IE360: CAD/CAM

Computer Aided Design and Computer Aided Manufacturing

Lecture (2)
Components of CAD/CAM Systems

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Outline

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- Hardware Components
- Hardware Configuration
- Software Components
- Exercises

Introduction:

- CAD/CAM requires specific types of hardware and software that enables interactive shape manipulation.

- Thus, as shown in Figure 1, graphics devices and their peripherals for input and output operations, in addition to normal computing machines, comprise the hardware for CAD/CAM systems.

- The key software components are packages that manipulate or analyze shapes according to the user's interactions with them, either in two or three dimensions, and update the database.

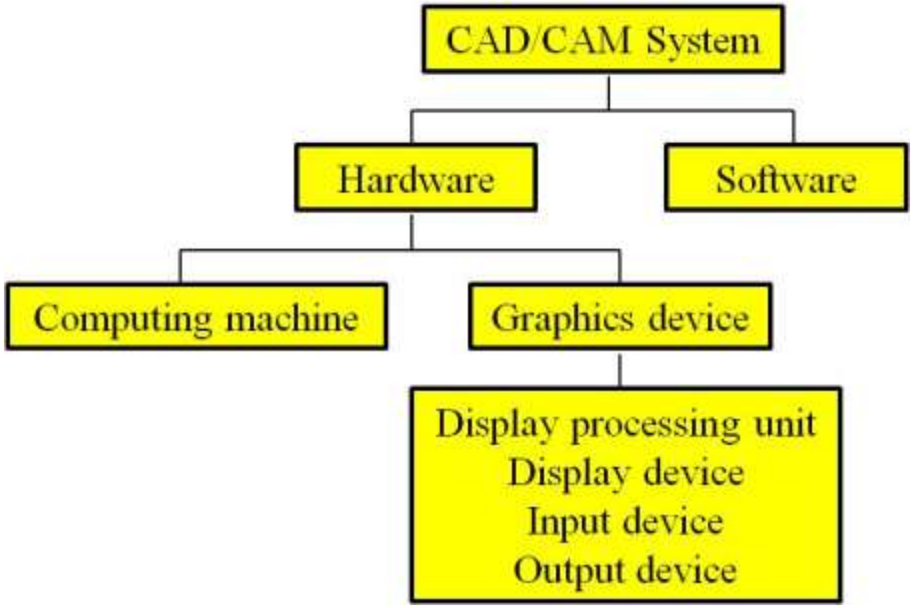

Figure 1: Components of CAD/CAM systems.

Hardware Components:

Graphics Devices:

- As illustrated in Figure 1, a **graphics device** is composed of a display processing unit, a display device (called a monitor), and one or more input devices.

- The **display device**, or monitor, functions as a screen on which a graphical image appears.

- The **display processing unit** locates a specific image on the screen. It accepts the signals corresponding to the graphics commands, produces electron beams, and transmits them to the proper locations on the monitor to generate the desired image.

- A graphics device is usually accompanied by one or a combination of various input devices. These **input devices** facilitate the interactive shape manipulation by allowing the user to provide graphics inputs directly to the computer.

- Each graphics device is also usually connected to output devices. With these **output devices**, any image on the display device can be transferred onto paper or other media.

- Examples of input/output devices are shown in Figure 2.

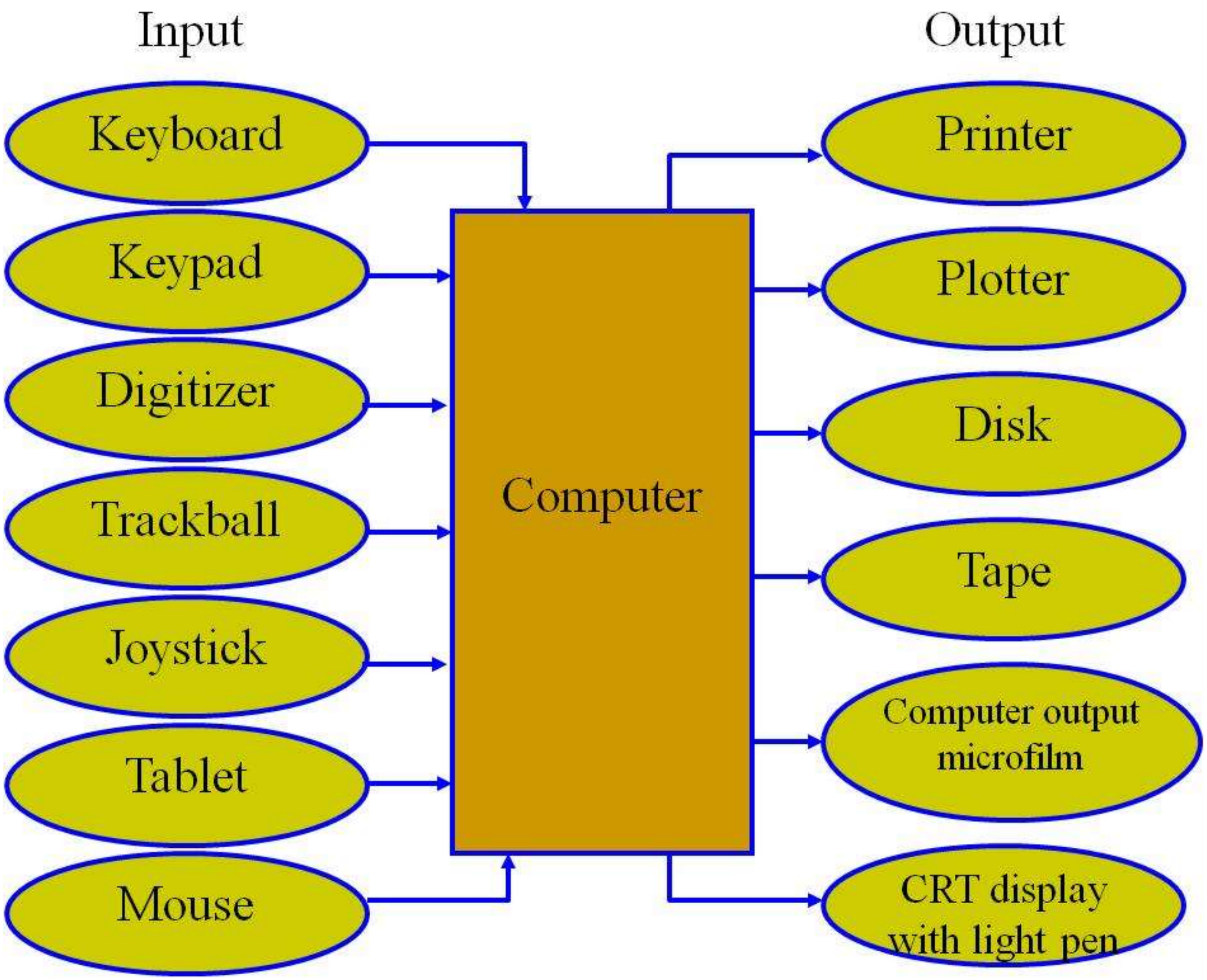

Figure 2: Input/output devices of a CAD/CAM system.

- **Graphics Display:** Various graphics display technologies exist and they are all based on the concept of converting the computer's electrical signals, controlled by the corresponding digital information, into visible images at high speeds.

- Among the available display technologies, the *Refresh Display* is the most dominating and effective display.

- In raster displays, the display screen area is divided horizontally and vertically into a matrix of small elements called picture elements or pixels, as shown in Figure 3. An N x M resolution defines a screen with N rows and M columns. Each row defines a scan line.

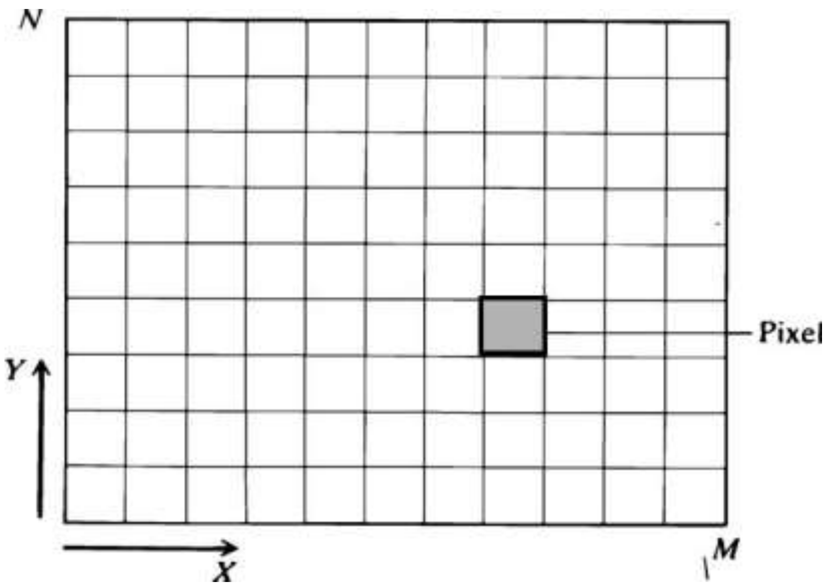

Figure 3: Typical pixel matrix of a raster display.

- Figure 4 shows a schematic of a typical color raster display.

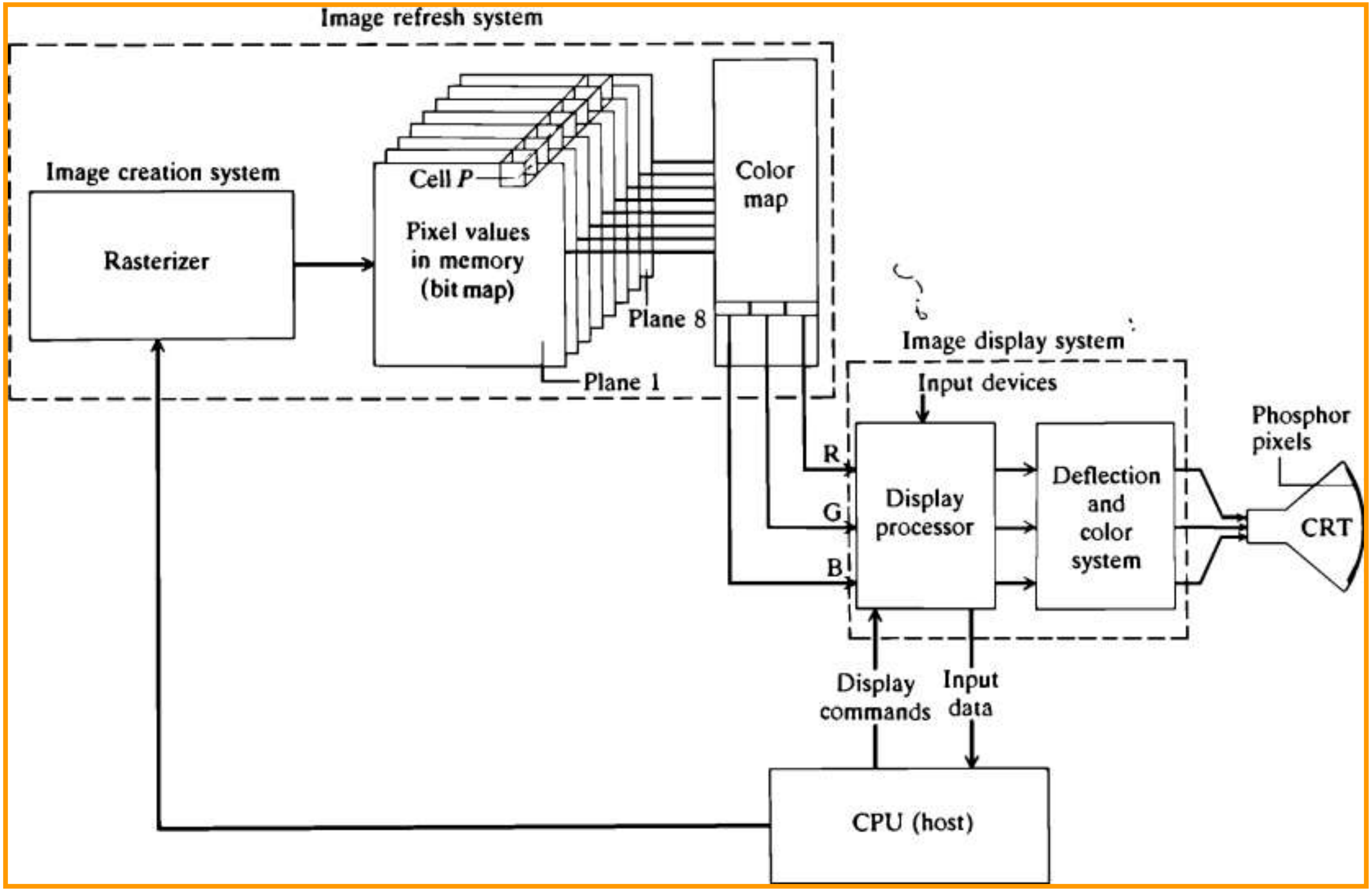

Figure 4: Color raster display with eight planes.

Raster display operation:

- In raster displays, images (shaded areas or graphics entities) are displayed by converting geometric information into pixel values which are then converted into electron beam deflection through the *display processor* and the *deflection system* shown in Figure 4.

- If the display is monochrome, the pixel value is used to control the intensity level or the grey level on the screen. For color displays, the value is used to control the color by mapping it into a *color map*.

- The creation of raster-format data from geometric information is known as scan conversion or ***rasterization***.
  - A rasterizer that forms the image-creation system shown in Figure 8 is mainly a set of scan-conversion algorithms.
  - These are standard algorithms which are used to draw a line by generating pixels to approximate the line. Similar algorithms exist to draw arcs, text, and surfaces.

- The values of the pixels of a display screen that result from the scan-conversion process are stored in an area or memory called *bit map* refresh buffer, as shown in Figure 4.

- Each pixel value determines its brightness (grey level) or most often its color on the screen.

- There is a one-to-one correspondence between every cell in the bit map memory and every pixel on the screen.

- The display processor maps every cell into its corresponding screen pixel brightness or color.

- In order to maintain a flicker-free image the screen must be refreshed at the rate 30 or 60 Hz.

- The refresh process is performed by passing the pixel values in the bit map to the display processor every refresh cycle.

- The bit map memory is arranged conceptually as a series of planes, one for each bit in the pixel value. Thus, an eight-plane memory provides 8 bits/pixel, as shown in Figure 8. This provides 2^8 different grey levels or different colors that can be displayed simultaneously in one image. The number of bits per pixel directly affects the quality of its display.

- The value of a pixel in the bit map memory is translated to a gray level or a color through a *lookup* table (also called a *color table* or *color map*). The pixel value is used as an index for this lookup table to find the corresponding table entry value which is then used by the display system to control the gray level or color.

- Figure 5 shows how the pixel value is related to the lookup table in an eight-plane display. If cell P in the bit map corresponds to pixel P at the location $P(x, y)$ on the screen, then the grey level of this pixel is 50 (00110010) or its corresponding color is 50.

- For the eight-plane display shown in Figure 5, the lookup table has 256 (2^8) entries, which correspond to all possible values a pixel may have.

➢ Figure 5 shows how the pixel value is related to the lookup table in an eight-plane display.

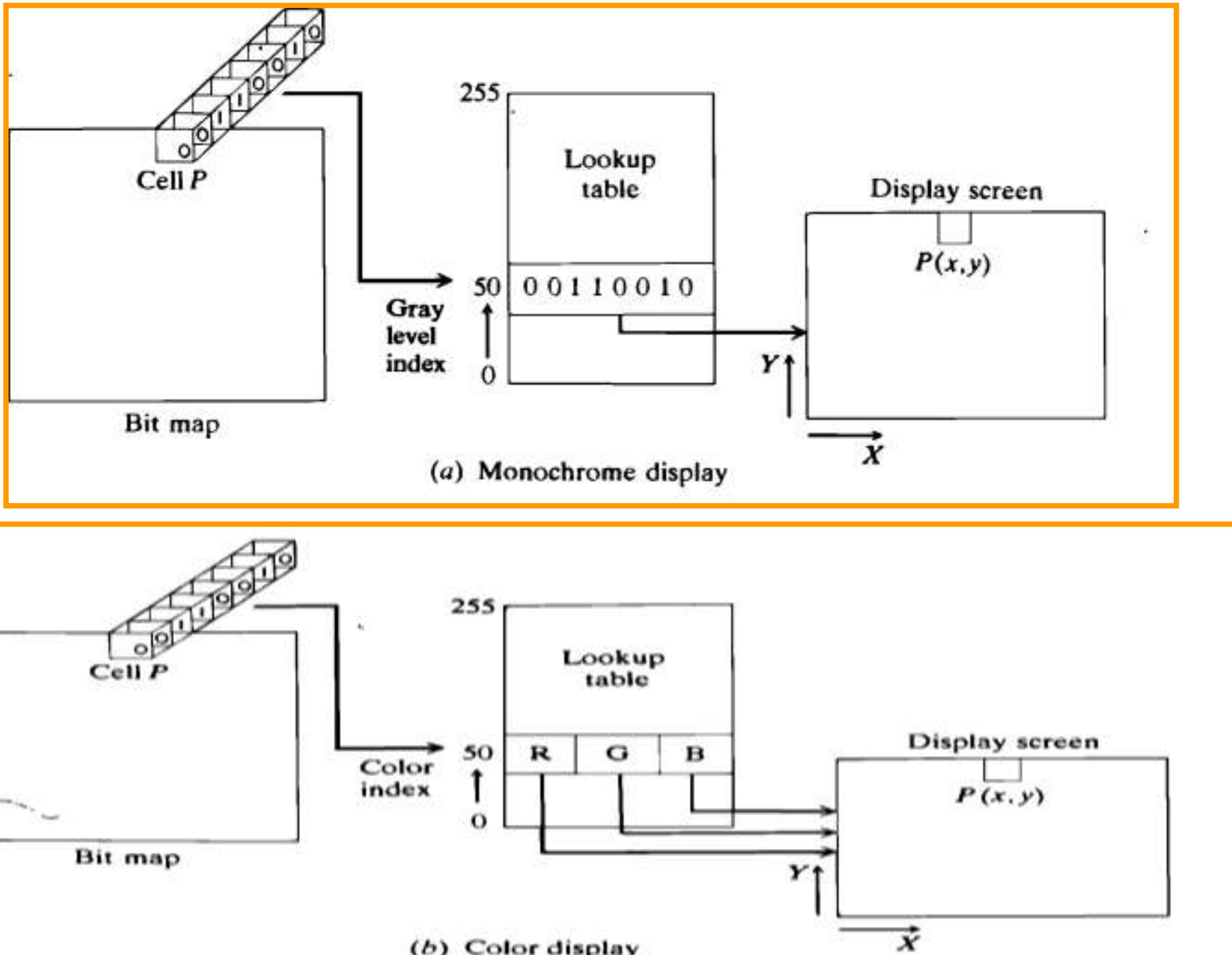

Figure 5: Relationship between pixel value and look up table.

- **Example 1:** A 12-plane raster display has a resolution of 1280 horizontal * 1024 vertical and a refresh rate of 60 Hz. Find:
    1. The RAM size of the bit map (refresh buffer).
    2. The time required to display a scan line and a pixel.
    3. The active display area of the screen if the resolution is 78 pixels (dots) per inch.
    4. The optimal design if the bit map size is to be reduced by half.

- **Answer:**
    1. The RAM size of the bit map = 12 * 1280 * 1024 = 15,728,640 bits = 15,728,640/(8*1024*1000) = 1.92 Mbytes.
    2. The time required to display a scan line = (1/60)/1024 = 16 microseconds. The time required to display a pixel = 16/1280 = 12 nanoseconds.
    3. The active display area = 1280/78 horizontal * 1024/78 vertical = 16.4 * 13.1 inch.
    4. Assuming there is only one bit map available, the two solutions are to reduce the number of planes by half and keep the resolution as it is or vice versa. The two choices are: a 6-plane 1280 x 1024 display or a 12-plane 640x512. The first choice is preferred, especially if 64 simultaneous colors are adequate for most applications that utilize the display.

- **Example 2:** What is the reasonable resolution of a 12-plane display refreshed from a bit map of 256 Kbytes of RAM?.

- **Answer:**
  - Bit map size per plane = (256 * 1024 * 8)/12 = 174,763 bits.

  - This could support a display with a resolution of 418*418, 512*341, or other combinations.

- **Quiz:**

  - What would be the resolution in the above example if four planes are used instead.

Hardware Configuration:

- There are basically three possible configurations of CAD/CAM systems: mainframe-based systems, workstation-based systems and PC-based configuration.

- Mainframe-based systems:
  - A typical mainframe-based CAD/CAM system consists of a mainframe computer and multiple graphics devices, as illustrated in Figure 6. Some output devices such as printers and plotters are also connected to the mainframe.

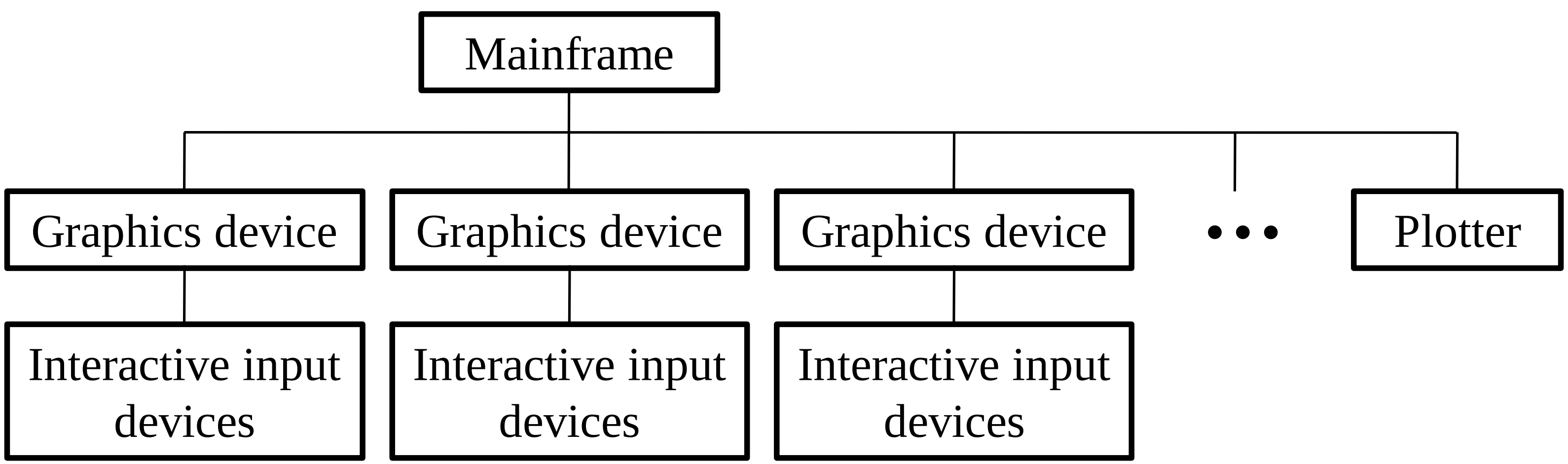

Figure 6: Hardware configuration using a mainframe.

- The mainframe approach is used by automobile manufactures and shipbuilders whose large databases are handled centrally. However, there are some disadvantages to this approach.
  - It requires a big initial investment for the hardware and software, and maintenance is expensive.
  - The system response time may be too slow as the application programs in each graphics device are competing with each other with the machine’s computing capability.

➢ Workstation-based systems:

- This configuration is composed of engineering workstations connected in a network environment, as shown in Figure 7. Output devices such as plotters are also connected to the network.
- The engineering workstation can be considered a graphics device with its own computing power.
- This approach has several advantages.
  - The user can choose the computing power of any workstation on the network, using the most appropriate workstation for the task, with system response not affected by other people’s tasks.

• Another advantage is the avoidance of a large initial investment.

➢ PC-based systems:

- This configuration is the same as the workstation-based approach, except that the engineering workstations are replaced by personal computers that are run by the Microsoft Windows 95 and NT operating systems.

- A PC-based configuration is popular with small companies, especially where the products being made are composed of small numbers of parts of reasonable complexity.

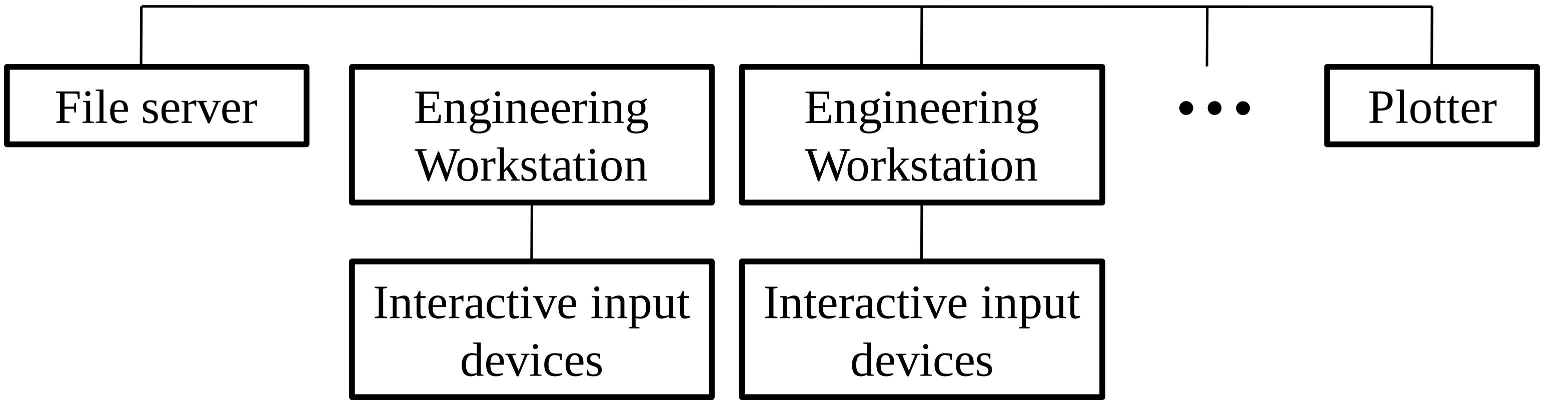

Figure 7: Hardware configuration using engineering workstations.

Software Components:

- Any software used in the product cycle to reduce the time and cost of product development and to enhance product quality can be classified as CAD/CAM software.

- Specifically, the key CAD software allows the designer to create and manipulate a shape interactively on the monitor and store it in the database.

- Similarly, any software used to facilitate the manufacturing process of the product cycle is classified as CAM software. That is, any software related to planning, managing, and controlling the operations of a manufacturing plant can be considered as CAM software. For example,
  - Software that generates a process plan to manufacture a part is a typical CAM software.

  - Another example is the software that generates a part program, simulates the tool motion, and drives an NC machine tool to machine the external surfaces of a part.

- Some commercial software widely used for CAD/CAM can be classified based on the application area as follows:
  - CAD – 2D drafting: CADAM, MicroCADAM, and AutoCAD.
  - CAD – Solid modeling: Solid Edge, SolidWorks, and SolidDesigner.
  - CAM – Camand, PowerMILL, and Mastercam.
  - Integrated Systems: Pro/ENGINEER, and CATIA.
- In addition to the CAD/CAM systems listed above, several *modeling tool kit software products* are becoming popular because they provide a flexible modeling environment that can be tailored to each application.
  - Specific application programs can be constructed by collecting just the necessary modeling tools from the kit. The result is a compact application program tailored precisely to the required function.
  - Examples of the modeling tool kits available these days are ACIS, SHAPES, Parasolid, CAS.CADE, and DESIGNBASE.

Exercises:

- Exercise 1: A 16-plane raster display has a resolution of 640 horizontal * 512 vertical and a refresh rate of 30 Hz. Find:

1. The RAM size of the bit map (refresh buffer).
2. The time required to display a scan line and a pixel.
3. The number of colors that can be displayed simultaneously.