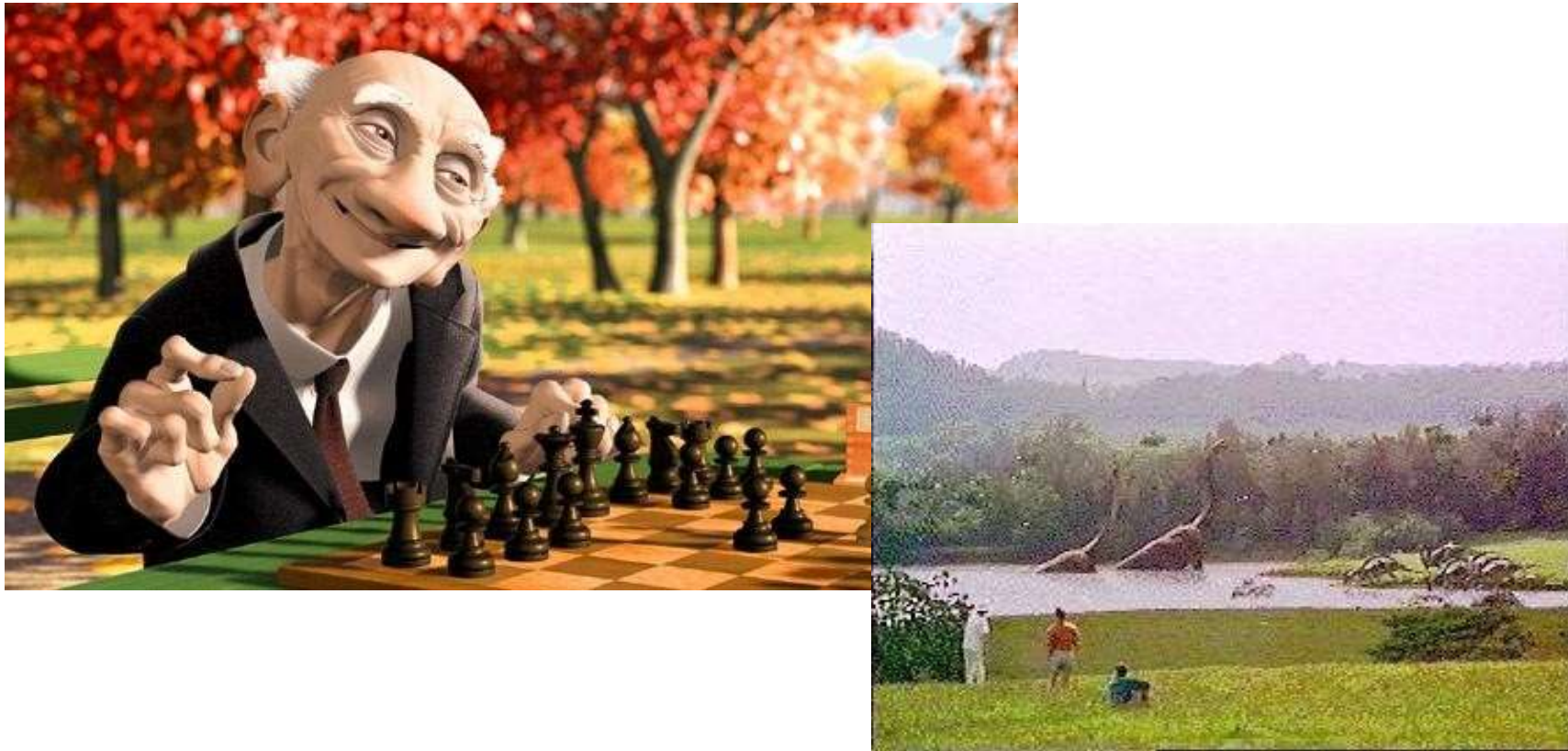# Basics of Computer Graphics

Computer Graphics is about animation (films)

Computer graphics

- It is the creation and manipulation of graphic images by means of a computer.

  - Computer graphics started as a technique to **enhance** the display of information generated by a computer.

  - This ability to interpret and represent numerical data in pictures has significantly **increased** the **computer's ability** to present information to the user in a clear and understandable form.

  - Large amount of data are rapidly converted into bar charts, pie charts, and graphs.

Why bother with CG?

All visual computer output depends on C G

- ◆ printed output (laser/ink jet/phototypesetter)
- ◆ monitor (CRT/LCD/OLED/DMD)
- ◆ all visual computer output consists of real images generated by the computer from some internal digital image
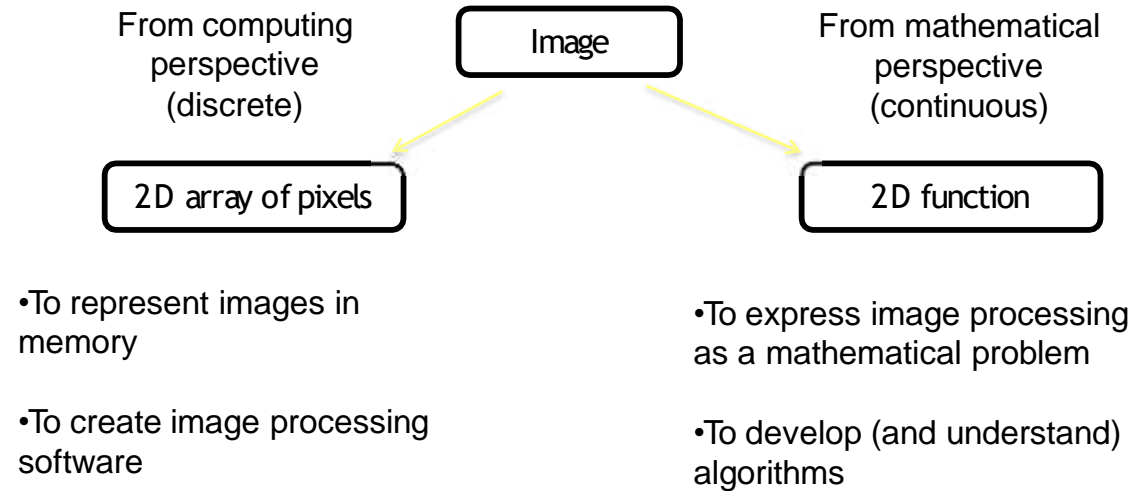
Much other visual imagery depends on C G

- ◆ TV & movie special effects & post-production
- ◆ most books, magazines, catalogues, brochures, junk mail, newspapers, packaging, posters, flyers

What is a (digital) image?

A digital photograph? ("JPEG")

A snapshot of real-world lighting?

From computing perspective (discrete)

Image

From mathematical perspective (continuous)

2D array of pixels

2D function

- To represent images in memory

- To create image processing software

- To express image processing as a mathematical problem

- To develop (and understand) algorithms

Image

2D array of pixels

In most cases, each pixel takes 3 bytes: one for each red, green and blue

But how to store a 2D array in memory?

row-major   column-major   interleaved, row-major

planar, column-major
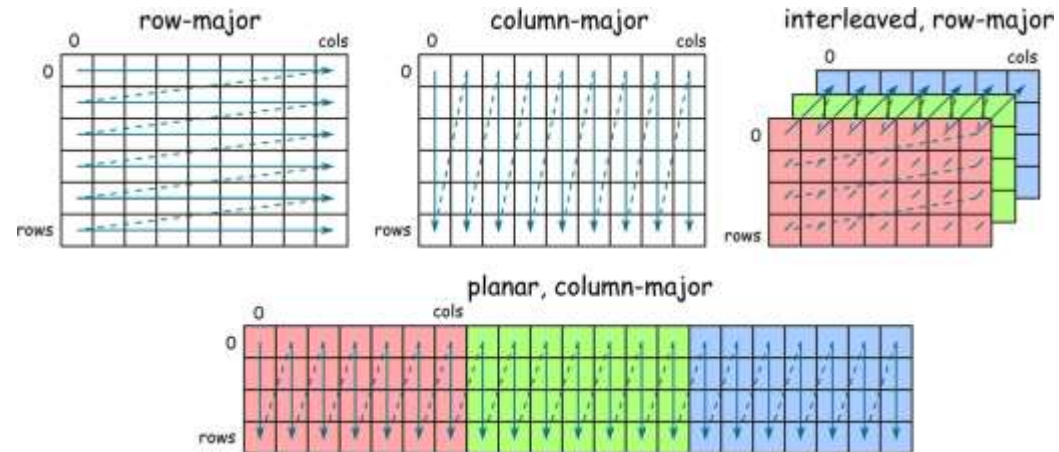
Pixel (PIcture ELement)

Each pixel (usually) consist of three values describing the color

<p align="center">(red, green, blue)</p>

For example

- (255, 255, 255) for white
- (0, 0, 0) for black
- (255, 0, 0) for red

Why are the values in the 0-255 range?

Pixel formats, bits per pixel, bit-depth

Grayscale – single **color channel**, 8 bits (1 byte)

Highcolor – 2^{16}=65,536 colors (2 bytes)

Sample Length:	5	6	5
Channel Membership:	Red	Green	Blue

Bit Number: 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0		
RGBAX	R. G. B. A. X	
Sample Length Notation:	**5.6.5.0.0**	

Truecolor – 2^{24} = 16,8 million colors (3 bytes)

Deepcolor – even more colors (>= 4 bytes)

Sample Length:	2	10	10	10
Channel Membership:	None	Red	Green	Blue

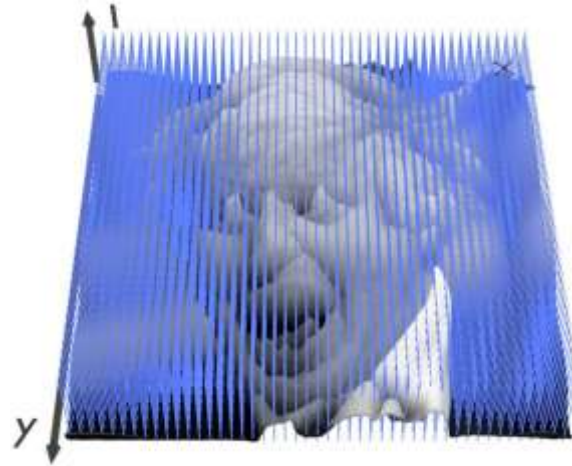|		
Bit Number: 31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0		
RGBAX	R. G. B. A. X	
Sample Length Notation:	**10.10.10.0.2**	

But why?

Image - 2D function

Image can be seen as a function I(x,y), that gives
intensity value for any given coordinate (x,y)

Sampling an image

The image can be sampled on a rectangular sampling grid to yield a set of samples. These samples are pixels.
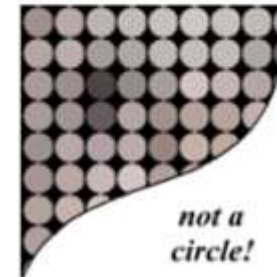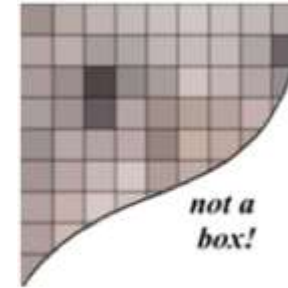
What is a pixel? (math)

A pixel is not
- ◆ a box
- ◆ a disk
- ◆ a teeny light

A pixel is a point
- ◆ it has no dimension
- ◆ it occupies no area
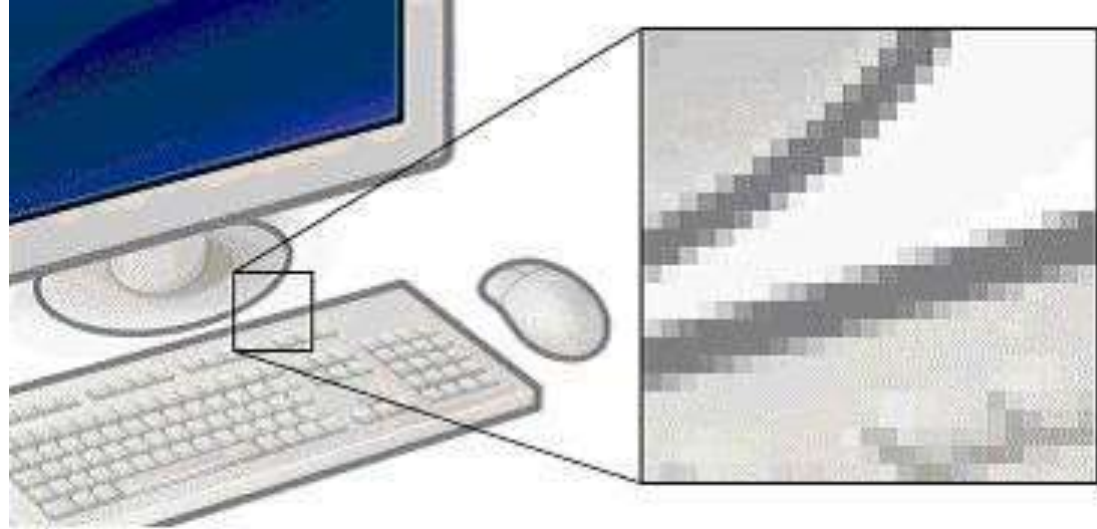- ◆ it cannot be seen
- ◆ it has coordinates

A pixel is a **sample**

not a box!

not a circle!

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Pixel (picture element)

a **pixel** is the smallest piece of information in an image.

- Pixels are normally arranged in a regular **2D grid**, and are often represented using **dots** or **squares**.

Pixel (picture element)

- Each pixel is a **sample** of an original image, where more samples typically provide a more accurate representation of the original.

- The **intensity** of each pixel is variable; in color systems, each pixel has typically three or four components such as red, green, and blue, or cyan, magenta, yellow, and black.

Let's Learn some terminology

- http://preservationtutorial.library.cornell.edu/tutorial/intro/intro-01.html

Resolution

- The number of pixels per unit length is referred to as the resolution of the image

- Based on this **resolution only the effect of picture appears on screen**.

- In other words greater the resolution greater will be the clarity of picture. That is resolution value is directly proportional to clarity of picture.

- Actual resolution is determined by the video controller.
  - Most monitors can operate at several different resolutions. They are
  - 640 X 480
  - 800 X 600
  - 1024 X 768
  - 1152 X 864
  - 1280 X 1024

Q) A 3 x 2 inch image at a resolution of 300 pixels per inch would have a total pixels of?

1) Image **Resolution**: It refers to pixel spacing. In normal **PC** monitor it ranges between 25 to 80 pixels per inch.

2) Screen **Resolution**: It is the number of distinct pixels in each dimension that can be displayed.

For example, a computer with a display resolution of 1280 x 768 will produce a maximum of 98,3040 pixels on a display screen. Each pixel has a unique logical address, a size of eight bits or more and, in most high-end display devices, the ability to project millions of different colors.

Applications of Computer Graphics

- **Computer graphics user interfaces** (GUIs) – A graphic, mouse-oriented paradigm which allows the user to interact with a computer.

- **Business presentation graphics** – "A picture is worth a thousand words".

- **Cartography** – Drawing maps.

- **Weather Maps** – Real-time mapping, symbolic representations.

- **Satellite Imaging** – Geodesic images.

- **Photo Enhancement** – Sharpening blurred photos.
- **Medical imaging** – MRIs, CAT scans, etc. - Non-invasive internal examination.
- **Engineering drawings** – mechanical, electrical, civil, etc. - Replacing the blueprints of the past.
- **Architecture** – Construction plans, exterior sketches - replacing the blueprints and hand drawings of the past.
- **Art** – Computers provide a new medium for artists.
- **Entertainment** – Movies and games.
- **Simulation and modeling** – Replacing physical modeling and enactments

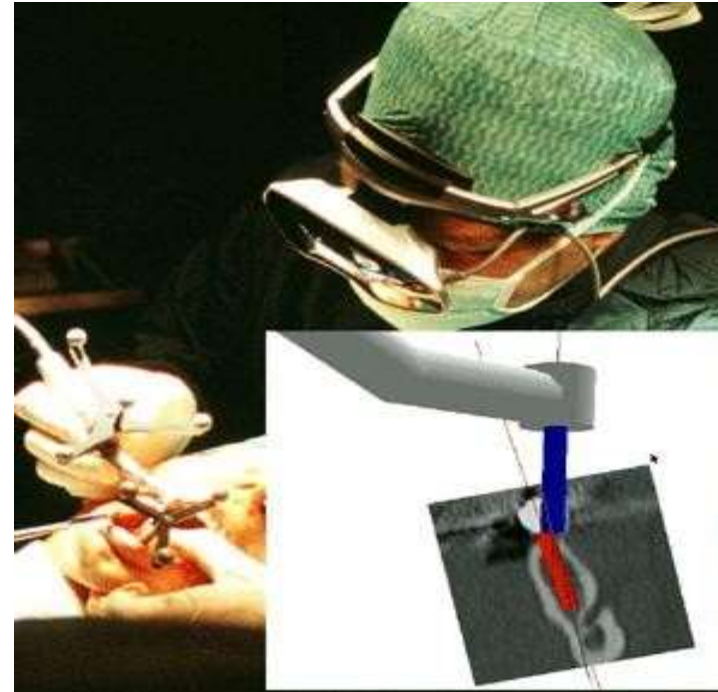# Applications

- **Entertainment**
  - More vivid
  - Move exciting
  - More attractive

Applications (Cont'd)

- **Medicine**
  - Practice performing surgery.
  - Perform surgery on a remote patient.
  - Teach new skills in a safe, controlled environment.

Applications (Cont'd)

- **Manufacturing**
  - Easy to modify
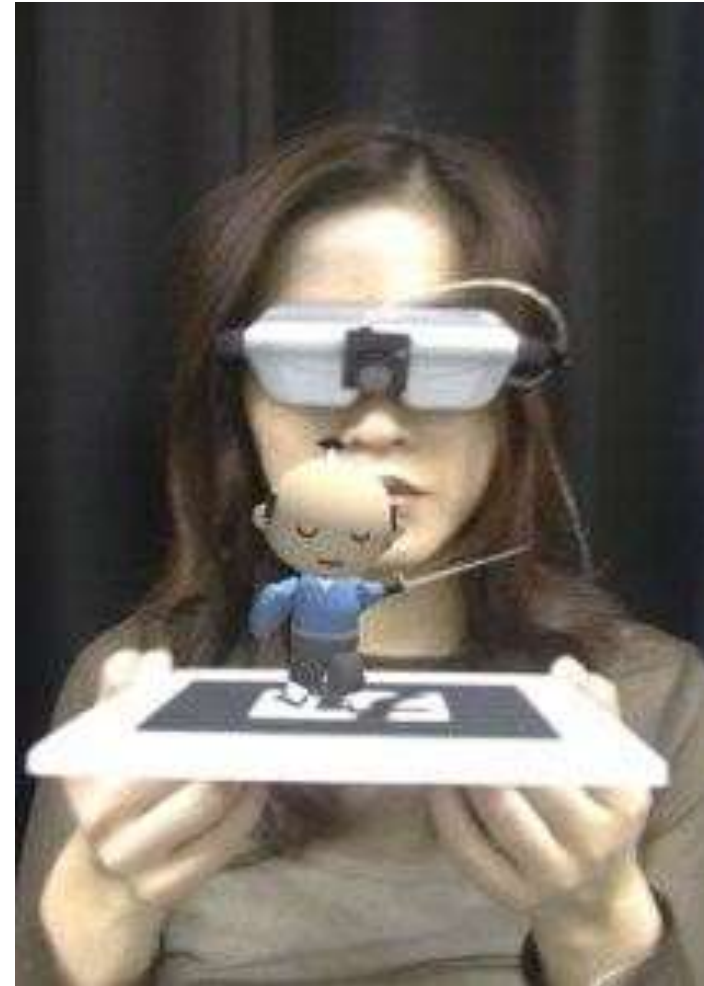 - Low cost
  - High efficient

Applications (Cont'd)

- **Education & Training**
  - Driving simulators.
  - Flight simulators.
  - Ship simulators.
  - Tank simulators.

What Is Augmented Reality (AR)?

- A combination of
  - a real scene viewed by a user and
  - a virtual scene generated by a computer that augments the scene with additional information.
  - ARToolkit demo movie
  - T-immersion 2004 video

What is AR? (cont.)

- Ronald Azuma defines an augmented reality system as one that:
  - Combines real and virtual world aspects
  - Is interactive in real-time
  - Is registered in three dimensions

Virtual Reality vs. Augmented Reality

- ## Virtual Reality (VR)

  a computer generated, interactive, 3D environment in which a person is immersed : virtual, interactive and immersive

- ## Augmented Reality (AR)

  Supplements the real world with the virtual(computer generated) objects that appear to coexist in the same space as the real world.

Augmented Reality vs. Virtual Reality
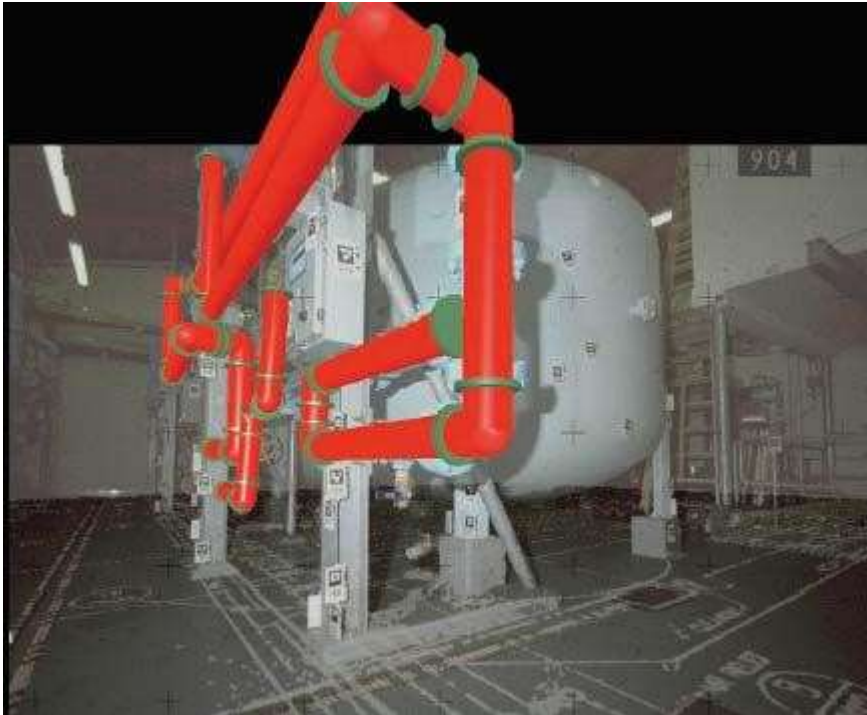
- Augmented Reality
  - System augments the real world scene
  - User maintains a sense of presence in real world
  - Needs a mechanism to combine virtual and real worlds
  - Hard to register real and virtual
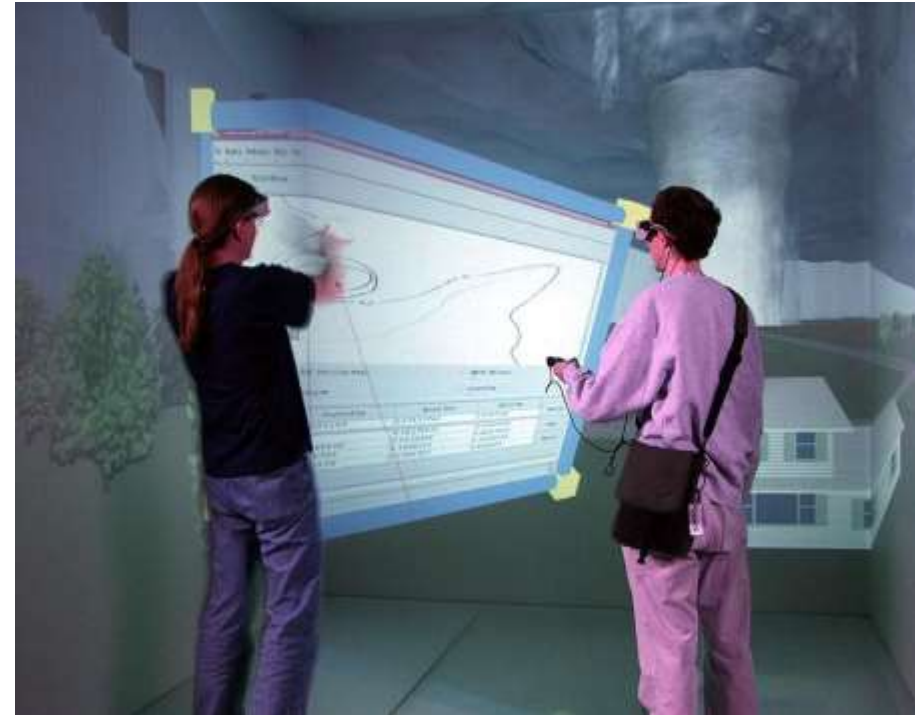
- Virtual Reality
  - Totally immersive environment
  - Senses are under control of system
  - Need a mechanism to feed virtual world to user
  - Hard to make VR world interesting

Augmented Reality vs. Virtual Reality

Engineering   Education –Virtual Storm

What is needed?

- There are three components needed in order to make an augmented-reality system work:
  - Head-mounted display
  - Tracking system
  - Mobile computing power

Course Coordinator : Mrs Deshmukh A.P.

Current Uses of AR

- Yellow first down line used on TV broadcasts of football games:
  - Real world elements: football field and players
  - Virtual element: the yellow line drawn over the image by computers in real-time

Current Uses of AR

- HUD (Head Up Display):
  - Used in commercial aircraft, automobiles, and other applications
  - Presents data without requiring the user to look away from his or her usual viewpoint

LifeClipper

- LifeClipper is a wearable AR system being used in Switzerland.

- When walking around a chosen culturally interesting area, the user will feel as though they are watching a film.

Wikitude – AR Travel Guide

- Mobile travel guide for the Android platform (open source OS for cell phones).

- Plan a trip or find about current surroundings in real-time.

Course Coordinator Mrs Deshmukh A.P.

Supplements:

- [How the human eye works](#)
- [PPI vs. DPI: what's the difference?](#)

Books & Resources:

- [https://drive.google.com/drive/folders/1PKGjHT_DGb4wNs-NTYjurEnndd-Mrvr?usp=sharing](#)