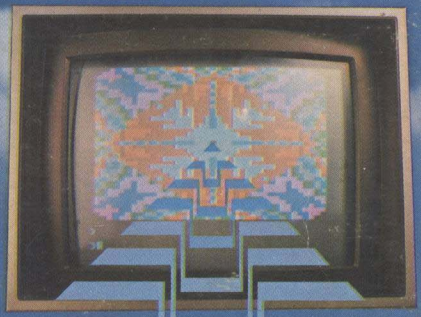
COMPUTER GRAPHICS PRIMER

By Mitchell Waite



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by
Mitchell Waite

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Preface

Perhaps no single technology has had more impact on people than television. Yet according to the experts the real impact is just starting.

The reason? Home computers that connect to a standard television and convert it into a machine with more raw power than any product ever offered to the consumer and with the capability to completely alter the way we relate to the visual world of electronics.

This book is about one of the most exciting uses of the new home computer products—computer graphics—the ability to create complex drawings, plans, maps, and schematics on the screen of an ordinary black-and-white or color television. It is divided into three chapters. Chapter 1, "Perspectives," presents what the entirely new field of home computer graphics is all about, explains how it got started, and illustrates some of the exciting applications for low-cost graphics displays. Chapter 2, "Basic Concepts," introduces the general hardware and software concepts behind computer graphics and continues by presenting a profile of the numerous products on the market today. A section on graphics accessories is also included.

Chapter 3, the meat of the book, is entitled "Graphics Programming." It introduces the graphics features of the Apple II computer used for this book, and then goes on to describe these concepts: plotting simple equations; drawing lines and vectors; creation of simple geometric shapes (rectangles, triangles, polygons, circles) as well as gaming figures (small tanks, jets, cars, rackets, animals); mandalas and other com-

puter art effects, including tunneling; shape shifting, random artwork; detailed drawings and the use of digitizing tables; and, finally, moving figure animation.

The first two chapters of the book can be read any time and will be of help in evaluating which personal computer to buy for graphics work. The third chapter can be studied whether or not you own a computer, but your understanding will certainly be enhanced if one is available to practice the examples on.

The author hopes that you find this journey into computer graphics exciting, comprehensive, and, most of all, enjoyable.

MITCHELL WAITE

To Tony Clemintino

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chapter 1

Perspectives

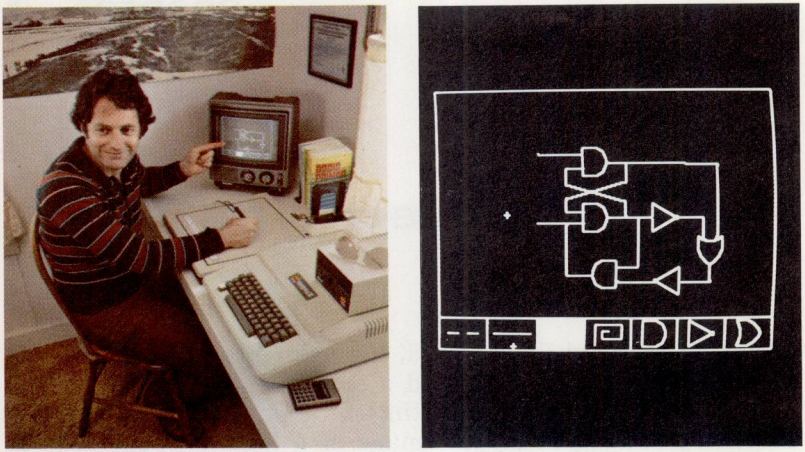
Rod leaned slightly forward, his eyes intently fixed on the screen before him. He pressed a small pen to the surface of a special digitizing table sitting in front of the computer. On the screen appeared the image of a logic element used in circuit schematics. As he moved the pen along the surface of the table the logic gate element floated out of the menu area and followed his movements on the screen, just as if the gate had been "captured" or hooked by the pen. The logic gate could be moved anywhere on the screen by his simply tracing the pen across the table. Amazing!

Next, when Rod had seemed to find the right place for the gate, he pressed the pen down gently on the table and the gate froze in place on the screen. Rod moved another gate up from the menu area and placed it next to the first. Rapid movements followed and soon wires appeared connecting the gates together. Finally the schematic diagram of a flip-flop circuit emerged on the screen, complete with lines indicating inputs and outputs in proper sequence.

Rod leaned back. A satisfied grin spread across his face as his partner stared wide-eyed in disbelief. "I see it but I don't believe it," his partner said.

Fig. 1-1 shows what Rod's partner had witnessed: the creation of a complex schematic diagram on a low-cost graphics computer. What made this schematic special was that no paper was ever used, no erasers, no whiteout, no ink, and no cutting. Everything was done on the screen of a low-cost computer. A special digitizing table allowed Rod to input his movements

to the computer. A program in the computer created the logic elements on the screen and allowed them to be moved from a menu area into a drawing area, then fixed there while wires were drawn from one point to another. A logic element could be rotated and moved elsewhere in seconds. Erasing was possible by simply reversing the drawing color to black.



(A) Setup of equipment. (B) Closeup of display screen.

Courtesy John Werner

Fig. 1-1. Creating schematic diagram by computer.

Sound like the future? Well it's not; in fact this very system can be purchased today, complete with drawing and design software, for under $1500. And you can learn to use it in less than an hour.

This book is about this and other aspects of the latest hobby and consumer market to sweep the nation—personal computer graphics, a new form of visual experience that utilizes low-cost personal computers in ways never before dreamed of.

WHAT IS A GRAPHICS COMPUTER ANYWAY?

It is a new breed of computer that can draw pictures on the screen of a television in ways up to now never imagined. It is a product that is available to the consumer today for under $1000. It can draw intricate pictures from simple programmed instructions or from pen movements on a special digitizing table. It can make a shape grow from a tiny, hardly visible point to a shape larger than the screen. It can rotate shapes through 64 different angles of a complete circle in a

fraction of a second. It can draw in eight different colors. It can draw the floor plan of your house faster than you can blink an eye, or it can just as easily plot the path of an orbiting satellite.

Personal computer graphics is a new activity that has developed around the numerous low-cost personal computers on the market today. Before the appearance of the personal computer there was no computer graphics, or, to be more exact, the buying public had no access to computer graphics. Occasionally we saw computer graphics effects in movies and television commercials. Or perhaps we saw a magazine cover with a computer design. Meanwhile, university and corporate scientists, engineers, and technicians were having all the fun playing with these powerful machines.

WHAT'S BEEN GOING ON?

The list of uses for computer graphic applications is for all practical purposes endless. To appreciate this consider the following examples of typical applications by end users of computer graphics equipment.

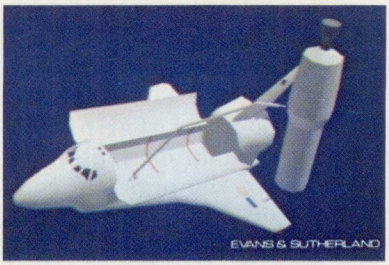
At NASA, for example, designers have created computer simulations of the actual flight of experimental aircraft. All aspects of the flight are programmed into the computer. Everything the pilot would see out the window of a real aircraft appears on the crt screen of the computer (Fig. 1-2). Safe at the display console a pilot can try difficult landings knowing that a crash simply means running the program again.

Fig. 1-2. Computer-simulated landing field.

Courtesy Evans and Sutherland

Recently NASA has used computer graphics to perfect the motions of the new Space Shuttle so it can maneuver with an attached telescope. (See Fig. 1-3.)

On the architectural front, computer graphics are used to help design complex building structures on the crt screen.

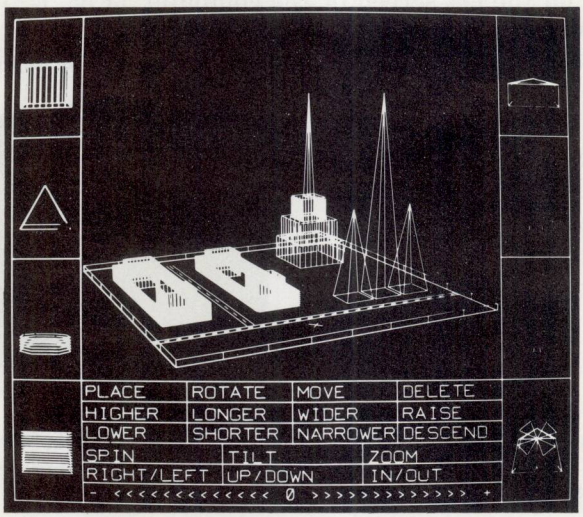


Courtesy Evans and Sutherland

Fig. 1-3. Simulating space shuttle with telescope.

Using special graphics controls the designer can maneuver the positions of the structures anywhere in three-dimensional space, even upside down. Special graphics programs allow the designer to manipulate perspective and scale to show the structure as if it were being viewed from a helicoper. See Fig. 1-4.

How does computer graphics help people care for their health? With new whole body scanners medical investigators are using computer graphics to view the complex parts inside the human body. The computer is fed information from a special scanner that circles around a person lying on a table. Once this information is inside the computer, a graphics "program" constructs a three-dimensional image of any part inside the body on the screen and in full color. (See Fig. 1-5.)



Courtesy Evans and Sutherland

Fig. 1-4. Architectural structures can be moved about.

Fig. 1-5. Internal organs may be represented from any viewpoint.

Courtesy Evans and Sutherland

From the display console the researcher can rotate the image, change its color, and even go inside it and look outwards. Such powerful devices allow researchers to probe the inner mysteries of the human body.

Motion pictures have begun to use some of the fantastic graphics technology. For example, in the movie *Star Wars* the scene in which the rebel pilots are briefed on the workings of the "Death Star" was done completely on a graphics computer. (There is a rumor circulating that Bally's new home computer uses a graphics language modeled after the one used to make the Death Star scene.)

The poor artist, however, has had little exposure to the capabilities of graphics computers. Only a specialized group of professionals with skills in computers, art, and engineering have had an opportunity to play with computer graphics (Fig. 1-6).

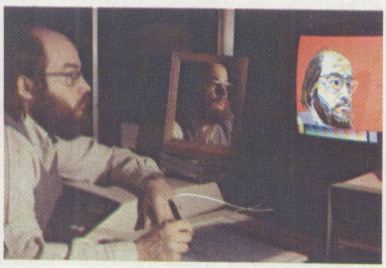


Fig. 1-6. Artists may utilize computer graphics.

Courtesy Evans and Sutherland

Now that personal computers have dropped in price so as to be no more expensive than a good stereo system, thousands of people are discovering the incredible potential that can be had with these devices. Soon we will see computer graphics being used in ways never before possible.

WHAT IS POSSIBLE TODAY?

The things that can be done with graphics-oriented home computers cover so many possibilities that it would take a separate book to describe them. Therefore we will touch on the most obvious uses, with a reminder that we are just scratching the surface of a deep and complex subject.

Education

Unquestionably the most noticeable effects of low-cost graphics computers will be in education. To understand this, consider that a major factor that makes a scientist great is the ability to visualize a complex idea. For example, some of the world's most honored mathematicians had an incredible ability to see intricate structures in their "mind's eye." What does this have to do with graphics computers?

Consider using a graphics computer to help teach a calculus class. The instructor would set up the graphics program so that students would see a mathematical function (curve) on the screen of the computer. Next the program would approximate the curve with straight-line segments, then start to make the segments smaller and smaller until they reach the limit and perfectly match the original curve. The students would "see" the process of differentiation. This graphics technique can be applied to integration, statistics, algebra, mathematical logic, and so on.

Visualizing abstract concepts in physics can be radically enhanced with the graphics-oriented home computer. For example, the orbits of planets can be traced out so students can watch the subtle perturbations of the orbit. The flight of a rocket or the flight of a bird can be followed. Electromagnetic fields, and for that matter any kind of field, can be instantly drawn out on the computer. Color can be used to accentuate certain features of the field, or to give it a three-dimensional nature. In fact, if green and violet are used to draw two slightly different views of the same object and then green and violet glasses are used to view the computer screen, a true stereoscopic (three-dimensional) image can be obtained!

In electronic technology and engineering classes the graphics computer can be used painlessly to draw and redraw circuit diagrams as we saw in our introductory example. The inner workings of a pn transistor junction could be dramatically illustrated with flowing electrons, a barrier field, floating holes, impurities, and so on. The flow of electricity could be watched, as could the effects of resistance, voltage, and power.

Ecological interactions can be animated on the graphics computer, and students can study the effects of nature, artificially speeded up or slowed down by the computer program. Modeling the gait and movements of animals is another possible use for the graphics computer. The list is endless.

Industry

Any industrial process that involves a flow of materials can take advantage of computer graphics. For example, in chemical manufacturing the computer can draw a real-time schematiclike picture of the process as it actually occurs. Colored pipes show the flow of materials, temperatures are indicated in color, as well as the position of valves (open or closed), the level of liquids in holding tanks, and so on.

Detroit will soon use computer graphics to simulate all the instruments in an automobile dashboard. Instead of several different gauges, there will be a single liquid-crystal flat-panel display in front of the driver (like the kind used on the new digital watches), and the gauges will be displayed and updated on the flat-panel "screen."

In the electronics industry the graphics-oriented computer is used for generating printed-circuit board patterns, complex