

# Microcomputer Graphics and Programming Techniques

Harry Katzan, Jr.

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## Preface

The most popular segment of the small-computer field is graphics, wherein images can be processed and stored through the use of a variety of computer hardware devices. In recent years, traditional computer graphics capability has been enhanced on several microcomputers through the use of color coding. As a result, a common interface can be made with a color monitor or TV set and color presentations can be made for business, educational, or artistic purposes. This book provides an introduction to computer graphics for small computers and covers recent advances in color coding and computer graphics technology.

The book will be of interest to persons engaged in everyday small-computer applications since the techniques inherent in computer graphics technology are common to most applications. Typical areas of major small-computer applications are:

- Engineering design
- Personal/home computing
- Data processing for small business
- Education
- Scientific analysis
- Business analysis

Graphics technology is inexpensive and is included in many small computers as part of the total systems package. This book tells how to use this valuable resource.

*Microcomputer Graphics and Programming Techniques* is complete and covers everything a person needs to know to do computer graphics. Topics covered in the book include:

- Basic computer concepts
- Modern graphics technology

- Graphics programming
- Low-resolution computer graphics
- High-resolution computer graphics
- Color coding
- 3-D computer graphics
- Projection techniques
- Rotation and presentation

Inherent in the above list of topics is the objective of the book: *to familiarize the reader with modern graphics technology*. After reading the book, a person should be able to do the following:

- Understand basic computer concepts and programming
- Understand computer graphics techniques
- Be able to write a computer graphics program using low-resolution or high-resolution graphics
- Enhance an image using color coding
- Understand projection and rotation

The subject matter of the book, the textual material, and the programs themselves have been class tested with architecture, art, design, and other fine arts students at Pratt Institute in New York. However, the usefulness of the book is not limited to the classroom. Small-computer graphics is of general interest to the professional person and to lay persons alike.

The book is complete with illustrations, examples, and listings of actual graphics programs. In fact, the book contains over 20 practical graphics programs worth several hundred dollars.

To a large extent, this book is a tribute to the small-computer field and the exciting world of microcomputers. The programs were written for and run on an Apple II Plus microcomputer system. Moreover, each program was “picked over” and understood by many students with nontechnical backgrounds. And that’s progress.

It is a pleasure to acknowledge the cooperation of my wife Margaret who assisted with manuscript preparation.

Harry Katzan, Jr.

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# Introduction to Small-Computer Graphics

One of the most popular applications of small computers is graphics, wherein a person with the assistance of a computer is able to generate visual images for business analysis, for artistic design, for entertainment, or for science and engineering purposes. Intertwined with the above applications is the educational dimension of small computers wherein the "computer in the classroom" can be used to augment traditional teaching methods. Through the use of computer graphics, all aspects of computer-assisted instruction, data analysis, and problem solving can be made more meaningful when information is presented in a visual form. Computer graphics has been used with architectural presentations, advertising, and even sports. The overall impact of a computer graphics presentation can be very great even though the level of sophistication of the computer technology employed is relatively low. Thus, a business person, designer, engineer, teacher, artist — to represent only a few professions — can effectively use computer graphics without being a computer expert. The objective of this book, therefore, is to present the subject matter of computer graphics in such a manner that it is accessible to the person who is definitely not a computer specialist.

## THE COMPUTER ENVIRONMENT

The computer environment for this book is the small computer that can be purchased at a computer store. Two popular names for equipment of this type are the personal computer and the home computer.

## 2 MICROCOMPUTER GRAPHICS AND PROGRAMMING TECHNIQUES

Some typical computers in this class are the Apple<sup>TM</sup>, the TRS-80<sup>TM</sup>, the Atari<sup>TM</sup>, and the PET<sup>TM</sup>. As computers go, these machines are relatively inexpensive, ranging in price from \$500 to \$6000. These limits are given only for informational purposes. Also, several computers in this class have more expensive counterparts intended primarily for small-business applications. The information presented in this book applies to these "larger" computers as well, since they almost always contain computer graphics facilities.

Even though modern small computers are not expensive, they are powerful. In fact, a computer about the size of an ordinary office typewriter has approximately the same computing power as a room full of computing equipment had only 20 years ago.

The small computer to which we are referring can be properly classed as a *microcomputer*. Some people refer to these computers as microprocessors, but to be perfectly accurate here, it is important to note that the term *microprocessor* denotes only the processing element of a microcomputer system, and not the other components of the system such as memory, display, and printer. In addition to covering computer graphics, this book also introduces modern computer technology. Full comprehension of the computer words is not necessary at this point.

This book has a natural orientation to microcomputers, but the computer graphics techniques that are presented are not limited to this class of computers. The methods apply equally well to larger computers, normally classed as small-business computers, mini-computers, medium-sized computers, and large computers.

Many microcomputers have the capability for color coding, so that multicolored visual images can be generated. In general, the methods of computer graphics apply equally well to black-and-white displays and color displays. The capability for generating color is a characteristic of the computer. However, a "color" device, such as a color TV set or a color monitor, is additionally needed to display a multicolored image.

### TYPICAL GRAPHICS SYSTEMS

In order to do computer graphics, a person needs a computer and a display device, such as the system shown in Figure 1.1. The display device is usually an ordinary TV set or a special device known as a



Figure 1.1 Home/personal computer system. (Courtesy Apple Computer Inc.)

display monitor. The computer is normally housed in the keyboard unit that contains the microprocessor, the memory, and the control circuitry of the computer. The keyboard is used for data entry, and output appears in textual or visual form on the screen. This description gives a minimum configuration. In order to store information, a tape cassette unit or a disk unit is needed. For hard-copy output, a printer is needed. Figure 1.2 depicts a more comprehensive computer graphics system within the “small-computer” domain.

The equipment covered above constitutes only the hardware of the system. Another ingredient that is needed in a graphics system is *software* — a term taken collectively to denote the commands and

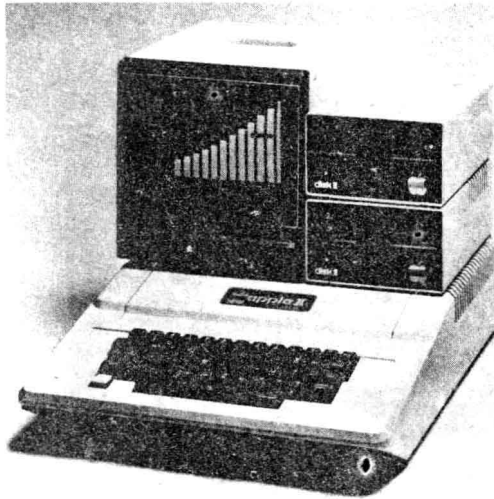


Figure 1.2 Microcomputer system. (Courtesy Apple Computer Inc.)

instructions that control the operation of the computer. In order to do small-computer graphics, you need both hardware and software.

Simple commands entered at the keyboard permit a person to do elementary computer graphics, but the results are not very dramatic. In fact, this chapter contains an example of a visual image generated only by commands entered at the keyboard. More complex images require the use of a *program*, which is an ordered collection of computer instructions. When the computer instructions are executed, a visual image is generated on the screen.

Graphics programs can be obtained in one of two general ways: A person can write his or her own program or a program can be obtained from an outside source. In order to make your own program, a knowledge of basic graphics technology and of computer programming methods is needed. The objective of this book is to supply both types of information. When a program is obtained from an outside source, it is either purchased, leased, borrowed, or received free of charge. Programs in the latter category tend to be more sophisticated because they are developed for widespread distribution. Although some knowledge of graphics technology is needed to use a "packaged" program, it is usually less than is needed to actually develop the program. Some of the names com-

monly associated with packaged programs for small-computer graphics are "the electric crayon," "the computer paintbrush," and so forth.

## FAMILIAR APPLICATIONS OF COMPUTER GRAPHICS

Computer graphics applications for medium to large computers are very complex and very sophisticated in advanced technological developments. This field is for specialists normally concerned with military and industrial control activities. For example, advanced graphics techniques are commonly employed with military and space systems, transportation systems, and energy management. Most of us have seen in real life or in the movies or on television large control rooms in which graphics displays are being used to monitor some sort of complex activity.

Small-computer graphics does not require a high degree of specialization and is frequently used in advertising, business presentations, games, engineering and science, and education. A common example of small computer graphics would be a television advertisement wherein a multicolored image, such as a human face, is generated by a computer as a collage of reasonably small rectangles — each of which can be individually color coded. This is an example of "low-resolution" graphics.

In a business presentation, data are conveniently displayed as a "pie chart" or as a frequency histogram. When graphic information is displayed as a collection of lines and points, as compared to rectangles, the technique is known as "high-resolution" graphics. This book introduces both low-resolution and high-resolution graphics.

In education, for example, the presentation of simple arithmetic can be enhanced by using visual images for the pupil to manipulate, such as adding two baseballs to three baseballs and then generating, in one form or another, a result of five baseballs. Computer games are commonplace and usually involve an interchange between the user and the computer for manipulation of moving visual objects such as automobiles, space ships, and Ping-Pong balls. In engineering and science, microcomputers are connected to laboratory devices and results are displayed in graphic form.

Figure 1.3 shows an assortment of small-computer graphic images.

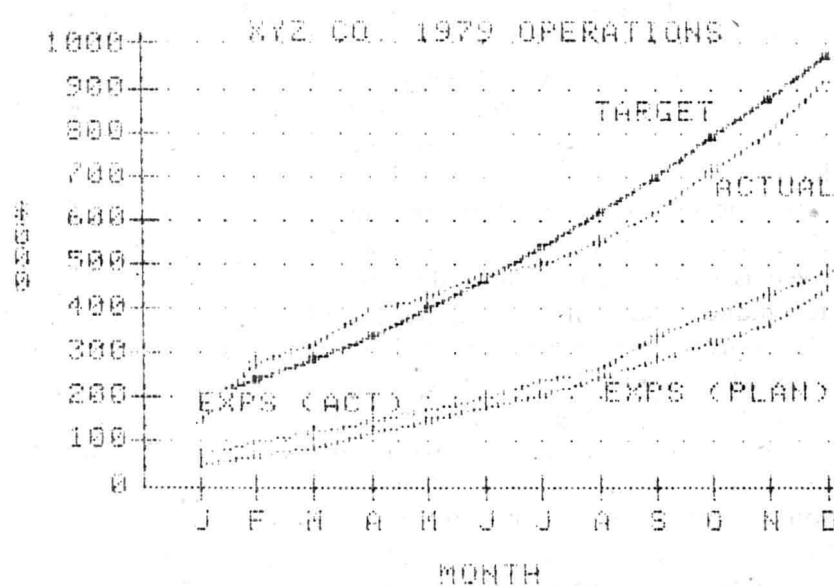


Figure 1.3 Assortment of small-computer graphic images.

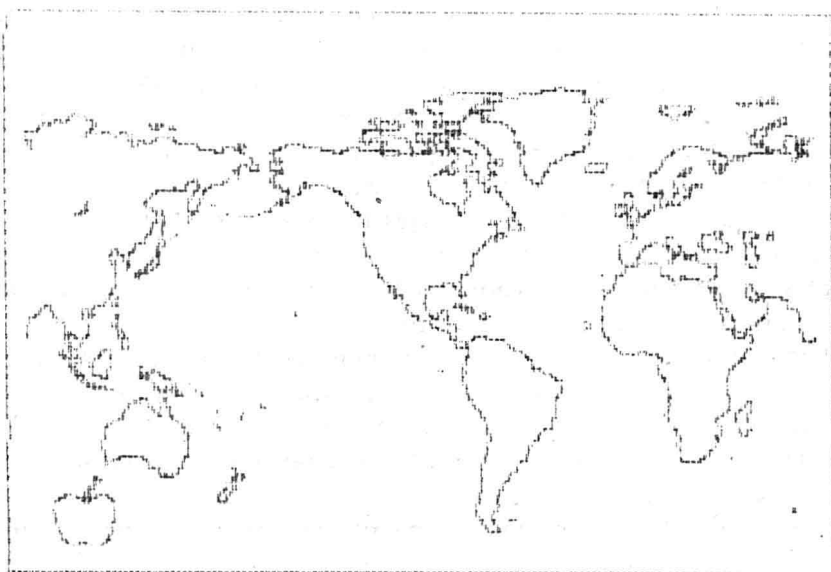


Figure 1.3 (Continued)

## THE GRAPHICS SCREEN

Since the device used to display computer graphics can in fact be a television screen, it is feasible to conceptualize the graphics screen as an ordinary television set. However, in some cases, the graphics screen is a black-and-white or color monitor device. In all cases, the result is practically the same. In order to put information on the screen, it is necessary to specify where the information should be placed. With most display systems, three modes are available: text mode, low-resolution mode, and high-resolution mode. Some graphics systems do not provide all three modes and others combine them to some degree. It is useful to cover them separately here. As explained later in this section, nominal values are given for the size of the screen, under the assumption that it is always better to deal with concrete ideas.

### Text Mode

In the text mode, the screen can be used to display 24 lines of characters with each line containing up to 40 characters. Each character is formed from a dot matrix that is five dots wide and seven dots high. There is a one-dot space on each side of the character and a one-dot line above each line of characters. Effectively, each character occupies a position on the screen that is seven dots wide and eight dots high. Figure 1.4 gives the 5 X 7-dot matrices for the commonly used computer characters. The text mode is used for the display of textual information, such as programs, reports, instructions, options, and operational menus.

The line positions on the screen are numbered 1 through 24, where line position 1 is on the top and line position 24 is on the bottom. Figure 1.5 gives a map of the text screen. The user normally does not have to be concerned with screen line positions when displaying textual information. Lines are displayed one below another until the screen is full. Then, the contents of the screen scroll up one line position as each additional line is added at the bottom. When text is combined with graphics, screen position is significant, and that is where the line position is used.



