PRESENTATION

GRAPHICS

FOR ENGINEERING, SCIENCE AND BUSINESS
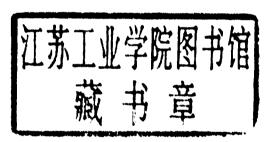
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Presentation Graphics for Engineering, Science and Business

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Preface

Industry, commerce, finance, government, education, and all scientific fields of technology are depending more on communicating knowledge and ideas through some form of audio or visual presentation. Several colleges and universities (like the University of Strathclyde) now include the subject of Communications in their lecture topics, covering a range of audio and visual presentation techniques. The chapters in this book cover examples for the visual presentation of graphics for engineers and scientists.

The use of a microcomputer (like the IBM PC) to analyse and display graphs and charts, rather than tedious columns of data, has revolutionized modern business reports.

Some twenty-seven different types of graphics presentations are included in the six chapters of this book (Table 6.1). Listings are given for twenty-nine programs, including two menu programs, three data entry programs, fourteen screen display programs and nine plotter conversion programs.

No prior mathematical knowledge of statistics is required to use the programs, and thus the text is suitable, not only for practising engineers and scientists, but also for college or university students who wish to enhance their reports. This book assumes the reader does have access to a microcomputer and is familiar with a BASIC programming language.

Each of the BASIC computer programs in this book can either be run independently by the first time user, or, the programs from any one chapter can be linked together to create a suite of programs. The latter option is only recommended to the experienced computer user with plenty of computer memory to spare. The programs could also be incorporated into a Computer Assisted Learning (CAL) package for students studying statistics.

To simplify the typing of programs, considerable use is made of utility routines, which are described at the end of chapter 1, and the listings given in Appendix A.

Also included in the Appendices are the computer listings used to create the figures used for illustration, together with a list of the global variables used. Example computer printouts are presented, together with computer graphic screen dumps to both dot-matrix and ink-jet printers and also plotters.

As some readers may wish to convert these programs to run on alter-

native microcomputers to the IBM PC, a conversion table of graphics commands is included. All printout routines follow a standard format with no ESCape codes, so they should run on any ASCII or IBM PC compatible printer. Users of my previous book *Computer Graphics for Surveying* will find they can now import their contour data files for display in full colour, either as shaded contour maps or as surface models.

I am extremely grateful to Professor A. McGown, the current chairman of the Department of Civil Engineering at the University of Strathclyde for his encouragement in publishing the results of my research work. I would also like to thank Mrs Sheena Nelson of the Mechanical, Civil and Chemical Engineering Drawing Office at the University of Strathclyde for assistance in the preparation of the hand-drawn figures in the book.

I am grateful to both Mr Michael Dunn and Mr Nick Clarke for helpful contact and advice in editing the book, especially in connection with the graphics presentations and computer listings.

Finally I would like to thank my family for their patience, support and understanding during the preparation of the book. I would also like to thank my two sons, Robert (studying Information Engineering at University) and Gordon, for assistance with the computer programming. This book could not have been completed without the wholehearted support of my wife, Helen, whom I thank most sincerely for her helpful suggestions and perseverance in typing the complete manuscript.

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PROGRAM DISC AVAILABLE

This book contains many lengthy program listings once all the routines have been added. To save typing them into your computer, the programs are available on $3\frac{1}{2}''$ and $5\frac{1}{4}''$ discs for the IBM PC, PS/2 and compatibles. For details of prices, etc., and availability of other microcomputer software/hardware formats, readers should contact the author.

TRADEMARKS

Please note the trademarks used in this book are the property of the companies with which they are associated, e.g. HPGL is a trademark of Hewlett-Packard Corp., IBM is a registered trademark of International Business Machines Corp., Macintosh is a trademark of Apple Computers.

Glossary of abbreviations and technical terms used with microcomputers and presentation graphics

Abscissa The horizontal or X-axis of a statistical grid.

Align To arrange letters, words etc. on the same vertical axis.

Annotation An explanatory note forming part of an illustration.

Area chart A graph chart that represents a quantity by the area under a line. Each series in an area chart is represented by a layer, the base of which is the previous series.

Arithmetic mean The sum of the values recorded in a series of observations divided by the number of observations.

Array An arrangement of elements (numbers, characters, etc.) in rows and columns.

ASCII American Standard Code for Information Interchange. A standard that assigns a specific code to each of 128 digits, letters, and control characters.

Average A measure of the most 'typical' value in a series of observations. There are three ways of expressing averages: arithmetic mean, median or mode.

Axis A fixed line adopted for reference. Graphs or charts are usually organized on axes which are at right angles to each other.

Bar chart A form of pictorial presentation where bars are used to provide comparison between items.

Base line The imaginary line on which the data stand, e.g. the zero line in a bar chart or histogram.

BASIC Beginner's All-purpose Symbolic Instruction Code. A high level computer language, with most commands in recognizable English.

Baud rate The rate of data transmission, often designed so that one baud equals one binary bit of data.

BASICA IBM BASIC for the IBM PC.

Best-fit This is a straight line, drawn using linear regression, through a set of data, where the same number of points or co-ordinates lie on each side of the line.

Border   A single or double line that surrounds a complete chart.

CAL   Computer assisted learning.

Color/Graphics Adapter (CGA)   The lowest graphics resolution available on an IBM PC or compatible, providing a choice of four colours. Requires a Color/Graphics Adapter card.

Character   The individual letter, numeral or punctuation mark. Note: when counting characters and calculating the space they will occupy, it is essential to count inter-word spaces as one character.

Chart   A drawing containing text or a graph.

Chart name   The name used to store a chart on, and retrieve it from, a disc. A chart name is equivalent to a DOS filename and must conform to DOS rules for filenames, i.e. no more than 8 characters with a three character extension.

Coefficient of variation   The standard deviation divided by the mean.

Column chart   A chart containing one or two vertical bars in which each column is divided into slices by horizontal lines.

Column width   The width of one column of data in a column chart or type as in books and journals.

Compatible   In hardware, the ability to work with or act in an identical manner to another piece of equipment. In software, the ability to interchange files or data without the need to re-enter them from the keyboard.

Contour   A line joining points of equal value (normally height) to plot isograms.

Coordinate   A precise reference, which locates a point, line or plane, in 2 or 3 dimensional space.

Correlation   Whether or not there is any association between two variables.

Cross hatching   The criss-cross patterns made by tiling to simulate textures.

Cumulative graph (or chart)   A graph chart in which each point represents the sum of all values up to that point.

Current chart   The chart in the computer's memory.

Cursor   The square on the screen that indicates where the next character typed will appear.

Curved line chart   A variation of the trend line chart in which a curved line passes through the graphing area.

Cut slice   A slice in a pie chart that is 'exploded' (moved slightly away from the rest of the pie). In a pie chart, a cut slice is used for emphasis.

DGM   see **Digital ground model**.

Default   A setting or value that the software will use unless you change it.

Dependent variable   A variable which is altered by changes in the independent variable. Dependent variables should always be placed on the vertical axis of a graph.

Digital ground model (DGM)   A digital representation of relief (ground surface).

Disc   A device used for the storage of information on a permanent or semi-permanent basis. See also **Disc drive**.

Disc drive   A device which contains a reading and writing head for loading data onto a disc, or reading data from a disc. Hard discs of much greater storage capacity are usually housed in sealed units, whereas flexible discs or floppies are easily swapped.

Dispersion   Measures of deviation or spread around a central point.

Dump   Transfer amounts of data straight to a peripheral, like a printer or disc.

Enhanced/Graphics Adapter (EGA)   This card provides a greater graphics resolution with a choice of sixteen colours.

Ellipse   An oval: if the pie chart looks elliptical on the graphics screen, change the value stored in **ASPECT**.

Export   To save on disc a graphics chart in order to use it with another program.

File   An organized collection of related records. The records on a file may be related by a specific purpose, format, or data source, and the records may or may not be arranged in sequence. A file may be made up of records, fields, words, bytes, characters or bits.

Fill   To display or draw a character in solid colour rather than as an outline, or to draw a shape with a centre that is a solid colour or pattern.

Fish-net mesh   A visualization technique for representing a surface in 3-D by plotting lines through each grid node.

Floppy disc   see **Disc**.

Frequency   If a set of data is divided into categories, the number of items in each category is known as the frequency distribution.

Graph   A 'grid' on which curves are plotted to illustrate the relationship between two variables.

Grid lines   The lines that mark the unit of measurement horizontally, and sometimes vertically, across a graph or chart.

GW-BASIC   A version of Microsoft BASIC for use on an IBM PC, PS/2 or compatible.

Hardcopy   A printed paper copy of a program or its graphic results produced by a printer or plotter connected to the microcomputer.

Hardware   Generic term for all manufactured computer equipment, i.e., the physical parts as contrasted with the programs (software).

Histogram   A stepped column chart, without gaps between the columns, in which the area of each column represents a frequency distribution. The horizontal scale represents types of occurrences or ranges of size, and the vertical scale represents frequency of occurrence. Charts drawn as histograms are useful for analysing cumulative distributions of data.

Horizontal chart   Typically, a bar chart in which the bars run horizontally and the uses of the X and Y axes are reversed.

Horizontal format   see **Landscape**.

HPGL   Hewlett-Packard Graphics Language, a set of two-letter mnemonic commands by means of which a computer controls a plotter or other output device.

Import   To retrieve from disc either data or a chart, created outside the current software program.

Independent variable   Any variable whose values are not affected by changes in other variables. Time is an example. Independent variables are normally placed on the horizontal axis of a graph.

Interface   A device for linking one component with another, such as a printer, plotter or digitizing tablet and a microcomputer, to permit transfer of data.

Label   A word, phrase, or other text that identifies a slice in a pie/column chart or a series in a bar/line chart.

Landscape   The orientation of a chart that is displayed or printed down the length of the page, i.e. with the X-axis along the longest dimension, instead of across the page, as is normally done (in portrait orientation).

Least-squares method   Produces a line drawn through the data which minimizes all positive and negative deviations of the data from this line.

Legend   The patterns, markers, or colours (with accompanying labels) that identify the series in an area chart, bar chart or line graph.

Linear trends   Methods of arriving at a linear or straight line trend.

Logarithmic   A scale type for the X and/or Y axes that uses base 10 logarithms for the numeric divisions along the axes. The distance between divisions decreases as you go up the scale.

Log-log   A graph chart in which both the X and Y axes are scaled logarithmically.

Loop   A sequence of instructions repeated until the loop is terminated.

Macro   A macro can be defined as the capability to combine many actions, e.g. keystrokes, into one simple command.

Marker   A symbol used to show a data value (or point) in a line or point chart.

Mean deviation   The arithmetic average of all the differences between the observations and their mean.

Median   The value of the middle item of a distribution, or series of observations, which is arranged in ascending order, e.g. 1 1 1 2 3 3 4 5 6 7 9, median 3.

Memory   Any device used to store data or instructions for the computer. Memory devices are compared in terms of storage capacity, access time and cost.

Menu   A list of options presented to the operator during execution of a program.

Monitor   A cathode ray tube (CRT) display screen for text and/or graphics, often called a VDU or visual display unit.

Monochrome   In one colour only.

MS-DOS   Microsoft disk operating system.

Multiple chart   A single chart that displays up to five sets of data on a single page, screen, or slide.

Ordinate   The vertical or Y-axis of a graph or chart. Can also be any vertical line which bisects the abscissa.

Orientation   The direction of the longest dimension of an object or illustration.

PAINT   see Table 1.1

Parallel communications   The standard character and ASCII code transmission method where bits are sent on eight lines at a time in parallel, normally used for printer communications.

Palette   The overall selection of colours or shades available.

Pattern   A design used to fill an area such as slices in a pie/column chart, bars in a bar chart, or layers in an area chart.

Perspective   A three-dimensional view.

Pie chart   A graph chart in which a circle is divided into slices by straight lines. The circle represents the total, or whole amount, and each slice represents a part of the whole.

Pixel   The smallest addressable picture element or point on a VDU,

generally given as a number of horizontal and vertical points, e.g. 640 × 200 for **SCREEN 2**.

Plotter   Hardcopy device with a resolution much superior to that of a graphics screen with straight diagonal lines.

Point chart   A graph chart in which each pair of X and Y data values is shown as a point, unconnected by a line.

Portrait   The orientation of a chart that is displayed or printed across the page in an upright mode, i.e. with the Y-axis vertical.

Program   A list of computer instructions connected in a logical format directing the computer to perform specific operations.

QuickBASIC   Another version of BASIC from Microsoft for IBM PC, PS/2 and compatibles with advanced features; user defined data types, recursion, sub-programs, flexible array dimensioning, merging of files, compiling and a good editor.

Range   The difference between the lowest and highest values observed.

Regression   Attempts to show the relationship between two variables by providing a mean line which best indicates the trend of the points or coordinates on a graph.

Resolution   The degree of detail that can be produced on a screen, printer, or plotter.

RS-232C   Serial communications interface for plotters etc.

Scale   The range of values covered by the X or Y axis of a graph chart.

Scatter chart   see **Point chart**.

Screen dump   An exact replica of the graphics screen on a dot-matrix or colour printer.

Screenshow   A slide show displayed on a computer screen.

Serial communications   The standard character and ASCII code transmission method where bits are sent, one at a time, in sequence, normally used for plotters and digitizing tablets.

Series   A set of data, which when displayed, represents a pie or column, a single line (in a line chart), a set of bars (in a bar chart), or a layer (in an area chart). A single chart can contain data for up to five different series.

Slide   A chart produced by a screen capture program and incorporated in a slide show.

Slide show   A list of charts, templates, and other files used to create batch output, practice cards, or a **Screenshow**.

Software   Generic term for computer programs and digitized information which is used to issue instructions to the computer hardware and peripherals for specific applications.

Stack   To display a chart so that each series uses the previous series as its base.

Standard deviation   The square root of the sum of the square of the deviations of the individual values from the mean of the distribution, divided by the number of items in the distribution.

Standard error of the mean   The square root of the arithmetic mean of the squares of the differences between the observations and their mean, plus one.

Statistics   Is concerned with scientific methods for collecting, organizing, summarizing, presenting and analysing data, as well as drawing valid conclusions and making reasonable decisions on the basis of this analysis.

String   This is a sequence of characters (letters or numbers, or a combination of both) that begins and ends with double quotation marks.

Surface model   A 3-D representation or visualization of the surface by plotting grid data as an isometric projection.

Tabulation   The systematic arrangement of data into columns.

Template   A pre-defined chart, with default settings, for the location of axes, data and text.

Tiling   A method of designing patterns on the screen where the colour attributes of each pixel can be varied within a given boundary, rather than plotted in a single solid colour. To use tiling, the **PAINT** attribute must be a string expression rather than a single colour.

Transfer format   The format used to transfer data between computer systems.

Trend line chart   A line chart in which a straight line, determined by linear regression, passes through the graphing area.

Value   In a pie/column chart, the quantity or percentage contributed by a slice to the whole.

Variable   Data subject to measured change.

Variance   The average of the square of the deviations.

Vertical format, see **Portrait**.

Video Graphics Array (VGA)   This is a higher graphics resolution than EGA, but cannot be used to display graphics written in BASIC. It will, however, emulate EGA.

Visual display unit (VDU)   see **Monitor**.

Window   The currently displayed portion of the screen used for the display of graphics.

Wireframe   see **Fish-net mesh**.

X **Axis**   Normally, the horizontal axis of a graph chart, which shows the way the data is classified. (In a bar chart, the *X* axis is the vertical axis).

Y **axis**   Normally, the vertical axis of a graph chart, which shows the quantity or amount. (In a bar chart, the *Y* axis is the horizontal axis).

Zigzag line chart   A line chart in which straight lines connect the data in each series.

100% chart   A variation of the stacked bar chart that shows the percentage contribution of each series to the whole.

Contents

1

Introduction to presentation graphics

1.1 INTRODUCTION

This chapter is an introduction to the use of presentation graphics, with specific reference to the graphics capabilities of the IBM PC, PS/2 and their compatibles. It explains the advantages of interactive computer graphics displays for the presentation of different types of graphs and charts for use by engineers, scientists and statisticians from all disciplines. In addition to screen presentations it is also important to look at printer and plotter output.

Also provided is an overview of the workings of the computer graphics hardware and software of the IBM PC, PS/2 or their compatibles, using an interactive high level language like BASICA, GW-BASIC or Quick-BASIC, to create and control the graphics output.

1.2 PRESENTATION GRAPHICS

The main aim of presentation graphics is to communicate statistical information, and the type of presentation will therefore depend on the requirements and interests of the people receiving the information. Just as a picture can be worth a thousand words, a graph or chart can be worth a thousand numbers. Those numbers or figures need to be arranged and presented in some specific format before the information contained in the data can be interpreted.

The various features to consider are:

(i)   clear presentation of the subject matter;
(ii) clarification of the most important points in the data;
(iii) consideration of the purpose of the presentation;
(iv) consideration of the amount of detail and accuracy required;
(v)   the use of the most appropriate method for presentation.

Several methods of data presentation can be used with a choice from:

(i)   written descriptions,
(ii) tabulation,