

# **CMP 477 Computer Graphics**

## ***Module 2: Graphics Systems – Output and Input Devices***

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# Introduction

- ▶ The widespread recognition of the power and utility of computer graphics in virtually all fields has led to the development of a broad range of graphics hardware and software systems.
- ▶ Graphics capabilities for both two-dimensional and three-dimensional applications are now common on general-purpose computers, including many hand-held calculators.
- ▶ With personal computers, we can use a wide variety of interactive input devices and graphics software packages.
- ▶ For higher quality applications, we can choose from a number of sophisticated special-purpose graphics hardware systems and technologies.
- ▶ In this module, we explore the basic features of graphics hardware components and graphics software packages.



# Graphical Output Devices

- ▶ Output devices are needed to generate graphical outputs.
- ▶ Without an output device, you cannot know what processing has been done.
- ▶ Just as words (spoken or printed) will betray a human heart, so will output devices betray the graphics processing inside the computer

# Types of Graphical Output Devices

- ▶ Two types of outputs are possible: soft and hard
- ▶ Soft output forms use various forms of displays or monitor – CRT or LCD Panels, etc.
- ▶ Hard output forms are generated using printers or plotters
- ▶ Graphical output devices can be categorized into two:
  - ▶ Computer terminals (Monitors)
  - ▶ Hard copy Devices (Printers/Plotters)

# Types of Graphical Output Devices..

- ▶ Graphical Output Devices can be also be classified according to the primitive technology used:
  - ▶ Raster Scan Devices
    - ▶ CRT Monitors
    - ▶ LCD Panel
    - ▶ Plasma Panel/Gas discharge display
    - ▶ Dot Matrix printers
  - ▶ Random or Vector Scan Devices
    - ▶ Storage Oscilloscope
    - ▶ Plotters



# Raster Scan Video Principles

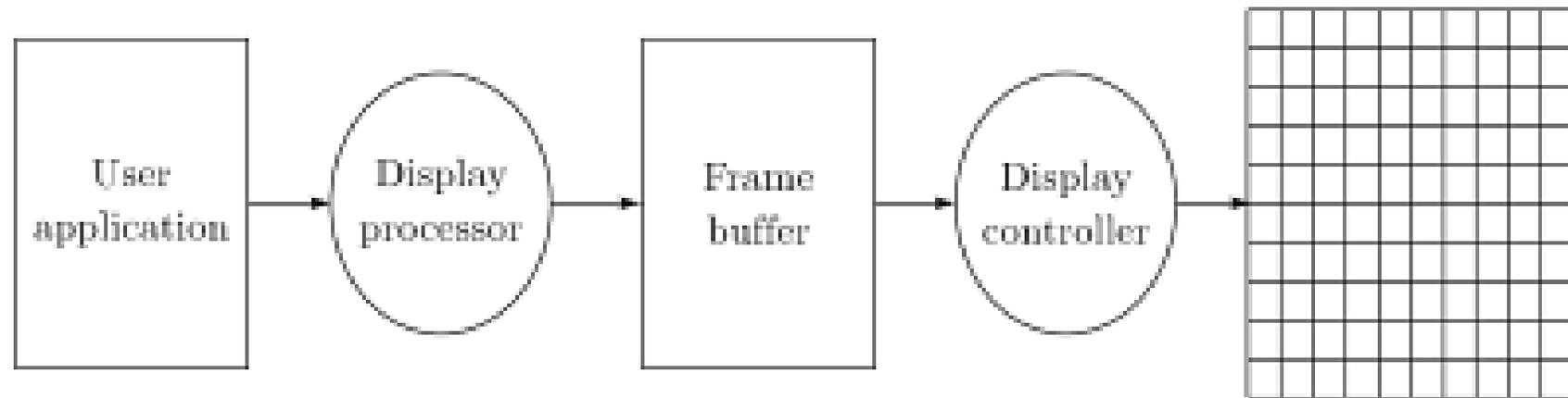
- ▶ In a raster scan display system, a frame buffer is used to store intensity information for each pixel (pel) – picture element
- ▶ The process of generating pixel information into the buffer is called scan conversion
- ▶ Scan conversion is done by a display processor
- ▶ A display controller displays the content of the buffer on the screen
- ▶ Interactive graphical systems use more than one processor which can interact with the CPU and control different operations on the display device
- ▶ The display controller scans the content of the frame buffer and produces output on the display device



# Raster Scan Video Principles..

- ▶ This process of converting a rasterized picture, stored in a frame buffer, to the rigid display pattern of video is called scanning
- ▶ This scanning is done at a particular frequency
- ▶ The frequency of repetition depends on the following:
  - ▶ Human vision perception system
  - ▶ Electronic principles and technology used (such as interlaced or non-interlaced system)

# Raster Scan Video Principles..



**Figure 2.8:** Block diagram of a raster scan display system.

# Raster Scan Video Principles..

- ▶ Human vision perception system
  - ▶ The human visual system requires a particular finite time to realize a particular intensity pattern
  - ▶ Meaning, we cannot detect any change in a display intensity, before our eyes, instantaneously
  - ▶ We have an illusion that the earlier pattern is sustained for a certain period of time
  - ▶ Generally this period is one tenth ( $1/10^{\text{th}}$ ) of a second
  - ▶ This phenomena is called visual persistence



# Raster Scan Video Principles..

- ▶ Persistence of Phosphorescence
  - ▶ Just like in human persistence of vision, display devices also has a limitation called persistence of phosphorescence
  - ▶ The phosphor coating on the screen has a persistence of glowing.
  - ▶ This persistence is defined as the time taken by the light emitted by the screen to decay to one tenth of its original intensity

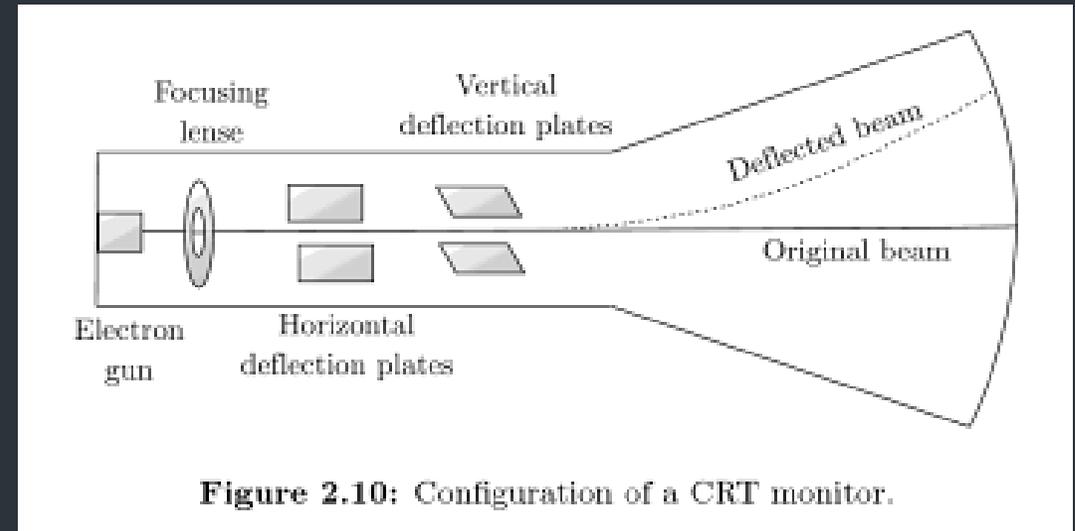
# Raster Scan Video Principles..

## ► Refresh Display

- The two types of persistence described above allows us to produce digital outputs on the refresh display monitors by reproducing the displayed intensity patterns of the monitor at a certain frequency
- Experience shows that the nominal picture update frequency should be 25 frames/second, provided that minimum refresh or repetition rate is twice this, that is, 50 frames/second.
- Each frame is presented twice for proper visual perception.
- The American standard video system uses 525 horizontal lines with an aspect ratio of 4:3
- The rate is 30 frames/second
- Each frame is divided into two fields, having half of the picture
- The fields are interlaced or interwoven
- These fields are presented at the rate of 60 fields/second to reduce the flicker frequency

# Raster Scan CRT Monitors

- ▶ Raster scan CRT Monitors were the most widely used graphical output devices
- ▶ The major components are:
  - ▶ Electron gun
  - ▶ Control electrodes
  - ▶ Focusing electrodes
  - ▶ Deflecting yoke
  - ▶ Phosphor-coated screen



# Raster Scan CRT Monitors..

- ▶ In the CRT, a beam of electrons are emitted from the electron gun (cathode or electrode)
- ▶ The beam passes through the focusing and deflection system and then strike the phosphor-coated screen
- ▶ Electromagnetic beam are used to direct and focus the beam to a particular spot on the screen
- ▶ When the beam strikes a phosphor coated spot, it glows with an intensity which is proportional to the strength of the impinging beam
- ▶ An image is produced on the screen by directing the beam to different locations and by varying its intensity

# Raster Scan CRT Monitors..

- ▶ The glow given off by the phosphor during exposure to the beam is called **fluorescence**
- ▶ The continuing glow of the beam after the beam has been taken off is called **phosphorescence** and its duration is called **persistence of phosphorescence**
- ▶ All phosphors have a limited life depending on the intensity of the electron beam and the time of exposure, after that they are burn out
- ▶ Due to persistence of phosphorescence, CRT must be refreshed frequently (50 to 60 times/second)
- ▶ Otherwise the image on the may appear to flash rapidly on an off
- ▶ This flashing is called flickering

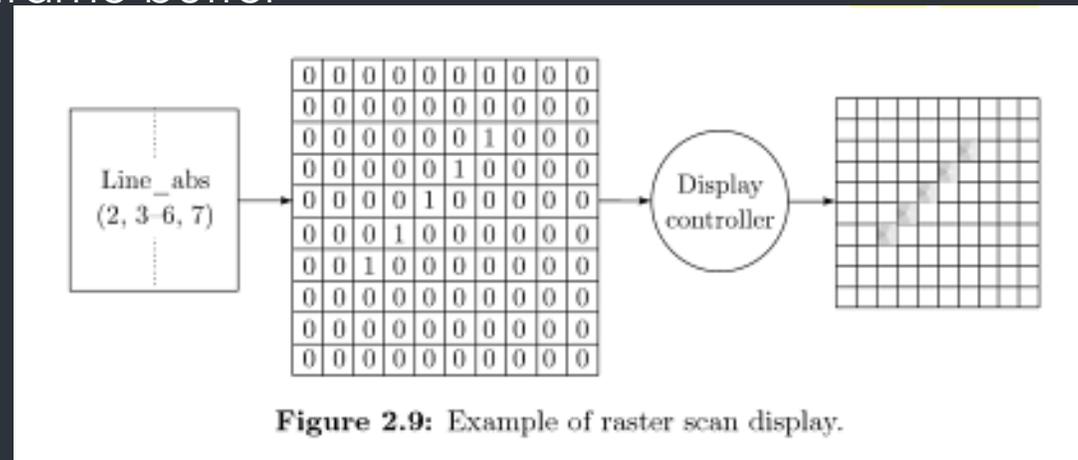


# Raster Scan CRT Monitors..

- ▶ Fortunately, people cannot detect visual changes below  $1/30^{\text{th}}$  of a second (persistence of vision)
- ▶ This limitation of human vision system is the reason TVs and movies and monitors can satisfy our visual sense

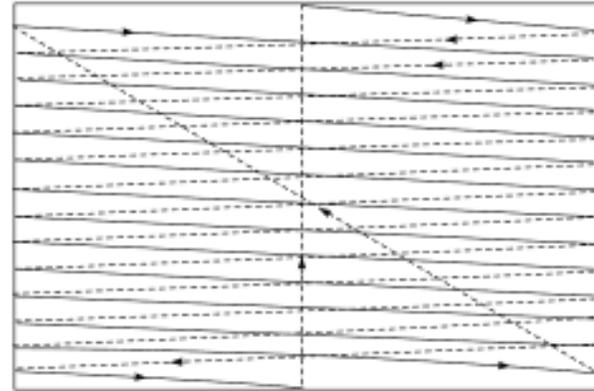
# Raster Scan CRT Monitors..

- ▶ Fig 2.9 shows an example of a raster scan display. We want to draw a line from points (2,3) to point (6,7).
- ▶ The frame buffer is filled with 1s in these range and 0s in the other cells
- ▶ The display controller then paints the screen on those ranges where 1s are found in the frame buffer

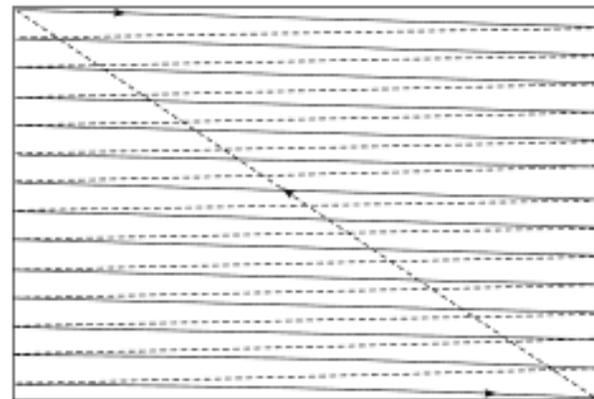


# Interlacing and Non-interlacing

- ▶ Two types of CRT are commercially available, the interlaced and non-interlaced
- ▶ The interlaced are better because it reduces flickering



**Figure 2.11:** Configuration of an interlaced display.



**Figure 2.12:** Configuration of a non-interlaced display.



# Aspect Ratio

- ▶ The device's width-height ratio is called aspect ratio
- ▶ Most CRTs have a display area, so a 14" monitor may have a width of 12" and height of 9" if the aspect ratio is 4:3
- ▶ The aspect ratio can also be defined in terms of pixels: the ratio of horizontal pixels to the vertical pixels

# Resolution

- ▶ The resolution of the CRT is the number of pixels per unit of the scan line
- ▶ Resolutions is measured in terms of horizontal and vertical
- ▶ A 600x400 mean 600 pixels/horizontal line by 400 pixels/vertical line

**Table 2.1:** Different types of monitors and resolutions

<i>Monitor type</i>	<i>Resolution</i>	<i>Number of pixels</i>
VGA	640 × 400	307,200
VGA	800 × 600	480,000
SVGA	1024 × 768	786,432
SVGA	1280 × 1024	1,310,720
SVGA	1600 × 1200	1,920,000



# Input Devices

- ▶ Various devices are available for data input on graphics workstations.
- ▶ Most systems have a keyboard and one or more additional devices specially designed for interactive input.
- ▶ These include a mouse, trackball, spaceball, joystick, digitizers, dials, and button boxes.
- ▶ Some other input devices used in particular applications are data gloves, touch panels, image scanners, and voice systems.



# Keyboards

- ▶ An alphanumeric keyboard on a graphics system is used primarily as a device for entering text strings.
- ▶ The keyboard is an efficient device for inputting such nongraphic data as picture labels associated with a graphics display.
- ▶ Keyboards can also be provided with features to facilitate entry of screen coordinates, menu selections, or graphics functions.
- ▶ Cursor-control keys and function keys are common features on general purpose keyboards.
- ▶ Function keys allow users to enter frequently used operations in a single keystroke, and cursor-control keys can be used to select displayed objects or coordinate positions by positioning the screen cursor.
- ▶ Other types of cursor-positioning devices, such as a trackball or joystick, are included on some keyboards.
- ▶ Additionally, a numeric keypad is, often included on the keyboard for fast entry of numeric data. (see Fig. 2a and 2b).

# Keyboards



**Fig. 2a Normal Alphanumeric Keyboard**



**Fig. 2b Ergonomic Keyboard**



# Keyboards..

- ▶ For specialized applications, input to a graphics application may come from a set of buttons, dials, or switches that select data values or customized graphics operations.
- ▶ Figure 2c gives an example of a button box and a set of input dials.
- ▶ Buttons and switches are often used to input predefined functions, and dials are common devices for entering scalar values.
- ▶ Real numbers within some defined range are selected for input with dial rotations.
- ▶ Potentiometers are used to measure dial rotations, which are then converted to deflection voltages for cursor movement.

Mouse..



**Fig. 2d Workstation with Keyboard and Mouse**

# Keyboards..

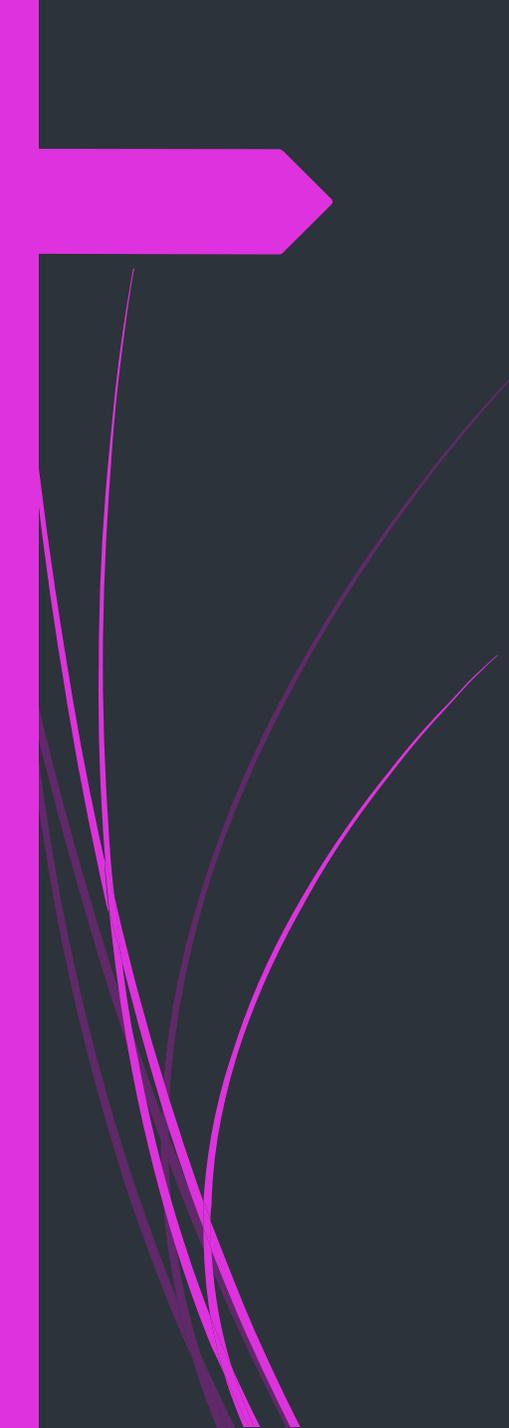


Fig 2c: Button box



# Mouse

- ▶ A mouse is small hand-held box used to position the screen cursor.
- ▶ Wheels or rollers on the bottom of the mouse can be used to record the amount and direction of movement.
- ▶ Another method for detecting mouse motion is with an optical sensor.
- ▶ For these systems, the mouse is moved over a special mouse pad that has a grid of horizontal and vertical lines.
- ▶ The optical sensor detects movement across the lines in the grid.
- ▶ Since a mouse can be picked up and put down at another position without change in cursor movement, it is used for making relative change in the position of the screen cursor.
- ▶ One, two, or three buttons are usually included on the top of the mouse for signaling the execution of some operation, such as recording cursor position or invoking a function.



# Mouse..

- ▶ Most general-purpose graphics systems now include a mouse and a keyboard as the major input devices, as in Fig. 2d.
- ▶ Additional devices can be included in the basic mouse design to increase the number of allowable input parameters.
- ▶ The Z mouse in Fig. 242 includes three buttons, a thumbwheel on the side, a trackball on the top, and a standard mouse ball underneath.
- ▶ This design provides six degrees of freedom to select spatial positions, rotations, and other parameters. With the Z mouse, we can pick up an object, rotate it, and move it in any direction, or we can navigate our viewing position and orientation through a three dimensional scene.
- ▶ Applications of the Z mouse include virtual reality, CAD, and animation.

# Mouse..



Fig. 2e Z Mouse

# Trackball and Spaceball

- ▶ As the name implies, a trackball is a ball that can be rotated with the fingers or palm of the hand, as in Fig. 2f, to produce screen-cursor movement.
- ▶ Potentiometers, attached to the ball, measure the amount and direction of rotation.
- ▶ Trackballs are often mounted on keyboards or other devices such as the Z mouse.
- ▶ While a trackball is a two-dimensional positioning device, a spaceball (Fig. 2g) provides six degrees of freedom.
- ▶ Unlike the trackball, a spaceball does not actually move. Strain gauges measure the amount of pressure applied to the spaceball to provide input for spatial positioning and orientation as the ball is pushed or pulled in various directions.
- ▶ Spaceballs are used for three-dimensional positioning and selection operations in virtual-reality systems, modeling, animation, CAD, and other applications.

# Track ball



Fig. 2f Trackball

# Spaceball



Fig. 2g Spaceball



# Joysticks

- ▶ A joystick consists of a small, vertical lever (called the stick) mounted on a base that is used to steer the screen cursor around.
- ▶ Most joysticks select screen positions with actual stick movement; others respond to pressure on the stick.
- ▶ Fig 2f shows a joystick.
- ▶ Some joysticks are mounted on a keyboard; others function as stand-alone units.
- ▶ The distance that the stick is moved in any direction from its center position corresponds to screen-cursor movement in that direction.
- ▶ Potentiometers mounted at the base of the joystick measure the amount of movement, and springs return the stick to the center position when it is released.
- ▶ One or more buttons can be programmed to act as input switches to signal certain actions once a screen position has been selected.

# Joystick..



Fig. 2h Joy Stick



# Data Glove

- ▶ Figure 2i shows a data glove that can be used to grasp a "virtual" object.
- ▶ The glove is constructed with a series of sensors that detect hand and finger motions.
- ▶ Electromagnetic coupling between transmitting antennas and receiving antennas is used to provide information about the position and orientation of the hand.
- ▶ The transmitting and receiving antennas can each be structured as a set of three mutually perpendicular coils, forming a three-dimensional Cartesian coordinate system.
- ▶ Input from the glove can be used to position or manipulate objects in a virtual scene.
- ▶ A two-dimensional projection of the scene can be viewed on a video monitor, or a three-dimensional projection can be viewed with a headset.

# Data Glove..



Fig. 2i Data Glove

# Data Glove..

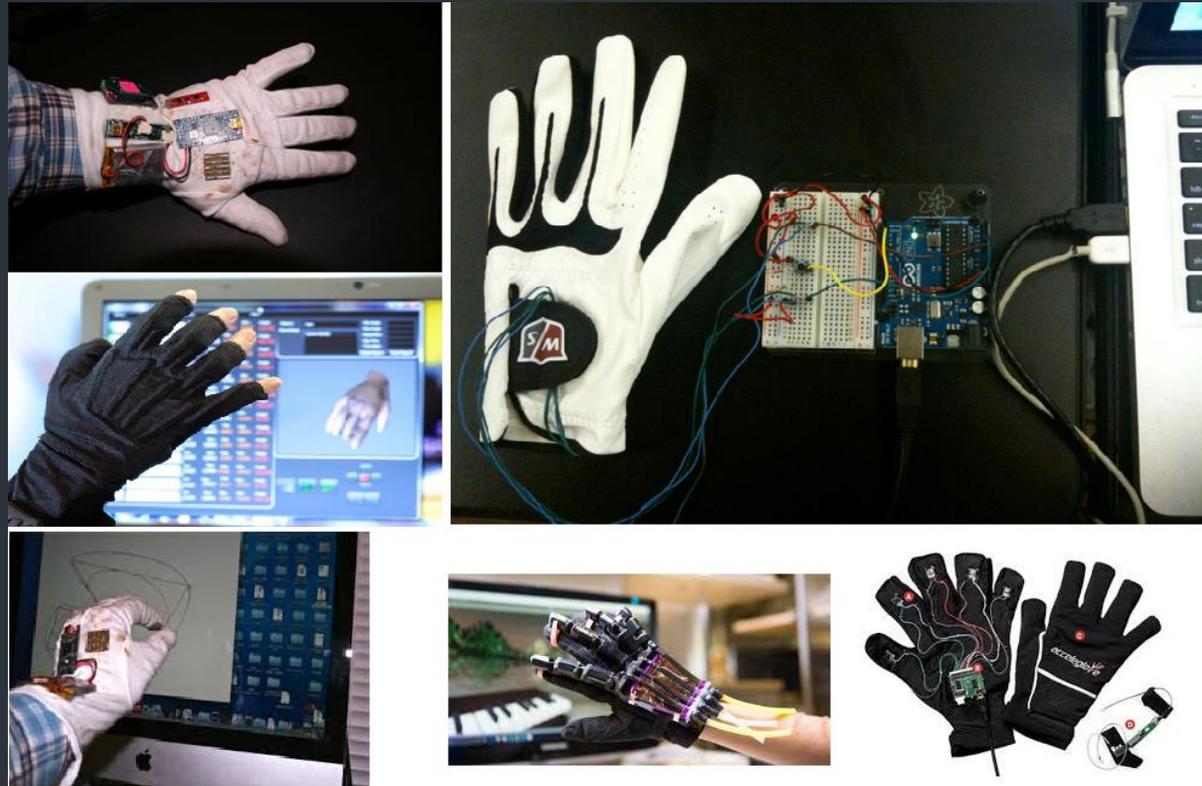


Fig. 2j Data Gloves



# Digitizers

- ▶ A common device for drawing, painting, or interactively selecting coordinate positions on an object is a digitizer.
- ▶ These devices can be used to input coordinate values in either a two-dimensional or a three-dimensional space.
- ▶ Typically, a digitizer is used to scan over a drawing or object and to input a set of discrete coordinate positions, which can be joined with straight line segments to approximate the curve or surface shapes.
- ▶ One type of digitizer is the graphics tablet (also referred to as a data tablet), which is used to input two-dimensional coordinates by activating a hand cursor or stylus at selected positions on a flat surface.
- ▶ A hand cursor contains cross hairs for sighting positions, while a stylus is a pencil-shaped device that is pointed at positions on the tablet.

# Digitizers..



Fig. 2j Digitizers