COMPUTING IN THE '80s

GRAPHICS ON MICROCOMPUTERS

J E LANE

NCC
The National Computing Centre

GRAPHICS ON MICROCOMPUTERS

J E LANE

PUBLISHED BY NCC PUBLICATIONS

FOREWORD

This publication is one of the outputs from the work that the NCC has been carrying out in the microprocessor field. In particular, it reviews the current trends in graphics on low-cost microprocessor-based systems and provides information on a number of commercially available products.

It is not intended to provide an in-depth study of graphics systems; the aim is simply to overview this area of computing in the light of the recent rapid changes in technology, and thereby promote an awareness amongst existing computer professionals and potential users of small systems. Because it is quite likely that a large number of such users will not have a graphics background, a brief introduction to the subject is included. This is developed in the final chapter to provide a wider feel for the subject beyond 'just making adjustments to display screen controls'.

ACKNOWLEDGEMENTS

Many people and organisations have assisted in the preparation of this publication and their contributions are gratefully acknowledged. In particular, thanks are due to the following for reading the draft and for their varied and helpful comments:

Derrick Grover	CAD Group, NRDC
Dr Paul Middleton	Negretti Automation
Richard Packham	Tektronix UK
Tim Roberts	Hi-Tech Electronics

I would also like to thank the following organisations which responded to my requests for specific advice and information:

Acorn Computers
Apple (Microsense Computers)
Commodore
Compucolour
Cromemco (Micro Centre)
Hi-Tech Electronics
ISC (Techex)
Radan Computational
Research Machines
Tandy
Tektronix UK

John Lane

Senior Consultant

NCC

The Centre acknowledges with thanks the support provided by the Computers, Systems and Electronics Requirements Board (CSERB) for the project from which this publication derives.

GRAPHICS ON MICROCOMPUTERS

CONTENTS

INTRODUCTION

Microcomputers are increasingly being utilised in a wide variety of applications covering a whole spectrum of environments. The physical size of the microcomputer and the developments in microelectronics also point towards a significant change in computing. Today's new 16-bit processor chips are being benchmarked alongside mid-range minicomputers. Large memory arrays with 16K memory chips pack 256 Kbytes into desk top computers, whilst the availability of 64K memory chips make tomorrow's memories even larger. In addition, the future use of 32-bit processor chips, 256K memory chips, and the theoretical unlimited size of bubble memories indicate the potential power and future growth of microcomputers.

This changing technology, coupled with an associated growth in computer applications, is creating new influences on the market place, particularly in the field of computer graphics and information display. Improved raster and colour tube technology, along with the availability of inexpensive read/write memory and microprocessors, has encouraged the development of low-cost computers with user-friendly graphics.

Computer graphics has been available for a number of years, but only recently has it become inexpensive and more friendly through the availability of small, low cost computer systems.

It is no longer necessary to dedicate large sums of money and effort to acquiring graphics since desk-top computers and microcomputers can now provide a level of graphics capability together with stand-alone computing power. Also software which offers turnkey solutions to business, statistics, engineering and scientific applications is now available.

This publication explores the type of graphics which is becoming increasingly available in these low-cost systems. It aims to promote an awareness of current practices and trends amongst existing computer professionals and the many potential users of microcomputers. Because a large number of these people are only likely to possess a limited knowledge of display technology and graphics techniques, a brief introduction to the subject is included.

After introducing the fundamentals of graphics systems, the publication concentrates on an examination of microcomputer and desk-top computer graphics systems. It illustrates the types of facilities available in practice by describing in some detail several examples of typical products. The remaining sections amplify the preceding descriptions, and at the same time, provide a closer look at graphics 'picture building' techniques used in microcomputers. Practical examples of popular microcomputer systems are included to illustrate the points made.

1 INTERACTIVE COMPUTER GRAPHICS SYSTEMS

Introduction

Interactive computer graphics systems have gained tremendous popularity since the appearance of the first minicomputer-based system less than ten years ago. One reason for this growth stems from the fact that a user needs very little understanding of computer technology to operate the system. An interactive computer graphics system appears to the user as a drafting and design tool dedicated to a specific function, for example electrical schematics drafting, mechanical component design, etc.

ICG Systems

A typical interactive computer graphics (ICG) system comprises a mini or microcomputer, a graphics input device, a graphics output device, a graphics display terminal and associated computer peripherals, for example, disks, printers, etc. In addition to the hardware, a software package which accepts graphics input and interaction and produces graphics output is provided.

In a typical installation, the user sits at a workstation comprising the display and keyboard and a graphics input device such as a digitizing tablet. To make a drawing the user simply selects a function such as DRAW LINE, DRAW CIRCLE

or ERASE LINE, often from a menu mounted on the tablet. The menu can include symbols, which the user can place on the drawing by selecting a symbol, then selecting the place it is to appear. In this way the system helps the user to construct the drawing.

Computer graphics data appears in two main formats, vector and raster.

In the vector format system, pictures are represented by lines, circles, arcs and splines, each of which can be symbolically represented in the computer by expressions that include the type, the co-ordinates of critical points, eg the end points of a line, or a parametric description, eg a formula for a geometric shape.

Graphics features are described by listing the co-ordinates of the points that characterise them, and stating the connectivity relationships between the points. Empty areas are not described.

In a raster format system, pictures are evenly divided into picture elements, or 'pixels'. Each pixel can have attributes, such as shade, colour or membership in some class of data. The picture is totally described by its component pixels; empty areas are described by empty pixels; each pixel is represented by a memory address. Raster displays produce pictures by covering the picture area, pixel by pixel, with impressions corresponding to the attributes of each pixel.

More information on graphics formatting is given in Chapter 4.

Peripherals

In addition to the associated computer peripherals, ie disks, printers, etc, a wide range of graphic input/output devices are available with ICG systems. In particular, numerous types of hard-copy output devices are offered. One example, the pen plotter, is very popular for line drawings. Plotter bed sizes typically range from 8½ ins x 11 ins to 6 x 40 ft, speeds from 1 to 45 ins. per sec, resolution 0.01 to 0.0005 ins and number of pens from one to eight. Electrostatic printer/plotters are also widely used as are matrix impact printers which provide an inexpensive, low-resolution alternative. For colour graphics, there are colour graphics copiers which interface electronically with the terminal and copy the image on the screen onto paper. Many vendors offer colour plotters, including interactive digital plotters which can produce camera-ready plots in as many as nine colours on paper or transparencies. Both optical and electronic cameras are available which reproduce the screen image on photographic paper, on 35mm slides or on plastic transparencies.

ICG systems accommodate a wide variety of graphics input devices, eg digitizers, joysticks, trackballs, thumbwheels and light pens. Digitizers are utilised for entering the relative positions of points on a plane, the others usually being used to position a cursor on the graphics display.

Software

Most ICG systems operate under standard minicomputer operating systems such as Digital Equipment Corporation's RSX-11M or Data General's AOS. Utility routines are usually incorporated which enable the user to develop application programs and link them with a graphics database.

ICG software also includes application and graphic subroutines such as basic graphics capabilities, eg drawing and editing lines, arcs, splines, symbols, etc; database management capabilities and facilities for linking with user-written programs in high-level languages such as FORTRAN.

ICG suppliers offer many application programs covering a wide range of user requirements. The number of uses for ICG systems increases daily, particularly as hardware costs decrease and software becomes more reliable. Significant application areas to emerge include process control and modelling, and computer-aided drafting and design.

2 DESK-TOP GRAPHICS

Introduction

Interactive graphics has been available on minicomputer systems for a number of years, but has only recently become inexpensive through the availability of desk-top computers and microcomputers.

A typical system, costing under £5,000, will comprise a microprocessor, a display unit, keyboard and backing store. Initially most desk-top computers provided monochrome display only, but the market is now seeing the gradual introduction of systems with low-cost colour graphics.

Hardware

Based on one of the popular microprocessor chips, eg Intel 8080, Motorola 6800, the CPU provides memory (RAM) for display refresh (in refresh systems) and user work space (typically 32 Kbytes). A wide variety of disk and cartridge tape drives are normally utilised for storage of data, programs and screen pictures. As an example a mini-floppy disk, up to 80 Kbytes, or a 300 Kbyte magnetic cartridge tape drive is included as an integral part of the system. The provision of a serial RS232/V24 interface allows the desk-top to be used either as a stand-alone computer or an intelligent terminal with a host computer. In a number of instances the

additional provision of the IEEE-488 standard or General Purpose Interface Bus (GPIB) allows the connection of a wide range of peripherals and scientific and industrial instrumentation thereby widening its scope of applications eg process control, laboratory automation.

Software

Desk-top computers in the majority of cases are programmed in BASIC, although because of their prominence in scientific and industrial markets, a FORTRAN compiler is often provided. An extended BASIC interpreter is normally utilised. Standard built-in features typically include maths and trigonometric, and character string functions and facilities for program preparation, memory management, program control, interrupt handling and input/output. Additional graphic commands ease the production of software for the creation of graphic images. For example the command MOVE X, Y, moves the electron beam to the specified X, Y co-ordinate position; the command DRAW X, Y, draws a line from the current position to the position specified by X, Y.

Desk-top computer software is structured hierarchically. At the bottom level of the hierarchy are device drivers and primitives that interface the software to graphic devices. At the top level are the application programs necessary for the user's requirements. In between these two levels are application and graphic subroutines, which make it

unnecessary for the user to program at the lowest level of graphic software.

An example of such routines can be seen in the Tektronix PLOT 50 Graphics Software Library. Available for their 4050 range of desk-top computers, this software provides routines aimed at the user in business, scientific and general purpose applications. These include mathematics, statistics, electrical engineering, graph plot, business planning and analysis and other general utility programs. On the one hand, mathematical routines include root finding, co-ordinate conversion, Bessel functions, linear programming and Fourier Transformation to aid the engineer and scientist; on the other hand, the business planning and analysis routine aids the use of graphics in commercial and business operations.

Another example is the data plotting package offered by Radan Computational Ltd, which allows the Commodore PET personal computer to be integrated with a Tektronix plotter. Data can be transferred from the PET to the plotter, scaled up or down, titles added and axes drawn. Alternatively, information from the plotter can be read optically and fed back to the PET.

In a similar manner, a number of application packages are offered as an alternative to user-written software. Both these approaches serve to minimise the user's involvement in software development and thereby encourage a more productive use of his time.

Applications

Graphics can be regarded as having varying levels of complexity. For example, the lowest level might consist of simple two-dimensional charts and graphs, eg bar charts and function plots, or simple symbolic representation; the next highest level having two-dimensional or polygon drawings and more complex symbolic representation; and the highest level consisting of three-dimensional drawings, hidden surfaces and images or 'real-world'simulations. At present, most desk-top graphics applications could be regarded as first level with some overlap into the second level. Typical applications include business charts and engineering plots of funtions. Applications at the second level might include simple circuit design work or display of a basic process control diagram. Applications at the highest level tend to require more processing power and a higher performance display system than that possessed by the desk-top computer.

To illustrate further the types of facilities which are found on many desk-top computer and microcomputer graphics systems, the next section provides descriptions of typical products.