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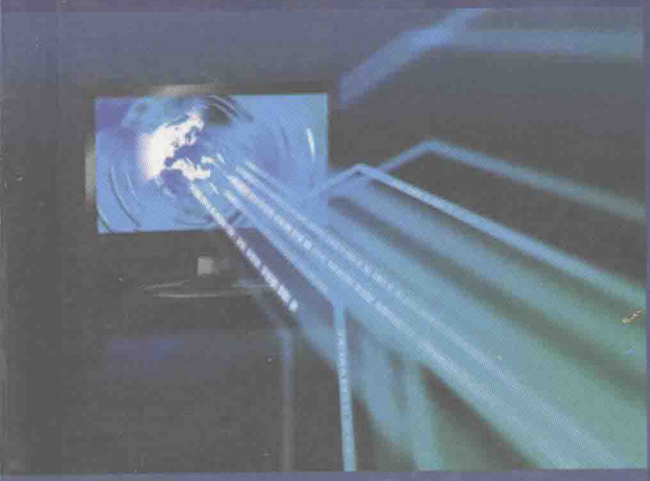
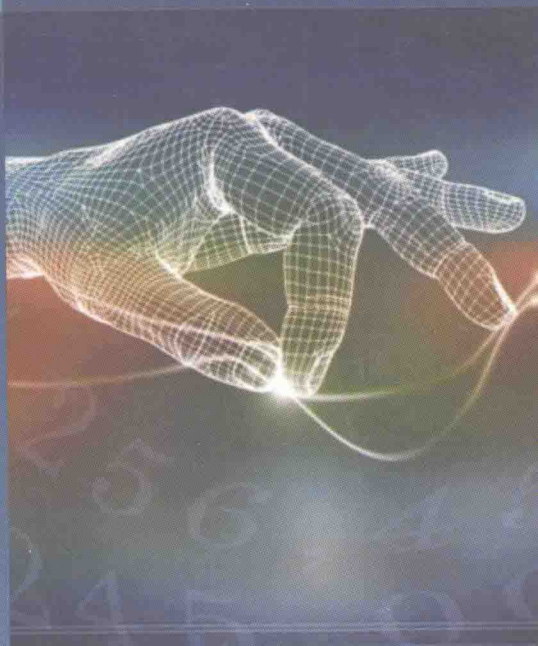
Computer Graphics



C.S. Verma



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Computer Graphics

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Dedicated
to

Our Families

whose love, affection and sacrifices made
us capable of carrying out such onerous work

Preface

It gives me great pleasure in presenting this book to my esteemed readers. The number of books that have been written on the subject of computer graphics in recent year is quite impressive. This shows that the interest in the phenomenon of about said subject is great. Of course, this is not itself a justification of writing yet another book on said subject. The reason why we have deemed it necessary to write this book is that the vast literature on said subject still shows a gaps which need to be filled by suitable approaches and examples which is easy to understand and create filling of the subject. This book therefore has been written in a simple language with suitable approach, examples and lots of solved problems in each topic. This book has been thoroughly structured to serve as an ideal textbook for various courses like Engineering courses, MCA, BCA, MSc computer science *etc* of various universities like UPTU, DU, CSVTU, RGPTU, PSSOU etc.

Computer today, is a very versatile and powerful tool in hands of engineers. A brief overview of computers has been included to introduce the reader the basic concepts of computer graphics hardwares and software. Important elements of computer graphics like display and viewing have been presented after discussing entity generation. Further manipulation of graphical elements represented in matrix form using homogeneous coordinates is described. Mathematical techniques for producing projection are given, along with generalized techniques for rotation, translation and scaling of geometric figures. Definitions for both explicit and parametric representations are presented for both curves and surfaces. The various aspects of geometric modelling have been presented through detailed description of 2D and 3D curves and surfaces generation techniques.

We would welcome any kind of feedback and comments on the book. In spite of our best effort, some errors may have gone unnoticed. We encourage the readers to provide suggestions and constructive inputs for the improvement of the book.

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Syllabus for

Uttar Pradesh Technical University
Gautam Buddha Technical University
Mahamaya Technical University

Year III, Semester Vth

ECS 504 : Computer Graphics

Unit-I *Introduction and Line Generation:* Types of computer graphics; Displays— Random scan displays, Raster scan displays; Frame buffer and video controller, Points and lines; line drawing algorithms, Circle generating algorithms; Mid-point circle generating algorithm, and parallel version of these algorithms.

Unit-II *Informations:* Basic transformation, Matrix Representations Homog enous coordinates, Composite transformations, Reflections and shearing.

Windowing and Cliping: Viewing pipeline, Viewing transformation, 2-D Clipping algorithms-line cliping algorithms such as Cohen Sutherland line clipping algorithm, Liang Barsky algorithm, Line clipping against non rectangular clip windows; Polygon clipping – Sutherland Hedgeman polygon clipping, Weiler and Atherton polygon clipping, Curve clipping, Text clipping.

Unit-III Three Dimensional 3-D Geometric primitives, 3-D Object Representation, 3-D Transformation, 3-D Viewing Projections, 3-D Clipping.

Unit-IV *Curves and Surfaces:* Quadric Surfaces, Spheres, Eilipsoid, Blobby Objects, Introductory Concepts of Spline, Bspline and Bezier Curves and Surfaces.

Hidden lines and Surfaces: Back Face Detection algorithm. Depth buffer method, A-buffer method, Scan line method, Basic Illumination Models – Ambient Light, Diffuse Reflection, Specular reflection and Phong Model, Combined approach, Warn Model. Intensity Allenuation. Color consideration, Transparency and Shadows.

Syllabus for

Chhattisgarh Swami Vivekanand Technical University, Bhilai

Semester IV

Code: 337411(37) : Computer Graphics

Unit-I *Introduction:* Application Areas. Input and Output Devices:- Keyboard, Mouse, Z mouse Trackball. Joysticks, Data Glove, Digitizers, Light pen, pane's image scanners, Printers and Plotters. Video Display Devices: Refresh CRT: Raster & Ranoom scan display; Color CRT monitor; Flat panel display; Co-ordinate representation.

Unit-II *Basic Raster Graphics Algorithm for drawing 2-D primitives:* Output Characteristics: Aspect ratio; Aliasing and Anti-alisasing. Line Drawing Algorithms: DDA algorithm; Bresenham's algorithm. Circle Generation Algorithm: Midpoint circle algorithm. *Ellipse Generation Algorithm: Mid-point ellipse alogorithm. Area filling: Inside-outside test; Boundary fill algorithm- 4 and 8 connected area; flood-fill algorithm.*

Unit-III 2-*D Geometric Transformation:* Window and View port: Window and View port relationship; World co-ordinates; Normalized device co-ordinates and Homogenous co-ordinates. Basic Transformatioins: Translation; Rotation and Scaling. Other Transformation: Reflection and Shear. Composite Transformation.

Unit-IV *2-D Viewing and Clipping:* Viewing world coordinates system, normalized coordinate system, image coordinate system, window definition, view port difinitions, viewing transformation. Clipping: Point clipping; Line: Cohen-Sutherland algorithm, Mid-point Polygon.

Unit-V *3-D Concepts and curves:* 3-D Display Methods: Parallel and Perspective projections; 3-D Transformation: Basic Transformations: translation, rotation and scaling.

Curves

Spline Representation, Bezier Curves single and multiple segements Cubic-spline and their parametric forms

Contents

1
Computer System for Graphics and Design

1.1 INTRODUCTION

Computer graphic started with the display of graphs on cathode ray tube (CRT) screens soon after the introduction of computer system themselves. A complete computer system means working computer as shown in fig. 1.1. The computer system includes not only the computer, but also any software and peripheral devices that are necessary to make the computer function. Therefore, in this chapter, we will discuss about computer, its peripheral devices, software and their functions which is useful in computer graphics. In addition to other areas, computer aided design (CAD) and computer integral manufacturing (CIM) are the areas in which computer graphics is useful.

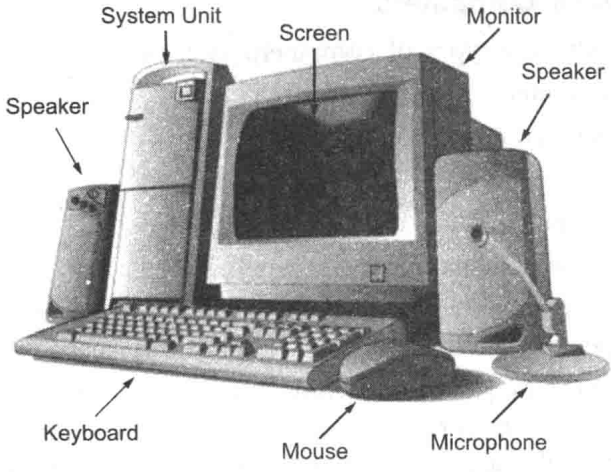

Fig. 1.1 *Computer system.*

1.2 COMPUTER

Computer is not only fascinating machines but also very useful. Not all computers are visible. In some machines, small dedicated computers are fitted (called as embedded computers) that are not visible. These embedded computers work behind the curtains. For example, embedded computers, controlled cars, lathe machines, washing machines, televisions and so on. Among the visible computers, the most popular computers are the personal

computer (PC) because of their affordable price. A computer is electronic data processing device which can read and write, compute and compare, store and process large volume of data with high speed, accuracy and reliability. It stores the instructions given to it and then executes them at a traffic speed automatically without manual intervention. It works on stored program concept. Once the data and instruction set is fed into its memory, it reads the instruction and executes them to produce result. Computer consists of two things which are hardware and software.

1.2.1 Hardware

The physical machinery that makes up a computer is known as hardware such as input devices, output devices, memory units, central processing unit (CPU) *etc*. Hardware professionals deal with manufacturing and maintenance of computer.

1.2.2 Software

Software refers to a set of computer programs and procedures for the effective operation of a data processing system. Without software, hardware is of no use. Software engineers (programmer, system analyst) develop and maintain software.

1.2.3 Types of Computers

There are mainly five types of computers such as:

1. Supercomputer
2. Mainframe computer
3. Minicomputer
4. Microcomputer
5. Stand-alone personal computer

Although their internal components are basically alike but above classification are given as per descending order of speed, storage capacity and cost *etc*.

Currently supercomputer is the word's fastest and most powerful. Generally those computers which work with the speed of 5 to 100 million instructions per second can fall under super computers. Super computers are generally used as network computers. For examples, account in a branch bank can be controlled by a supercomputer in head office. Similarly airlines and railways traffics control and its reservation is simplified by supercomputer.

The mainframes are often used to solve complex engineering and scientific problems, such as interactive calculations in fluid dynamic analysis, heat transfer, analysis, mathematical modeling, and stress analysis. With the use of special work station, mainframe is used for running graphics and CAD software shown in fig. 1.2.

The minicomputer is less powerful than a mainframe. Speed of minicomputer is approximately 100 to 500 kilo instruction per second. The minicomputer is cost efficient in commercial and industrial applications.

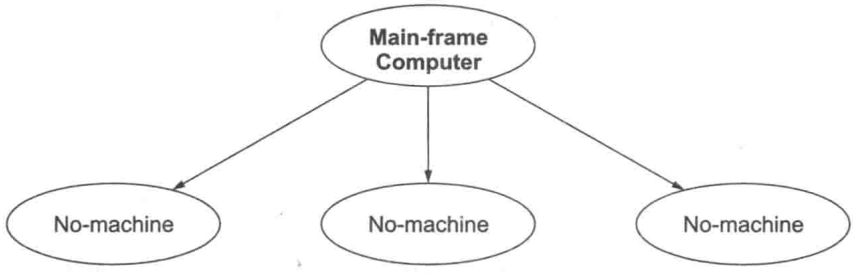

Fig. 1.2 *Mainframe computer for running CAD machines.*

Today's personal computers are becoming more powerful and except a real challenge which is in mainframe computers. The computing systems while in operation can be compared to the human being in terms of its operating characteristics. The basic configuration of a typical compute graphics system used in CAD to operate machine for producing products is shown in fig. 1.3. CNC Lathes, CNC Milling, CNC Grinding, CNC EDM, CNC Boring, Drilling etc. are CAD machines.

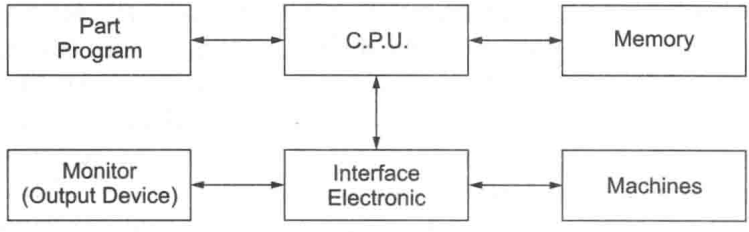

Fig. 1.3 *Computing system used in CAD.*

1.2.4 Central Processing Unit

The heart of any computing system is the central processing unit (CPU), where all the necessary functions of a computer are carried out. The main function performed in the CPU is arithmetic and logic functions. The CPU communicates with the external world through input\output devices. These are similar to the sensory organs by which a human being maintains contact with the outside environment. These external devices are collectively called peripheral units. Through input devices, the user can either to enter certain data or to control the operation of the CPU. The output device is a means through which the CPU gives the results of the computations. The computer works on stored program where program is the set of instructions. This program is stored in the memory of computer. The CPU read an instruction

and continues to do so till it reaches the end statement of the program. This stored program is called software in computer terminology. With the help of this program, sequence of operation is generated by CPU. Thus software runs computers. Based on the software, CPU organizes the information for processing any given application. The flow of information in the CPU is shown in fig. 1.4.

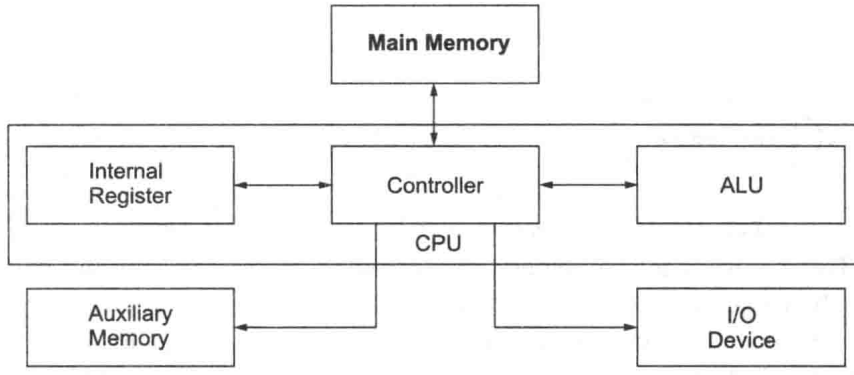

Fig. 1.4. *Basic configuration of typical CPU.*

CPU contains three main parts which are internal resisters, controller units and ALU (Arithmetic and logic unit). Controller unit consists of electronic circuit. It selects, interprets and executes instructions with the help of ALU and registers. It governs input/output operations, data transfer to and from storage (memory units) and guide the routing of data between storage location and ALU. ALU consists of electronic circuits which behave like brain of human being. Therefore, because of ALU, CPU is called brain of computer. It performs calculation and comparisons. ALU works at tremendous speed and executes millions of instructions per second. The CPU also contains a number of registers to store data temporarily during the execution of the program. The number of registers differs from processor to processor. Depending upon the type of CPU, these registers could be 8 bit, 16 bit, 32 bit or 64 bit long where 64 bits word-size register is the most popular in CAD. Register also control the electricity consumption and heat dissipation. The speed of the CPU operation is traditionally measured in terms of MIPS (million instructions per second). With the advance in LSI and VLSI technology it becomes possible to build the whole CPU on a single IC. A CPU of a digital computer fabricated as a single circuit (called chip) is termed as microprocessor. Intel 4004 was the first microprocessor developed by the Intel Corporation. The important aspect to be considered with the microprocessor is the speed with which they operate is called system clock rate. Clock rate for microprocessor are varies from 1 MHz to 1 GHz.

For typical CAD/CAM computers, microprocessor should be at least 32 bits, but 64 bit size and 60 MHz clock rate is preferred. Well-known

microprocessor manufacturing organization are Intel Pentium, IBM, silicon graphics, Hewlett packed, Sun Ultra etc.

1.2.5 Memory Units of Computer System

Memory is used for the storage of data. For execution of programs, computer uses this data. There are two types of memory as shown in fig. 1.5.

1. Main memory is also called Primary memory
2. Auxiliary memory is called secondary memory.

Main memory/Primary memory

Main memory is an integral part of the computer for storing data, traditionally, in main frame computer, memory cell are formed by small magnetic core (called core memory) of about 15 mm in size wound around thin material of wires. By magnetizing, they obtain a specific orientation, which would not be erased even when the electric supply is put off. However, this method is very expensive and is now hardly used due to the availability of semiconductor memory.

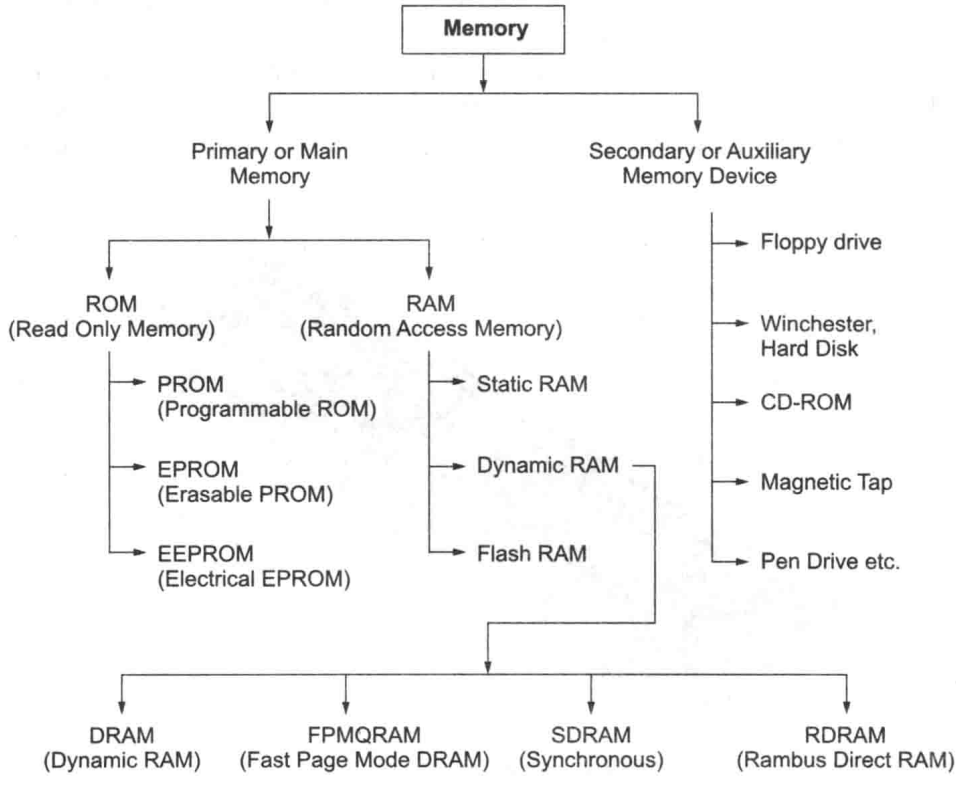

Fig. 1.5 *Memory Units.*

In semiconductor memory, the memory locations are organized as a series of small on/off switches. Developments in the semiconductor industry have decreased the cost of the memory units, along with raising their capacity for storage. These memories are of two types—RAM and ROM and its detailed classification is shown in fig. 1.5.

RAM chips come in two varieties, static and dynamic. In static RAM, the information is to written only once whereas in dynamics RAM, information after having been written would have to be continuously refreshed for merely being retained, even though there may be no change in it. There are four types of DRAM (dynamic RAM) in which SDRM is generally used in PC because it is cheap and fast. RAM is a volatile memory units. It gets washed out the moment when the machine is switched off, unless a battery back-up is provided for the RAM (Fig. 1.6). RAM is used to store data temporarily which need to be updated or erased several times. We worked generally on RAM for writing, storing and updating data in computers such as writing letters, essays, document, thesis etc. and part programs in-manufacturing industries. Part programs for running CNC lathes/CNC milling are stored in RAM. Part program will be different for manufacturing of different products. The machine should be equipped with enough RAM to store and process longest possible programs. In a machine, RAM is usually extendable for which empty slots are available in the MCU (Machine Control Unit). In addition to memory, the MCU also contains hardware and software necessary to read and interpret the coded program for obtaining the desired movements in the machine.

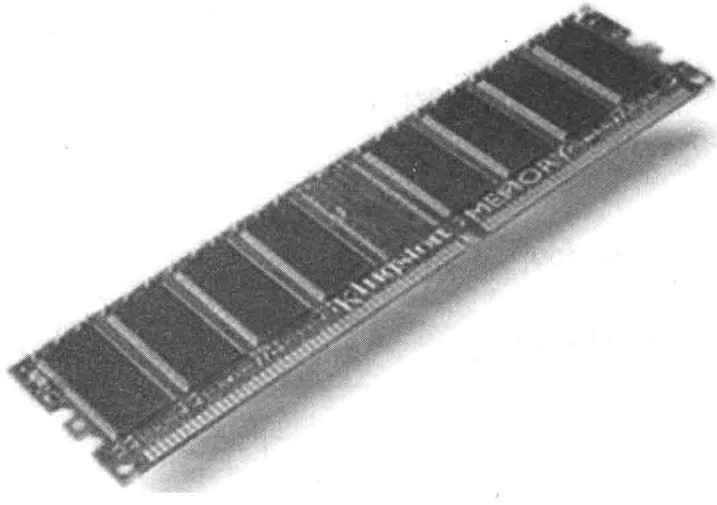

Fig. 1.6 *RAM hardware part.*

ROM, on the other hand, is a non-volatile memory. It stores information permanently which can be read any number of times unless the information is deliberately erased or overwritten. It does not need any power supply to retain the information fed to it. ROM is used to store information for repetitive functions such as on online help, default parameters and operating instruction such as in operating software. This information is stored in ROM at the time of manufacturing of machine in the factory. Thus most of the system software is normally provided in the ROM. They remain available to the user for the lifetime of the machine even if power is removed or the machine is down. This is the reason why permanent information is stored in ROM. Flash memory is a type of non-volatile memory that can erase and reprogrammed in units of memory. It also called flash RAM.

Auxiliary memory/Secondary memory

Secondary memory is used for the permanent storage of data required for CAD/CAM computers as well as for other computers. There is no need of power supply to retain the data. Data stored in these memories can be used in future. One can take his data from one place to another with the help of secondary memory. There are various types of secondary storage devices are available.

(*i*) **Floppy Diskette:** The floppy disk is the most convenient medium for storing either temporary or *permanent datas*. The diskette is made from plastic material and its drive (A) is shown in fig. 1.7. The base is coated with an iron oxide which is recording materials. Data is recorded as tiny magnetic spots. The floppy disk can store upto 10 M bytes per floppy. The standard sizes available nowadays are 5.25 inch and 3.5 inch.

(*ii*) **Hard Disk:** Hard disks are most popular INPUT/OUTPUT devices for data storage. Winchester hard disk is more popular. These are thin, rigid metal plates coated on both sides with a thin film of magnetic material shown in top-left of fig. 1.7. These have a large storage capacity and have been extensively used because of their low access time, low cost and compact sizes. Typical storage size of hard disk presently available is from 6GB to 180 GB. Data is stored on both surfaces in a number of invisible concentric circles which are called tracks. Each track is further divided into stores which can store a fixed number of bytes.

(*iii*) **Magnetic Tape:** The greatest limitation of magnetic tape is the serial nature of storage, necessitating all the tapes to be wound before accessing any inside information. As a result, the magnetic tape is used only for data exchange or back-up. A 10.5-inch reel can store about 180 MB of data.

(*iv*) **CD-ROM:** Current development in mass storage of very large capacity are based on the optical technology rather than on magnetic principal,