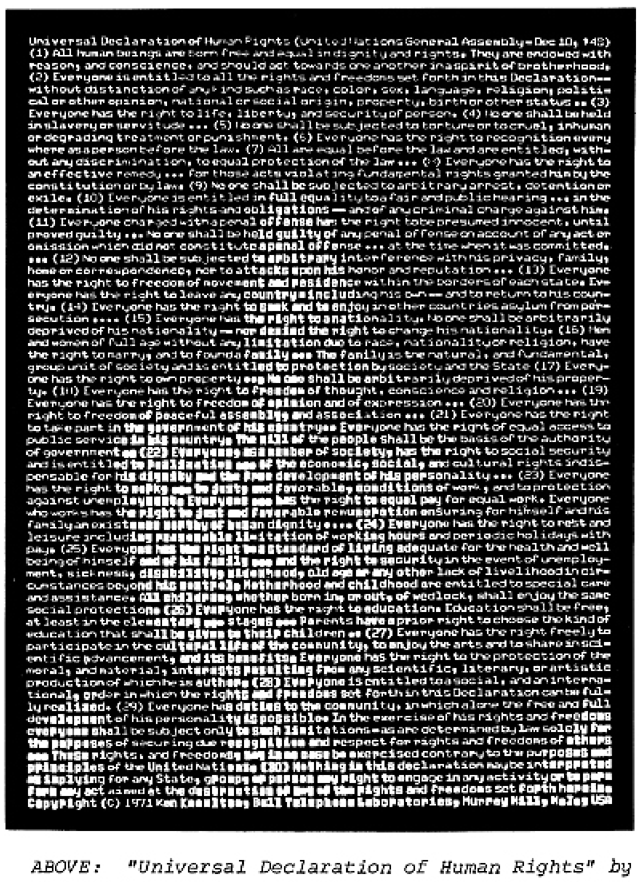
Boeing adapted the computer's capabilities to the visualization of several problems in airplane flight. It was Boeing who popularized the term "computer graphics," still the most common designation for two-dimensional works generated by computers. Science and industry continue to be the primary beneficiaries of the graphic output of computers.

EARLY COMPUTER GRAPHICS

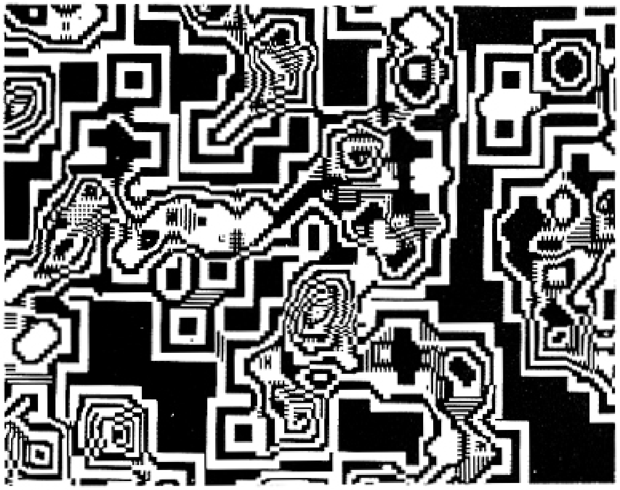
Producers of computer graphics very quickly conceived the idea of using the computer as a tool for producing art. Although the initial computer graphics were intended to illustrate mathematical and physical phenomena, these works pleased the sense of visual design of some scientists and, more importantly, at this stage, stimulated the imagination of others.

Early experiments were more interesting because of their implications for the future role of machines in heretofore exclusively human endeavors than for the intrinsic beauty of the works. Many people who saw pictures made with computer printouts dismissed them as curious by-products of technology. Nevertheless, the increasingly sophisticated techniques of scientists and the attempts by a few intrepid artists brought a measure of attention to computer graphics as art by the mid-1960's.

In 1968 the first important international exhibition of computer-generated art was organized at the Institute for Contemporary Arts in London, with the felicitous title "Cybernetic Serendipity." The principal organizer and editor of the accompanying book was Jasia Reichardt. Articles in this volume deal not only with computer graphics but also with the relationships between technology and many arts.



ABOVE: "Universal Declaration of Human Rights" by Kenneth Knowlton. CRT output. This is an example of computer techniques that has a strong social commentary. The work was executed in 1971.



ABOVE: "Tapestry" by Ken Knowlton and Lillian Schwartz, an example of early collaboration between computer scientists and artists. CRT output photograph.

John Cage wrote on computers and music. Wen Ying Tsai exhibited early examples of his lovely kinetic sculpture. Lowell Nesbitt contributed paintings, and James Seawright "Cybernetic Sculpture" (as they have again in the other current Huntsville exhibition on "Art of the Space Era").

The computer-assisted graphics of six artists in the Huntsville "International Invitational," Ken Knowlton, Stan Vanderbeek, Ben Laposky, Frank Malina, Peter Milojevic and Duane Palyka, can be compared to their contributions ten years ago in "Cybernetic Serendipity." Knowlton and Vanderbeek were then producing films which were primarily of an illustrative nature. Their recent prints are more colorful, more textural, and more aesthetically pleasing. Palyka has accomplished enormous stylistic advancements from mathematical printouts composed of typewriter symbols -- and with no direct artist contact with the computer -- to his recent, colorful works of imagination. Milojevic's work, similarly, now shows more humor and fancy than his earlier networks of lines and cubes. Malina is represented here, not by a kinetic light work, as in 1968, but by two miniature paintings of extra-terrestrial scenes. Perhaps Laposky is the most consistent of this group in that he is still producing oscilloscope photographs.*

BELOW: "Metamorphosis" by Jacques Dupre, Paris, France. CRT output, with emphasis on transformation of design.

The present state of computer-assisted art parallels somewhat that of kinetic art, as outlined by Carolyn H. Wood in "Art of the Space Era": after a period of excitement and optimism, technical difficulties have overwhelmed some early artists, who have abandoned the field to those who are dedicated enough to master the technical requirements, and to go beyond facile diagrams in search of genuine aesthetic achievement.

TECHNIQUES

Much of the resistance to computer-assisted art is founded on the mistaken assumption that the machine usurps the traditional role of the artist as creator. There may be an element of truth in this belief in that the artist as craftsman is, in some cases, supplanted by the automatic operation of the computer's printmaking function. The creative power, however, remains uniquely within the human mind; the computer performs according to its instructions. Any computer-generated image must be prepared by a program.

The computer's instructions must be fed into it in a way that the machine can handle. The "rules of the game" are determined for the computer by the "program," the set of instructions given by the programmer.

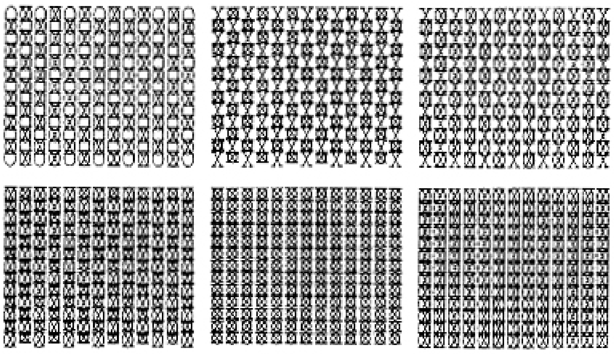
Programs are fed into the computer (hardware) on punched cards (software), which determine the coordinates of points, much like those on the "X" and "Y" axes of a graph. Lines connecting these points form linear drawings. There are several "languages" or sets of coded instructions in general use by computer programmers.

An important point in the development of computer-assisted art came when artists realized that accomplishing their objectives depends on the creation of programming languages that allow the sophisticated aesthetic thought of the artist to be transmitted to the computer. The necessary collaboration between artist and computer programmer is difficult and has limited the success of artists' experiments in this field.

The response of many kinetic artists to technical problems has been to use simpler technology. The nature of computers, however, requires sophistication and specialization of programs. The future of computer-assisted art may depend on the artists' mastery of computer languages so that they can produce programs suited to their needs. Much of the contribution of Kenneth Knowlton at Bell Laboratories is his authorship of programming languages for producing images.

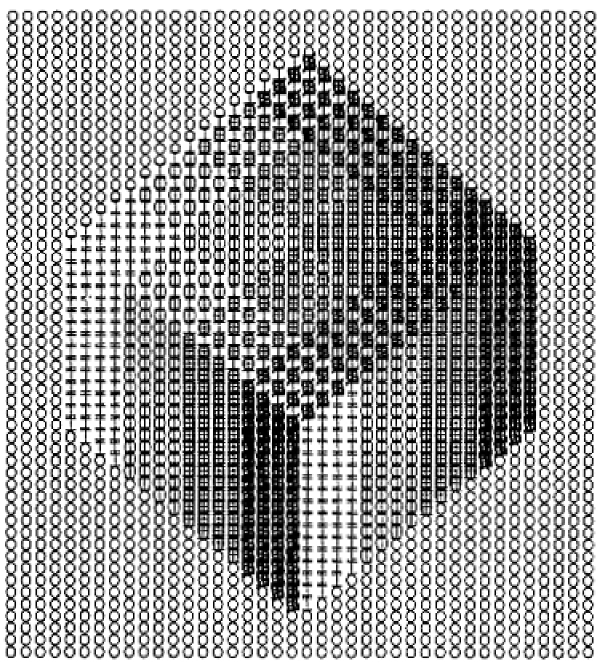
Computers do not make images. They simply store, organize and reproduce information which is fed into them. In order to generate a computer print, one of several types of devices must be added. These devices are either typewriters (line printers), plotters, or cathode ray tubes.

*For additional illustrations of works cited in this discussion, see the February and May, 1978 Computer Graphics & Art.



ABOVE: Line printer output by Klaus Basset, Stuttgart, Germany, with examples of varied patterns that may be achieved.

1. <u>Printers</u> - The first method of data retrieval from computers was the printout. By operating a typewriter, the computer can print verbal and mathematical information. Since these machines print typewriter letters and symbols in whatever order is asked of them by the operator, the symbols may be arranged to form a picture, rather than words. Some symbols appear darker than others and are used to print dark areas of the picture. Additional contrast can be produced by having combinations of symbols further darken some area. This method has the advantage of gradations of grey from black to white, but offers little intrinsic beauty unless greatly refined. Printouts are usually black and white pictures on industrial paper. Printout pictures based on scanned photographs can often be obtained in amusement parks, in which case they are more novelties than aesthetic works.



ABOVE: "Diagonale, Raumbeschreibende Matrixform" by Klaus Basset. These works have a specific appeal in their "solidity", departing from the linear emphasis so predominant in most computer art.

2. <u>Plotters</u> - The development of the plotter enormously enhanced the visual interest of computer graphics. A plotter is a device that, when given instructions by a computer, moves a pen to make a line drawing. While most early computer graphics were black and white, any color ink may be used in the plotter pen, and either in felt-tip or ball-point form. The drawings are, of course, linear -- with little variation in thickness of line. Texture can be produced by combinations of line patterns, as Jean Bevis does in his his "Seated Nude."

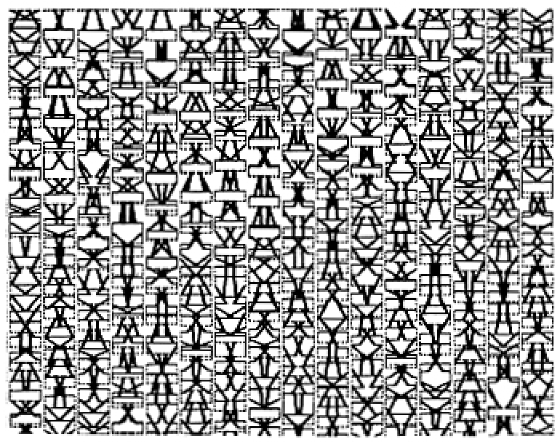
The plotter has the additional benefit of allowing in some cases, a variety of good quality papers to be used. If the paper moves, it must be of a kind that will go through the machine.

Many arresting visual diagrams describe curving lines based on the actions of physical forces; for example, the regular changing motion of a swinging pendulum, or mathematical functions. These patterns of curving lines, often overlapping to form variations of texture and shade, are called Lissajous figures, after the 19th century French scientist who used a mechanical device to describe them. Although among the most elegant early plotted drawings, Lissajous figures seem less prominent among computer-assisted artists than a decade ago.

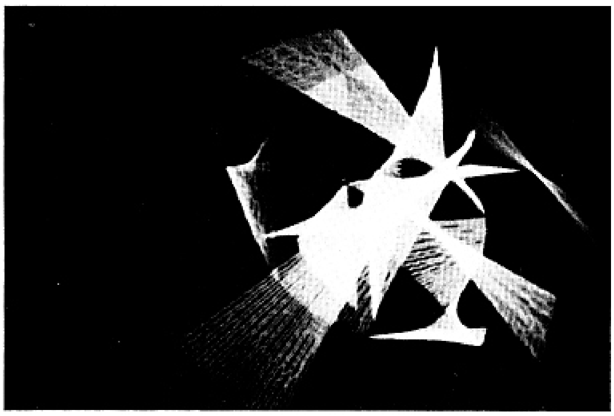
Plotters have produced a wide variety of images from representational to abstract. "Abstraction" is perhaps an appropriate term for many geometric forms taken from nature, but it is not applicable to purely nonrepresentational line patterns.

One gift of the computer to the artist is the capability of forming combinations of lines based not on his conscious or unconscious bank of images and associations, but on random numbers as coordinates. These patterns are abstracted from nothing, thus taking art a step closer to "art for art's sake."

The range of plotted drawings can be seen by comparing William Kolomyjec's easily recognizable "Flying Elephants" with Mutsuko Sasaki's "Maples in Storm," a combination of representational and nonrepresentational patterns produced on a CalComp plotter, and with Shao and Dunker's purely geometric "Zup Tze 30."



ABOVE: Detail of "Meta Language II" by Manfred Mohr, plotter output - an example of mathematics approaches to computer art.



ABOVE: Example from "The Flower Series" by Richard Land and Dan Cohen, CRT output. (See the May, 1978 Computer Graphics and Art for an article by the two artists.) Work is displayed in black and white, and then photographed with color filters.

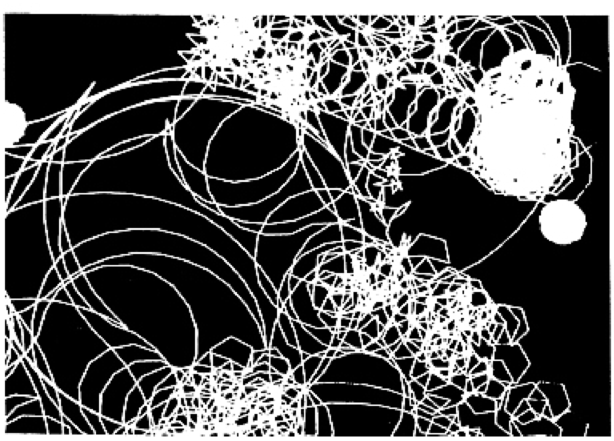
---

3. Cathode Ray Tubes - The third medium of computer graphics is the cathode ray tube (CRT). Ben Laposky pioneered printmaking with the CRT in the form of an oscilloscope as early as 1950. (Figure 7) Within the CRT, lines are produced by directing a stream of electrons at a fluorescent screen, rather like a television monitor. The image on the screen becomes a print only when photographed. This method has been used extensively for computer-assisted movies. In fact, many computer prints are "stills" from films.

The CRT gives the artist a measure of control, in that he may alter the image as he sees it appear on the screen before making a print. Originally white lines on black, CRT prints were later photographed in color by using combinations of red, blue and green filters for the primary colors of light.

Richard Land and Dan Cohen's Dance is a pattern of lines photographed in color from a CRT. Although "Dance" is a nonrepresentational pattern of curving lines, it suggests motion and the visual beauty of choreography. This work is one of a series called "Flowers" and "Birds," all linear abstractions and yet capturing some of the essence of delicacy and flight.

BELOW: Detail from CRT output in chemistry and physics teaching, by Charles J. Fritchie and Robert Morriss, Tulane University, New Orleans.



LIMITATIONS OF HARDWARE

The existing hardware for printing computer graphics has limited the development of the artists' aesthetic styles. Computer art has been dismissed by some critics who object to the linearity and the absence of color and texture in the drawings. Many artists have felt severely limited as well by their hardware. Their solutions to these problems will be seen in the discussion below of the "New Directions" in computer art.

THE CREATIVE IMPULSE

Two motivations direct the experimentation of computer artists: the intellectual and the aesthetic.

Computer graphics were born as diagrams of mathematical formulae and illustrations of unrealized objects in hypothetical situations; the ability of the computer to diagram these concepts remains the animating force behind much of the work being done.

Computer images transcend the level of illustration, however, only when the eye is stimulated along with the intellect. Some artists emphasize the intellectual quality or the sensory quality over the other.

THE INTELLECTUAL MOTIVATION

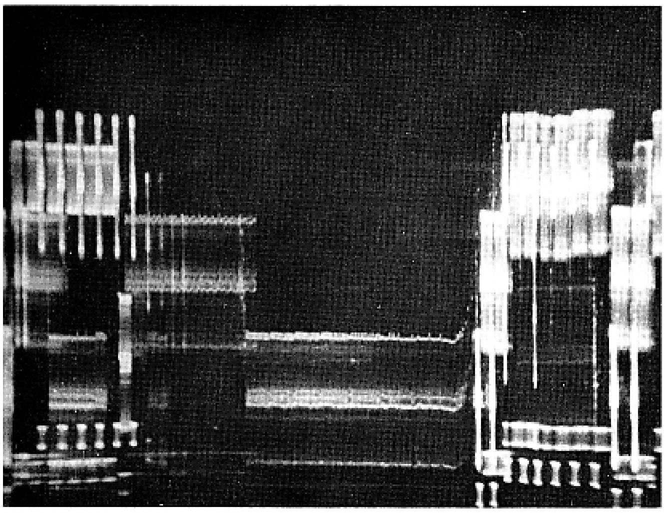
Scientists and mathematicians are more likely to produce diagrams based on logic than on intuition. The predominance of angular drawings from point-to-point plotting is a result of their scientific usefulness as well as of limitations on hardware. Manfred Mohr's art is typical of computer generated prints controlled by mathematics.

Many scientists and computer specialists have not responded enthusiastically to less rational art. The philosophy of Edvard Zajec presents this intellectual point of view: "The most promising aspect underlying computer art is the possibility for the visualization of thought ...the far reaching consequences that these new possibilities will have on the mode of expression are not to be seen in the art objects themselves (computer graphics) but rather in the process by which they were made." The emphasis in Zajec's statement, as in those of William Kolomyjec and other artists in the exhibition, is more on the cybernetic function of the computer in art than on aesthetic form.

THE AESTHETIC MOTIVATION

An attitude fundamentally different from that of Zajec is shared by artists who are object-oriented, rather than process-oriented. Vera Molnar's statement leaves no doubt as to her motivation: "The task of the painter is to create forms, combinations of forms, according to criteria called 'plastic' by aestheticians...'plastic' means 'a feast for the eyes.' A feast must have sensorial bases; painting which is not done for the eyes is not painting."

Molnar's "2500 Trapeziums" has a geometric appearance similar to that of many mathematically plotted drawings. Her work shows that geometry can be the source of both intellectual and sensory simulation.



ABOVE: "Scene Design" by Otto Beckmann, Vienna, Austria. CRT output from a hybrid computer system designed for this purpose by Otto Beckmann and his colleagues in Vienna.

James C. Ver Hague exemplifies the mathematician who, through experiments with computer-assisted forms, has discovered the intrinsic beauty of well designed objects.

It is -- in the tradition of Leonardo -- the scientist who is sensitive to the aesthetic value of form and the artist who has absorbed the knowledge produced through technology who will benefit most from computer art. It is the complete being who will produce the satisfying images that increase human perception of the world in some new way, the art Vera Molnar describes as "Unimaginable Images: An Art of the Space Era."

THE ROLE OF GEOMETRY IN COMPUTER ART

The intellectual significance of a large number of computer images lies in the computer's exploration of the geometric structure of the universe. The graphic function of the computer is based on coordinate geometry. By manipulating horizontal and vertical coordinate points, the hoputer reveals the configurations possible from a given set of instructions. A semiotic analysis of geometric structure is impossible here, but some classification can be made of the approaches to geometric structure by the artists in the exhibition.

Artists may either break natural forms into simple components (analysis) or combine forms into superstructures (synthesis). Either of these operations, which the cubists anticipated throuth intuition, can be accomplished in the computer by logic.

GEOMETRY: THE ANALYTICAL APPROACH

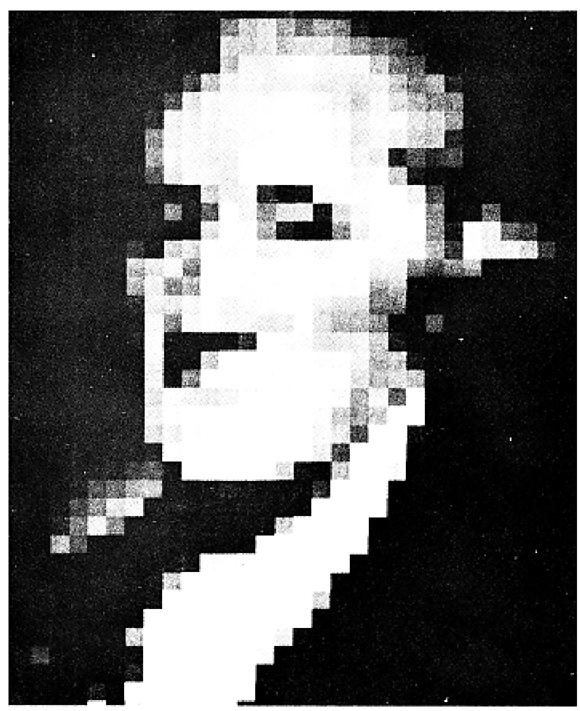
Three artists have used machines to analyze the structure of objects. E. T. Manning's block picture, "Werhner Von Braun" simplifies the human form into squares of various single colors. This process utilizes an optical processor to accomplish a task somewhat reminiscent of Cezanne's analysis of objects in planes of color. Lillian Schwartz in her "Lillian II" transforms a human face into tiny blocks, ranging in shade from black to white. She also separates and shifts planes, causing structural permutations. Representing a different subject, Otto Beckmann's "Architecture of Stage" analyzes white and black. These black and white masses have the effect of an x-ray photograph, which eliminates the unessential portion of an object so that one may recognize the sub-structure.

GEOMETRY: THE SYNTHETIC APPROACH

Synthesis is the principle underlying the structure of a considerable number of computer-assisted designs. Edvard Zajec's "Scherzo for Matrix and Figures" overlaps simple shapes formed by bold black lines. The combinations of rectangles, triangles, and ovoid figures are delimited within rectangular frames. The entire series of eight compositions together on one sheet of paper form a superstructure.

The apparently random distribution of Zajec's varying figures contrasts with the very regular organization of Shao and Dunker's "Zup Tze 30." The latter is a tightly constructed shape composed of reiterations of lines and crosses. "Zup Tze 30" suggests the harmony of nature, while Zajec's figures give an impression of diversity.

Other comparisons place in relief the variety of syntheses among the linear, geometric products of the computer. Javier Segui's combinations of lines and circles seem to represent chaos in comparison with Vera Molnar's subtle, rhythmic variations on the theme of the trapezoid. Herbert Franke's "Sicogram" and Mutsuko Sasaki's "Maples in Storm" both convey energy in motion by building patterns of small rectangles, but the former is a sharp, angular movement, while the latter depicts a switling rhythm appropriate to its subject.



ABOVE: "George Washington" by E. T. Manning, 7' X 9' - an example of a spatially quantized image.

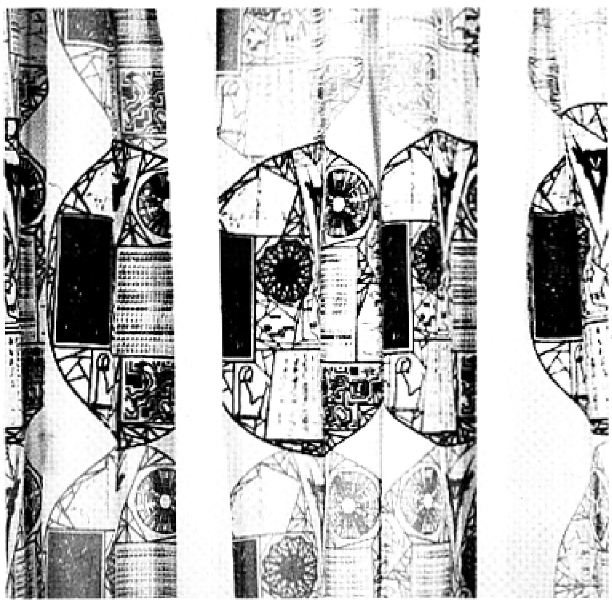
Some artists' experiments in synthesis probe the function of syntactic relationships. Manuel Barbadillo speaks of the computer-generated modules arranged in his serigraphs as his "alphabet." He uses this modular alphabet to create larger structures. The drama of his syntheses, usually in groups of four modules, comes from the differing perception of the four modules because of their positions in the group. The Groupe Couleur de Belfort creates a similar syntax with two modules. Here the halves are matrices of flat colors containing reverse rectilinear patterns. Since the two modules are otherwise identical, color and the position of the pattern function as morphemes within the syntactic structure.

GEOMETRY: THE AESTHETIC APPROACH

Geometry -- whatever its significance within a work -- is also a link between computer-assisted imagery and the aesthetic theories of some of the most important artists of the 20th century. Mondrian is a precursor of much computer art in that he introduced simple geometric shapes as a subject of art. He began painting representational landscapes and then distilled his designs to geometric shapes. Mondrian's many experiments with combinations of rectangles could be carried out in a tiny fraction of time by a computer. Recognition of the aesthetically successful combinations would, of course, depend on the eye of the artist.

Computer-generated images frequently meet the criteria of minimalist art set by Frank Stella and others. Geometric forms are perfect material for the construction of more representational pictures for their own sake, pure visual objects. The stripe paintings of Stella or Morris Louis might be compared with some of the computer works of Robert Mallary.

BELOW: Detail of a computer-designed textile by Grace C. Hertlein. In the past three years, the artist has experimented with computer art applications in textiles and wallpapers.



Perhaps the most widely accepted artist who is associated with computer-aided art is Josef Albers. Albers' Bauhaus philosophy of bringing art through technology to a mass audience is being continued today by the Groupe Couleur de Belfort, who have applied computer-assisted images to subway decoration. Albers' interest in serial imagery predated his computer prints by several decades but reached its conclusion in the series "Embossed Linear Constructions" produced at Gemini G.E.L. in Los Angeles in 1969. These embossings were printed from plates engraved by an entirely automatic process activated by digital tape. Albers had written in 1942 that the effects of his prints based on parallel lines "require the use of ruler and draughting pen and establish unmodulated lines as a legitimate artistic means. In this way they oppose a belief that the handmade is better than the machine made, or that mechanical construction is anti-graphic or unable to arouse emotion."[1]

NEW DIRECTIONS

The emergence of more versatile hardware now allows more varied forms and richer color in computer-assisted art. Artists are currently drawing on special tablets which allow input to the computer to be more painterly and less linear, more organic and less angular. The "Strange Bird" of Duane Palyka, executed with a frame buffer and film, perhaps goes furthest from geometry among the works in the exhibition. The image is fantastic and organic. It is also disturbing to one's sense of logic and order. This type of work subjects the rationality of the programmer to the imagination of the artist.

The hybrid (analog-digital) computer used by Otto Beckmann yields further variety of form. While there is an element of similarity among most analog computer graphics, the hybrid computer is more versatile and enriches the field with new styles.

In addition to new means of generating images, there are now more ways of printing them. A great number of computer-assisted artists are dissatisfied with the limitations of the plotter and the CRT. Since about 1975, they have enhanced the color, texture, and painterliness of their computer-assisted works by transforming computer designs into serigraphs or paintings. Manuel Barbadillo considers his printout pictures only quickly produced sketches to be transformed by him into works of art like his serigraph in the exhibition. Grace Hertlein's silk-screened textile work is an example of the application of computer-generated patterns to decorative arts. Stan Vanderbeek, an early computer filmmaker, is represented here by etchings. These artists have not lessened the importance of computer-generated images; rather they have multiplied the media in which computer designs can be printed and thus have increased the artists' control of the aesthetic value of the finished works.

The shift to traditional art media by some artists after years of experimentation with computer images may indicate the beginning of a period of maturity in computer-assisted art.

---

[1] *Quoted by Riva Castleman in* Contemporary Prints*, New York: Viking, 1973, 146 pages.*

computers and people formerly *Computers and Automation*

The magazine of the design, applications, and implications of information processing systems.

BERKELEY ENTERPRISES, INC.
815 WASHINGTON ST.
NEWTONVILLE, MASS. 02160
617-332-5453

Dear Friend,

You may be interested in our monthly magazine "Computers and People" (formerly "Computers and Automation") -- the oldest magazine in the field of computers and data processing, published since 1951.

Our policy is to publish factual, useful, and understandable information related to computers, their applications, their implications, and society, and controversies connected with the computer.

Our authors have included:

Dr. Jerome B. Wiesner, President, Mass. Inst. of Technology
C. P. Snow, English statesman, author of "The Two Cultures"
Prof. John Kenneth Galbraith, Harvard University
Ralph Nader, consumer advocate
Dr. Simon Ramo, Chairman Executive Committee, TRW Inc.
Dr. Carl Sagan, Cornell University

and many more distinguished persons with important views

We would like to offer you a subscription, whereby if you subscribe now and send payment, we will send you TWO FREE issues -- and we refund your money within 10 days if the magazine is not satisfactory to you.

HOW CAN YOU LOSE?

May we hear from you?

Yours sincerely,

Edmund C. Berkeley

Edmund C. Berkeley
Editor, Computers and People

ECB;bc

TO: Berkeley Enterprises Inc., 815 Washington St., Newtonville, MA 02160

( ) YES, please send me ( ) 2 FREE sample issues. I enclose:
( ) payment of $11.50 annual subscription price (U.S.A.), or
( ) my organization's purchase order, signed

( ) My name and address are attached

COMPUTER GRAPHICS AND ART

COMPUTER GRAPHICS and ART is a new international quarterly of interdisciplinary graphics for graphics people and computer artists. This new periodical is aimed at students, teachers, people from undergraduate and graduate institutions, researchers, and individuals working professionally in graphics. Its topical coverage is broad, embracing a variety of fields. It is useful, informative, entertaining, and current.

IT'S RENEWAL TIME

THE STATE OF THE ART OF *COMPUTER GRAPHICS AND ART*

COMPUTER GRAPHICS and ART is a new international quarterly of interdisciplinary graphics for professional graphics people and computer artists. COMPUTER GRAPHICS and ART is now in Volume 3 of publication.

This periodical is aimed at students, teachers, people from undergraduate and graduate institutions, researchers -- and individuals working in graphics. Its topical coverage is broad, embracing a variety of fields. It is useful, informative, and current.

CONTRIBUTING EDITORS TO *CG&A*

Alfred Bork, Univ. of California, Irvine
Charles Csuri, Ohio State Univ., Cleveland
Herbert W. Franke, Munich, Germany
Arthur W. Luehrmann, Dartmouth College, Hanover, New Hampshire
Abraham Moles, Univ. of Strasbourg, France
Nicholas Negroponte, Mass. Inst. of Technology, Cambridge, Mass.
Jackie Potts, Social Security Adm., Baltimore, Maryland
Eric Teicholz, Harvard University, Cambridge, Mass.

ADVISORY BOARD MEMBERS

Edmund C. Berkeley, Editor and Publisher, Newtonville, Mass.
Charles Glassmire, Robert Morris College, Coraopolis, Pa.
Kenneth Knowlton, Bell Labs, Murray Hill, NJ
Frank Malina, Editor, Leonardo, Paris, France
Frieder Nake, Univ. of Bremen, Germany
Joseph Raben, Editor, Computers & the Humanities, Queens College, Flushing, NY
Richard Speer, Evergreen State College, Olympia, Washington

COMPUTER GRAPHICS and ART is edited by Professor Grace C. Hertlein, California State University, Chico. Her work in pioneering computer graphics and art courses has received national and international recognition. She is a writer, bibliographer, artist, and educational innovator, and her work is featured in many national and international conferences.

COMPUTER GRAPHICS and ART is a magazine that encourages participation from its readers-- in the form of articles, papers, illustrations. We cordially invite your participation.

Send your manuscripts, papers, art, and ideas to:

Editor, *COMPUTER GRAPHICS and ART*
Berkeley Enterprises, Inc. – Chico Branch
555 Vallombrosa – No. 35
Chico, California 95926

TO: COMPUTER GRAPHICS AND ART
Business Office
Berkeley Enterprises, Inc.
815 Washington St.
Newtonville, MA 02160

( ) Please enter my PERSONAL (U.S. & Canada) subscription for $10 per year.

( ) Please enter my FOREIGN PERSONAL subscription for $13 per year.

( ) Please enter my LIBRARY/DEPARTMENTAL subscription for $15 per year.

( ) Enclosed is my PERSONAL CHECK and/or PURCHASE ORDER.

( ) Enclosed is $2.50 for a SAMPLE COPY of CG&A, applicable toward a subscription.

FULL REFUND IN 30 DAYS IF NOT SATISFACTORY.

Name ______________________

Title ______________________

Organization ______________________

Address ______________________

____

HERE IS YOUR OPPORTUNITY FOR FEEDBACK TO US:

( ) I hope to submit material for publication on the following topics ______________________

( ) I am interested in reading materials by the following authors ______________________

( ) I am interested in coverage of the following subjects ______________________

( ) Additional comments (attach another paper if needed) ______________________

SPECIAL RATES FOR VOLUME 3

Special rates apply to students and to members of computer graphics and art societies. Please attach evidence of membership with application.

PERSONAL, SPECIAL: $8 per year, USA & CANADA. FOREIGN SPECIAL: $11 per year. (See page 2 for details.)