Unit 1 : Fundamentals of Multimedia Computing

Multimedia Systems

- Multimedia is something people can see, hear, touch and read on websites, radio, television, video games, phone applications, retail stores, cinema halls and ATMs.
- Multimedia is the medium which provides information to the users in the form of text, audio, video, animation and graphics.
- Multimedia is progressively becoming data-driven and object-oriented which allows applications with cooperative end-user innovation and personalization on many forms of content over a period.

Characteristics of multimedia

- Multimedia presentations can be viewed in person on stage, projected, transmitted, or played locally with a media player.
- Broadcasts and recordings can be either analog or digital electronic media technology.
- The various formats of technological or digital multimedia may be intended to enhance the users' experience.
- Online multimedia is increasingly becoming object-oriented and data-driven, enabling applications with collaborative end-user innovation and personalization on multiple forms of content over time.

Desirable features of Multimedia Systems

- **Very High Processing Power** : needed to deal with large data processing and real time delivery of media. Special hardware is required.
- **Multimedia Capable File System** : needed to deliver real-time media. e.g. Video/Audio Streaming. Special Hardware/Software needed e.g RAID technology.
- **Data Representations/File Formats that support multimedia** : Data representations/file formats should be easy to handle yet allow for compression/decompression in real- time.
- **Efficient and High I/O** : input and output to the file subsystem needs to be efficient and fast. Needs to allow for real-time recording as well as playback of data. e.g. Direct to Disk recording systems.
- **Special Operating System** : to allow access to file system and process data efficiently and quickly. Needs to support direct transfers to disk, real-time scheduling, fast interrupt processing, I/O streaming etc.

- **Storage and Memory** : large storage units (of the order of 50 -100 Gb or more) and large memory (50 -100 Mb or more). Large Caches also required and frequently of Level 2 and 3 hierarchy for efficient management.
- **Network Support** : Client-server systems common as distributed systems common.
- **Software Tools** : user friendly tools needed to handle media, design and develop applications, deliver media.

Components of multimedia

The Components (Hardware and Software) required for a multimedia system:

Capture devices
Video Camera, Video Recorder, Audio Microphone, Keyboards, mice, graphics tablets, 3D input devices, tactile sensors, VR devices. Digitising/Sampling Hardware

Storage Devices

Hard disks, CD-ROMs, Jaz/Zip drives, DVD, etc Communication Networks -- Ethernet, Token Ring, FDDI, ATM, Intranets, Internets.

Computer Systems

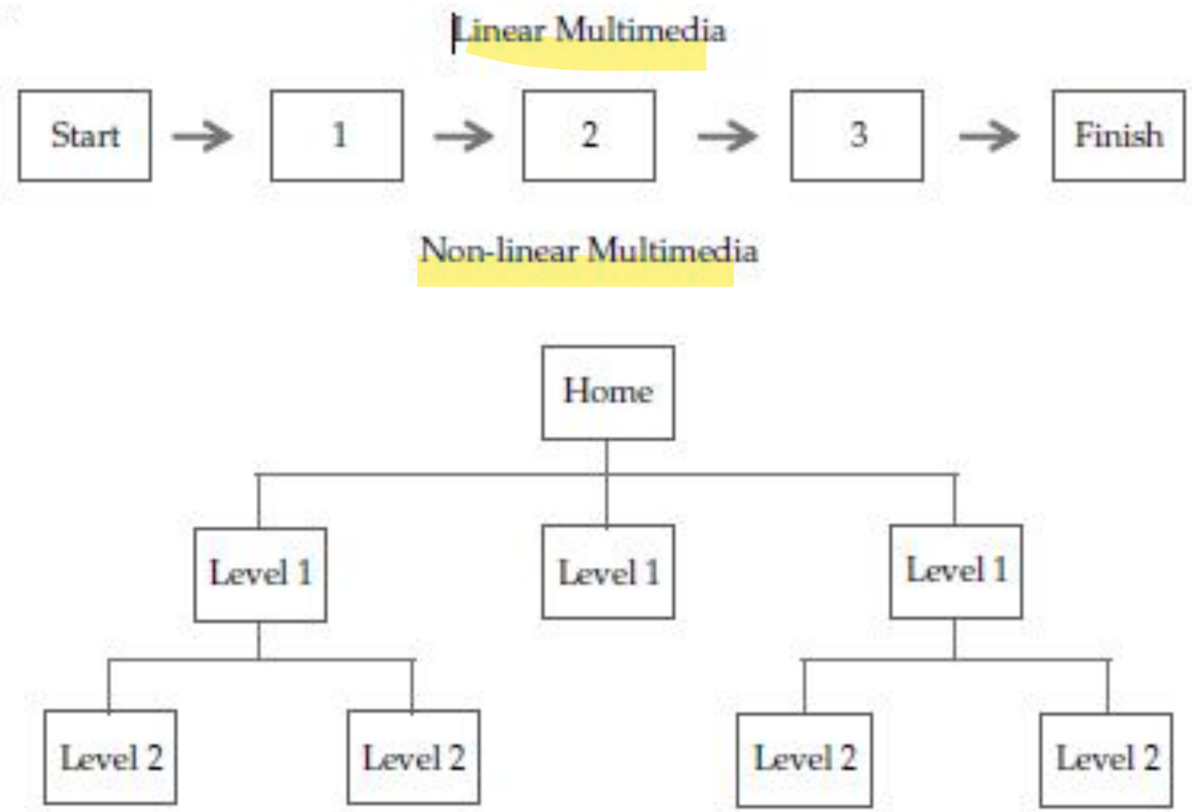
Multimedia Desktop machines, Workstations, MPEG/VIDEO/DSP Hardware

Display Devices

CD-quality speakers, HDTV,SVGA, Hi-Res monitors, Colour printers etc.

Categories of Multimedia

1. Linear Multimedia
2. Non Linear Multimedia



Linear Multimedia	Non Linear Multimedia
Linear active content progresses without any navigational control for the viewer.	Non linear content offers user interactivity to control progress as used with a computer game.
Eg, Cinema presentation	Eg, Hypermedia

Applications of Multimedia

- **Business :** Multimedia is used for advertising and selling products on the Internet. Some businesses use multimedia tools such as CD-ROMs, DVDs or online tutorials for training or educating staff members about things the employer want them to learn or know.
- **Research & Medicine :** Multimedia is increasingly used in research in the fields of science, medicine and mathematics. It is mostly used for modelling and simulation. In Medicine, doctors acquire training by watching a virtual surgery.
- **Public Access :** Public Access is an area of application where several multimedia applications will be available very soon. One of the application is the tourist information system, where a travel enthusiast will be shown glimpse of the place he would like to visit. With the help of multimedia various source providing applications could be created.
- **Entertainment :** Multimedia is used to create special effects in films, TV serials, radio shows, games and animations. Multimedia games are popular software programs that available online as well as on DVDs and CD-ROMs. Use of special technologies such as virtual reality turn these games into real life experiences. These games allow uses to fly aeroplanes, drive cars, do wrestling, etc.

Multimedia formats include

The following extensions commonly used to lay up multimedia documentation:

- MOV
- MP4
- 3GP
- VOB
- FLV.

- Files with augmentation **MOV** are used to lay up capture on film and song in order.
- **MP4** is fundamentally identical to MOV format and lone differs by provided that roughly added metadata.
- MP4 put on record augmentation is supported by multiple applications with Apple ITunes, XBox 360.
- **MPEG** is an align of compressions methods designed for audio and visual data.
- **3GP** on PC may perhaps be viewed VLC media player, RealPlayer, QuickTime, GOM Player and Media Player Classic.
- File Extension **VOB** (Video Object) is commonly locate such documents in DVD-Video media.
- File Extension **FLV** is used to deposit Macromedia Flash Player collection. It can assign vector graphics, spill videocassette, audio and text.

Features of Multimedia

- Text
- Audio
- Pictures
- Video
- Animation
- Interactivity

Text

- Text is the most widely used and flexible means of presenting information on screen and conveying ideas.
- Text is an essential aspect of presenting the information.
- Like each element of the multimedia design, effective use of text can either direct users/readers attention or divert it.

Audio

- Audio refers to sound. Multimedia can include files which contain sounds.
- Audio songs also come under the heading multimedia.
- Multimedia presentations often have some audio tracks which makes it easier for people to understand.
- Multimedia phones have music players to run audio music.
- Various audio software include VLC media player, real player, etc.

Pictures

- Pictures(images) is a two-dimensional screen display, and as well as a three-dimensional, such as a statue or hologram.
- Graphs, pie-charts, painting etc. all come under images.
- Images are a very useful feature of multimedia. Multimedia presentation uses pictures or clip-art to make people understand.
- Various file formats of images are .jpg, .png, .gif etc.

Video

- A video is unedited material as it had been originally filmed by movie camera or recorded by a video camera.
- The embedding of video in multimedia applications is a powerful way to convey information which can incorporate a personal element which other media lack.
- Video enhances, dramatizes, and gives impact to your multimedia application.
- The advantage of integrating video into a multimedia presentation is the capacity to effectively convey a great deal of information in the least amount of time.

Animation

- Animation is the rapid display of a sequence of images of 2-D or 3-D artwork or model positions in order to create an illusion of movement.
- The effect is an optical illusion of motion due to the phenomenon of persistence of vision.
- Animation adds visual impact to the multimedia project.
- Animation are used in cartoons, scientific visualization.

Interactivity

- Interactivity can be termed as the dialog that occurs between an individual and a computer program.
- Interactive multimedia refers to the multimedia applications that allow users to actively participate rather than being passive recipients of information.
- Technologies such as DVDs and digital TV are classic examples of interactive media devices, where a user can control what they watch and when.
- Interactivity also relates to new media art technologies where humans and animals are able to interact with and change the course of an artwork.

Multimedia Coding

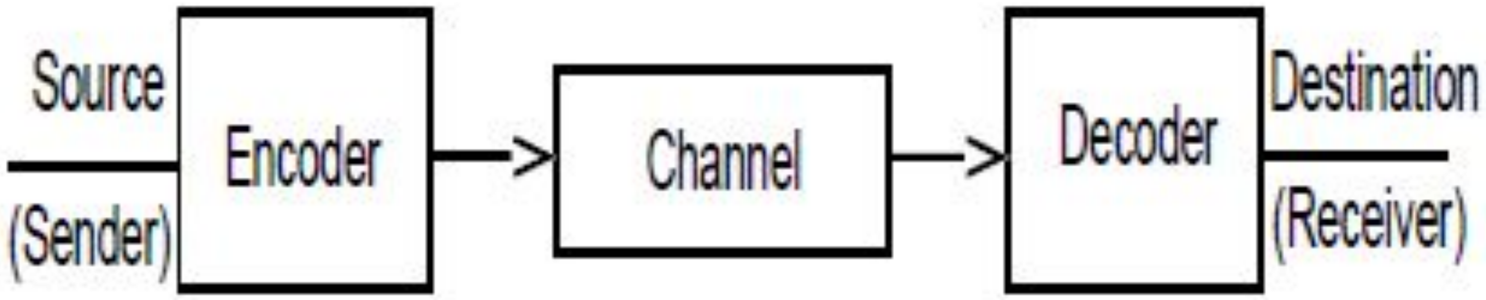
Multimedia information is inherently voluminous and therefore requires very high storage capacity and very high bandwidth transmission capacity.

There are two approaches that are possible:

1. To develop technologies to provide higher bandwidth (of the order of Gigabits per second or more)
2. To find ways and means by which the number of bits to be transferred can be reduced without compromising the information content.

Transformation of a string of characters in some representation (such as ASCII) into a new string (eg, of bits) that contains the same information but whose length must be as small as possible is called ***Data Compression***.

Shannon's Communication System Model



Two basic issues addressed by Communication Model

1. How can a communication system efficiently transmit the information that a source produces?
2. How can a communication system achieve reliable communication over a noisy channel?

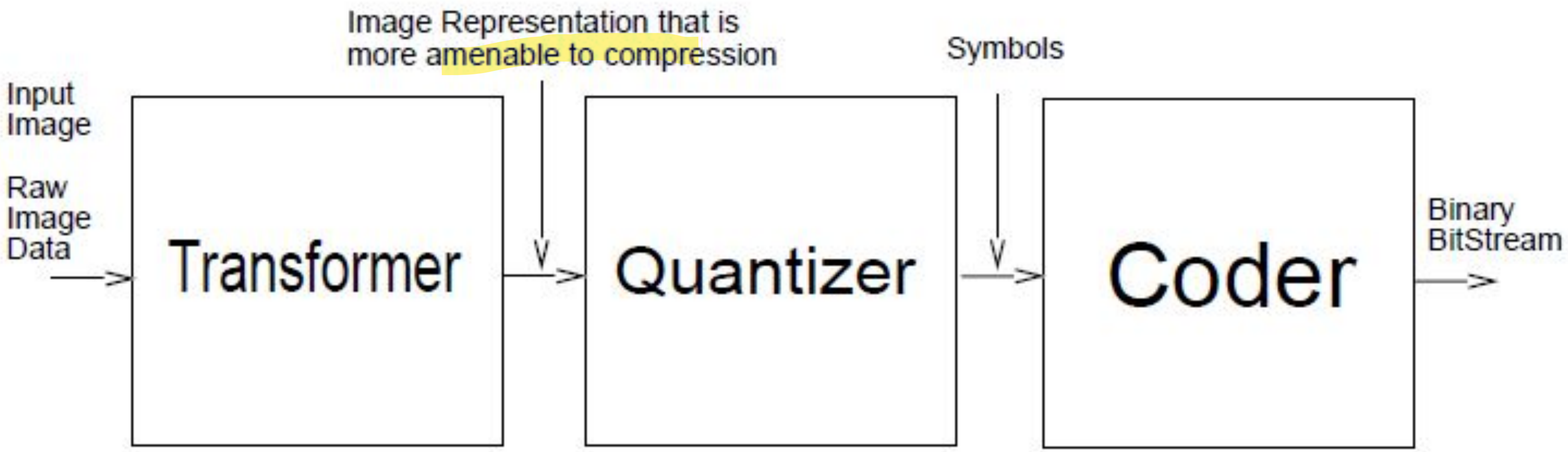
Image Compression

Image data can be compressed without significant degradation of the visual (perceptual) quality because images contain a high degree of:

- Spatial redundancy, due to correlation between neighboring pixels (this is also referred to as statistical redundancy)
- Spectral redundancy, due to correlation among color components
- Psycho-visual redundancy, due to perceptual properties of the human

visual system.

Image Compression System



Transformer applies a one-to-one transformation to the input image data. The output of the transformer is an image representation which is more amenable to efficient compression than the raw image data.

Quantizer generates a limited number of symbols that can be used in the representation of the compressed image.

- Scalar quantization refers to element-by-element quantization of data
- Vector quantization refers to quantization of a block at a time

Coder assigns a code word, a binary bit-stream, to each symbol at the output of the quantizer. The coder may employ fixed-length or variable-length codes.

Image compression systems can be broadly classified as:

Lossless: Compression systems, which aim at minimizing the bit-rate of the compressed output without any distortion of the image. The decompressed bit-stream is identical to the original bit-stream. This method is used in cases where accuracy of the information is essential. Examples of such situations are computer programs, data, medical imaging etc. Lossless compression systems are also referred to as bit-preserving or reversible compression systems. The transformation and coding stages are lossless.

Lossy: Compression systems, which aim at obtaining the best possible fidelity for a given bit-rate (or minimizing the bit-rate to achieve a given fidelity measure). Such systems are suited for video and audio. The quantization stage is lossy.

Key	Lossy Compression	Lossless Compression
Data Elimination	By using lossy compression, you can get rid of bytes that are regarded as unnoticeable.	Even unnoticeable bytes are retained with lossless compression.
Restoration	After lossy compression, a file cannot be restored to its original form.	After lossless compression, a file can be restored to its original form.
Quality	Quality suffers as a result of lossy compression. It leads to some level of data loss.	No quality degradation happens in lossless compression.
Size	Lossy compression reduces the size of a file to a large extent.	Lossless compression reduces the size but less as compared to lossy compression.
Algorithm used	Transform coding, Discrete Cosine Transform, Discrete Wavelet transform, fractal compression, etc.	Run length encoding, Lempel-Ziv-Welch, Huffman Coding, Arithmetic encoding, etc.
Uses	Lossy compression is used to compress audio, video and images.	Lossless compression is used to compress files containing text, program codes, and other such critical data.
Capacity	The data holding capacity of the lossy compression approach is quite significant.	Lossless compression has low data holding capacity as compared to lossy compression.

Encoding Techniques

- ***Run Length Encoding***

In this technique, the sequence of image elements (or pixels in a scan line) x_1, x_2, … ,x_n is mapped into a sequence of pairs (c_1,l_1), (c_2,l_2) …., (c_k,l_k) where c_i represents a color (or intensity) and l_i the length of the i^{th} run (sequence of pixels with equal intensity).

Example: Let digits 1, 2, 3 represent Red, Green, and Blue. These will correspond to c_i. Let a scan line be of length 35 consisting of

11111111111333333333322222222211111

as x_i. Then, the run-length encoded stream will be the series of tuples (1,11), (3,10), (2,9) and (1,5), where 11,10,9,5 are the l_i .

Huffman Coding

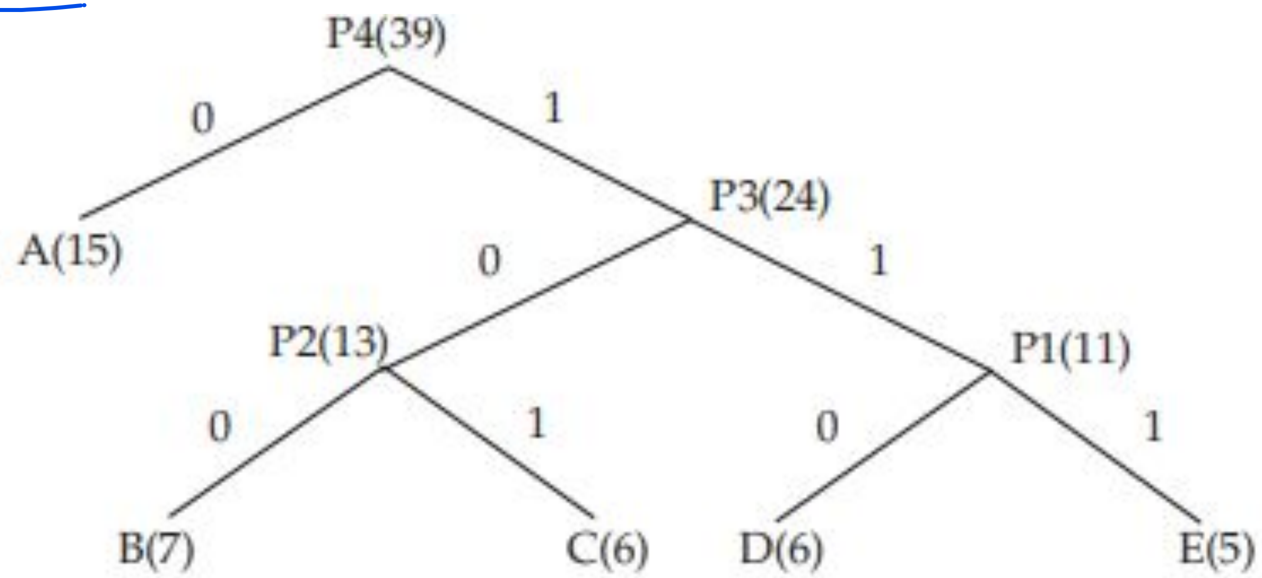
Huffman coding is based on the frequency of occurrence of a character (or an octet in the case of images). The principle is to use a lower number of bits to encode the character that occurs more frequently. The codes are stored in a codebook. The codebook may be constructed for every image or for a set of images, when applied to still or moving images. In all cases, the codebook should be transferred to the receiving end so that decoding can take place.

Input: ABACDEAACCAABEAABACBDDABCADDBCEAEAAADBE

Symbol : A B C D E
Count : 15 7 6 6 5

total:39*3=117 bits
Output: 15*1+(7+6+6+5)*3=87 bits
Compression ratio: 117/87 = 1.34

A	0	1
B	100	3
C	101	3
D	110	3
E	111	3



Transform Coding

Transformation based coding consists of three stages:

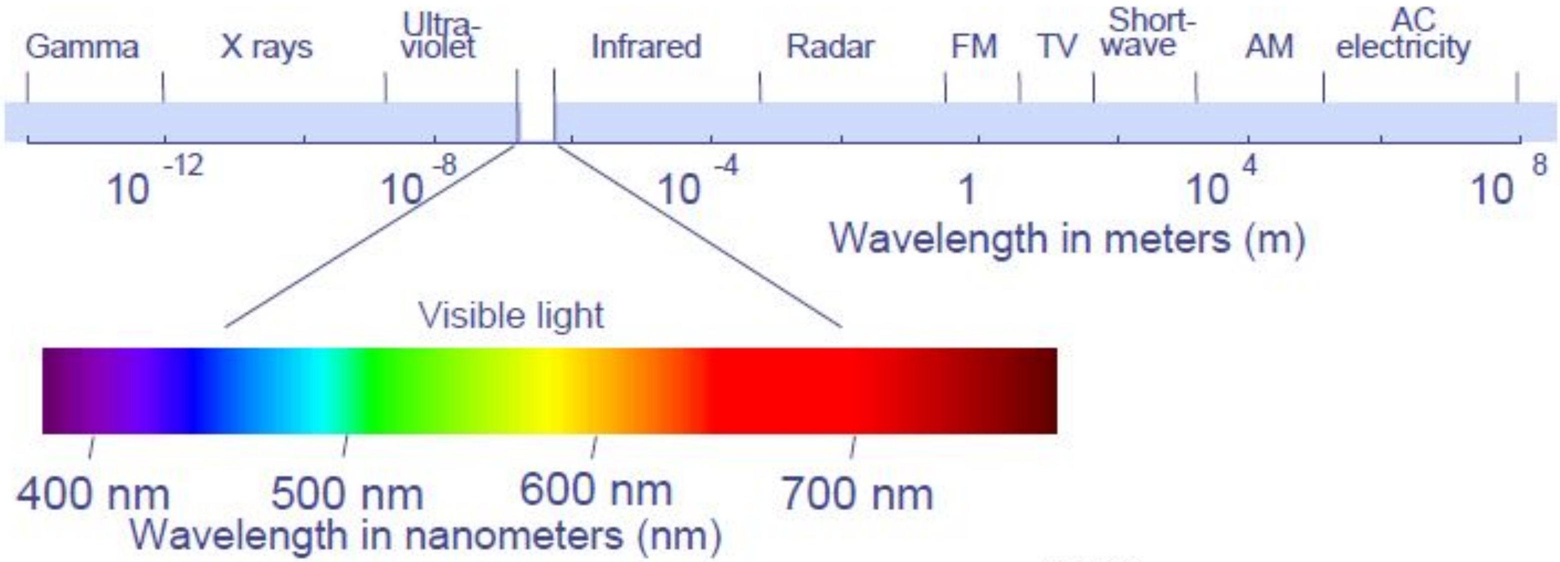
- **Transformation**: It is used to map from one space to another along the graphics pipeline.
- **Quantisation**: A variety of techniques can be applied to map the transform coefficients to a small alphabet, the size of the latter being selected corresponding to the target bit rate. Most rate-control procedures are applied in this stage.
- **Lossless encoding of coefficients**: A variety of techniques is applied in order to encode the quantised transform coefficients close to the entropy bound. Typically, a combination of run-length (zero-runs !) and Huffman coding (for the older standards like JPEG, MPEG- 1, 2, 4) or arithmetic coding (for the more recent standards like JPEG 2000 H.264) is used.

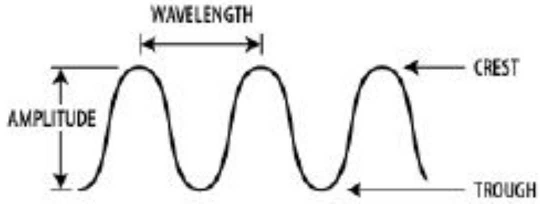
Color Space and Human Visual System(HVS)

What is color?

- Color is the spectrum of light being perceived by the human visual system.
- Visible light is electromagnetic energy in the 400 to 700 nm wavelength range of the spectrum
- Why discuss color?
  - Many ways to talk about color: tint, shade, hue, brightness, luminance, color, chromaticity etc.
  - Useful to understand how the eye perceives color

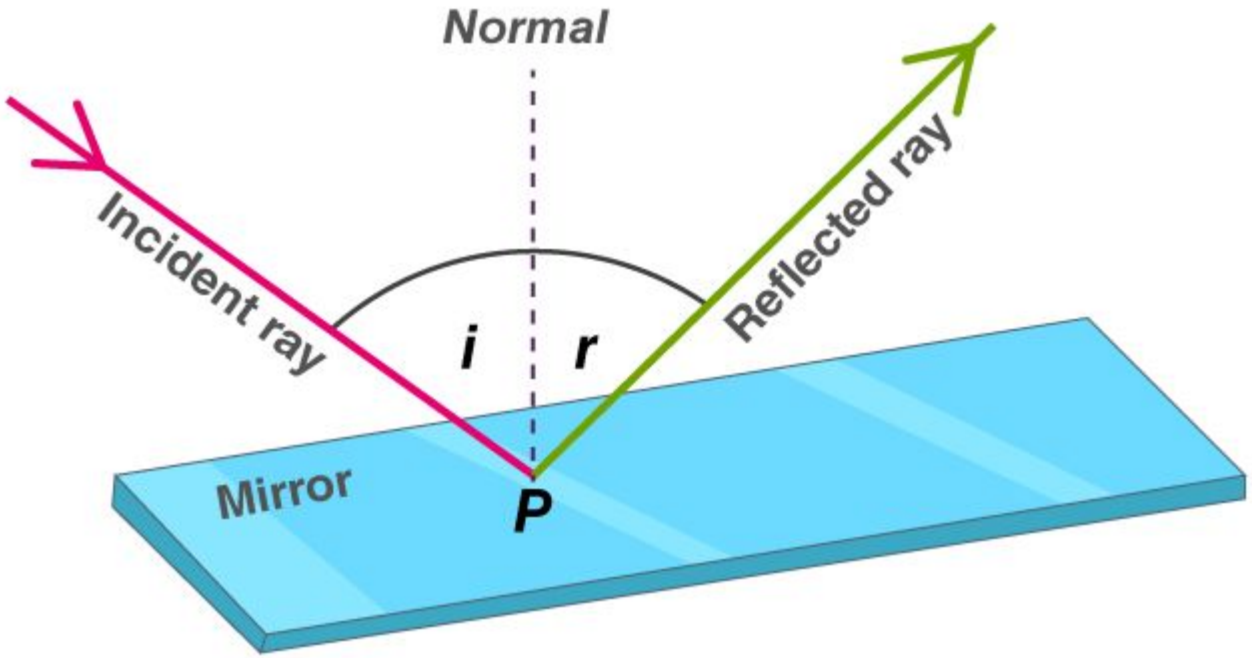
Electromagnetic Radiation - Spectrum





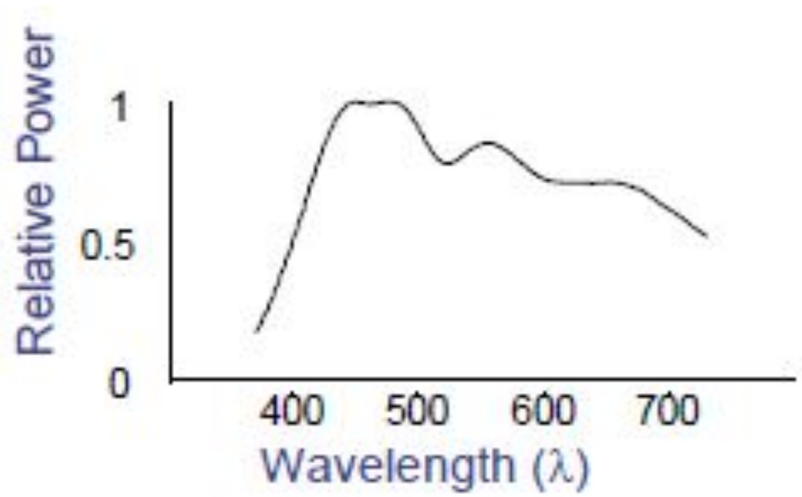
The interaction of light and matter

Some or all of the light may be absorbed depending on the pigmentation of the object.

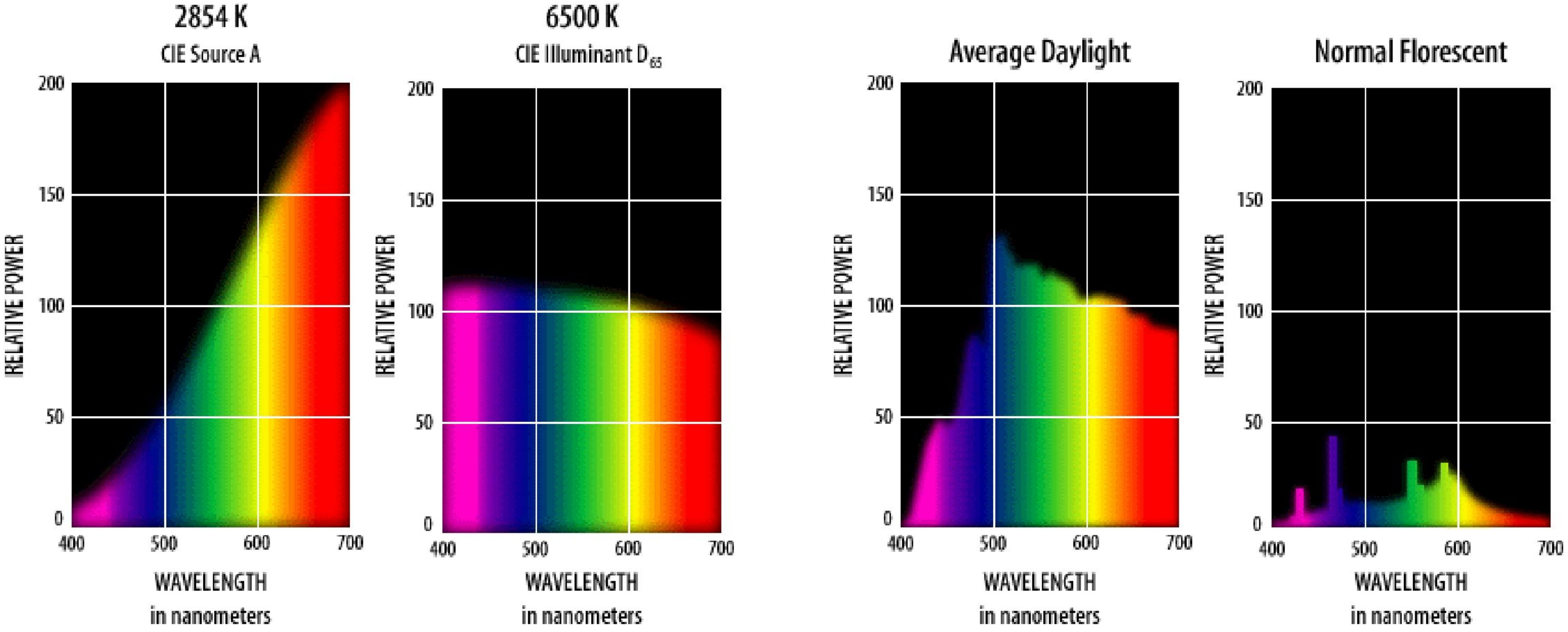


Spectral Power Distribution

The **Spectral Power Distribution** (SPD) of a light is a function P(λ) which defines the power in the light at each wavelength.



Examples


2854 K
CIE Source A
6500 K
CIE Illuminant D65
Average Daylight
Normal Florescent
RELATIVE POWER
0
50
100
150
200
400
500
600
700
WAVELENGTH
in nanometers

Color Spaces

History

- **Thomas Young (1773-1829)**

“A few different retinal receptors operating with different wavelength sensitivities will allow humans to perceive the number of colors that they do. “

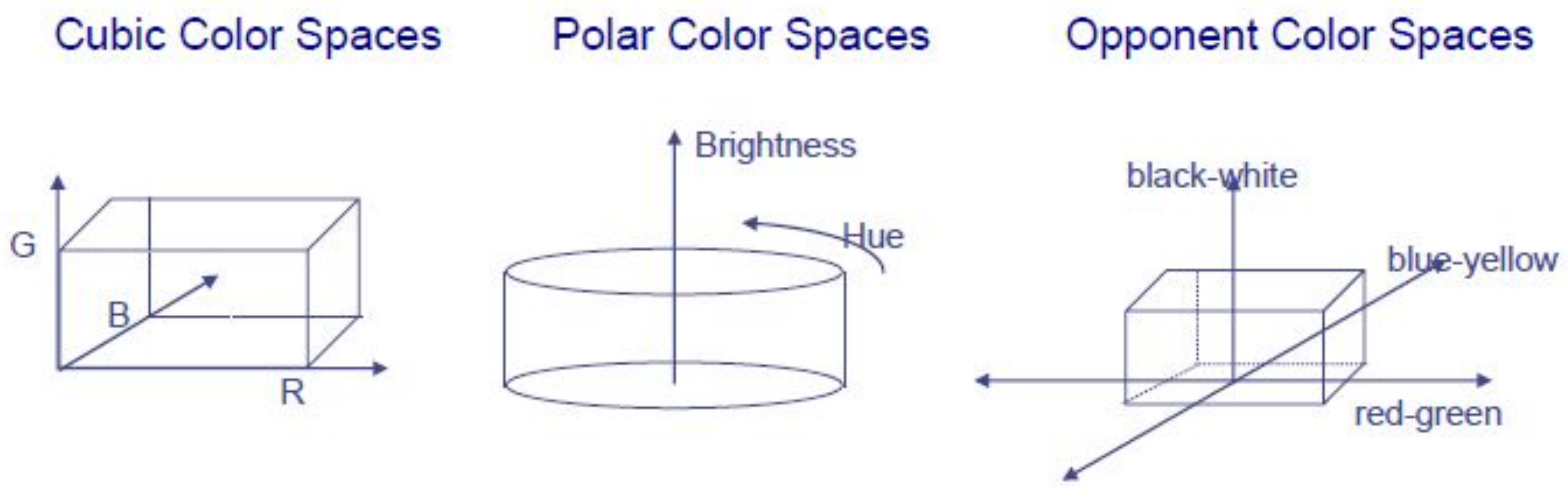
- **James Clerk Maxwell (1872)**

“We are capable of feeling three different color sensations. Light of different kinds excites three sensations in different proportions, and it is by the different combinations of these three primary sensations that all the varieties of visible color are produced. “

- **Trichromatic**: “Tri”=three “chroma”=color

3-D Color Spaces

Three types of cones suggests color is a 3D quantity. How to define 3D color space?



The RGB Color Model

- The simplest color model is to attempt to model these three stimulus values: red, green, blue
- 24-bit color: one byte each for red, green, and blue
- Each is called a channel

RGB Image


111 14 126 36 12 36
200 36 12 36 14 36
10 128 126 200 12 111
17 36 36 14 36 72
12 17 126 17 111 200
14 200 36 12 126 17
126 200 111 14 36 72
36 12 17 72 106 155

Luminance and Chromaticity

RGB isn’t the most intuitive model of color

Artists usually think of dark/light and color as two different things:

- Luminance
- Chromaticity

Luminance

- Luminance
- Intensity
- Brightness
- Lightness
- Luma
- Value

- All refer to the light/dark properties of the stimulus
- Some models use linear, non-linear, or perceptually linear encoding

Chromaticity

Requires two parameters

Example:

- Hue : The dominant wavelength
- Saturation : How pure/deep that color is relative to gray

Note: Some models use different chromaticity parameters

Color Gamuts

- The color space spanned by a set of primary (base) colors is called a color gamut
- Example: the space of all colors that can be displayed by a device with three color phosphors is the gamut of that device
- No three-primary color (with positive weights) spans the full space of perceivable colors!
- The CIE chromaticity diagram spans the gamut of human color vision

The RGB Model

When light is mixed, wavelengths combine (add)

The Red-Green-Blue (*RGB*) model is used most often for *additive models*

Adding a color and its complement create white

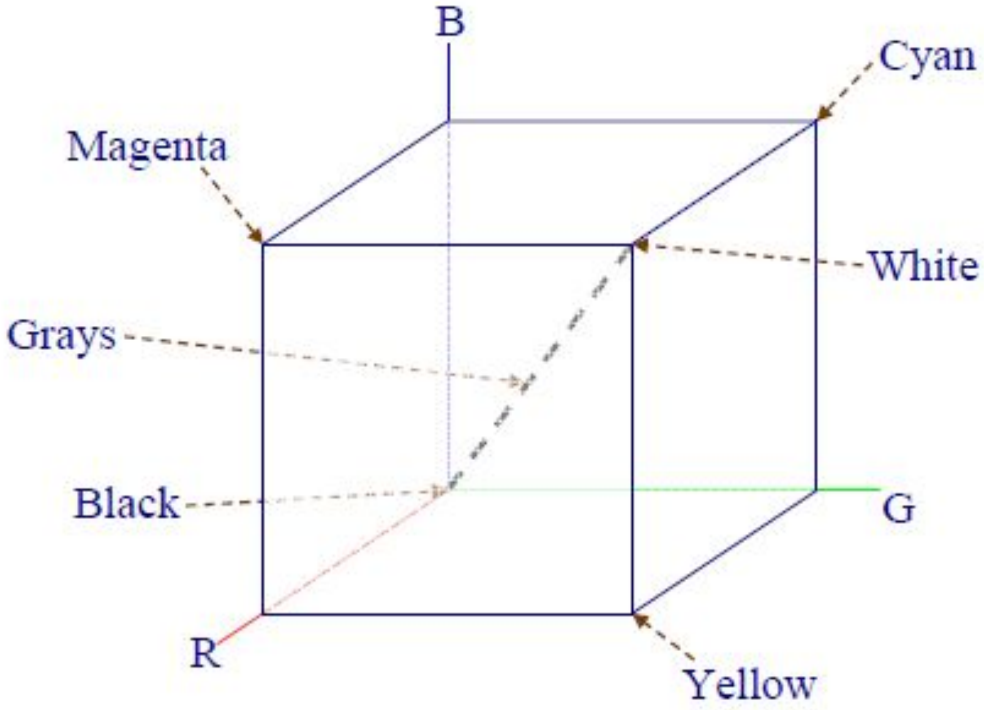
Primary	Complement
Red	*Cyan*
Green	*Magenta*
Blue	*Yellow*

RGB Space

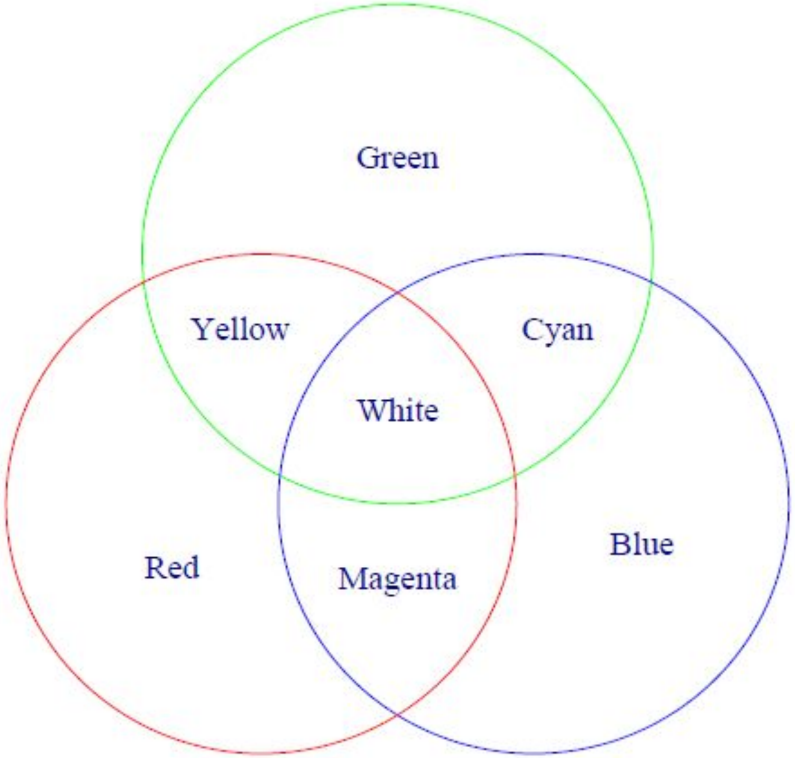
- Can’t produce all visible colors
- Additive to produce other colors
- Perfect for imaging since hardware uses three color phosphors

RGB Color Space

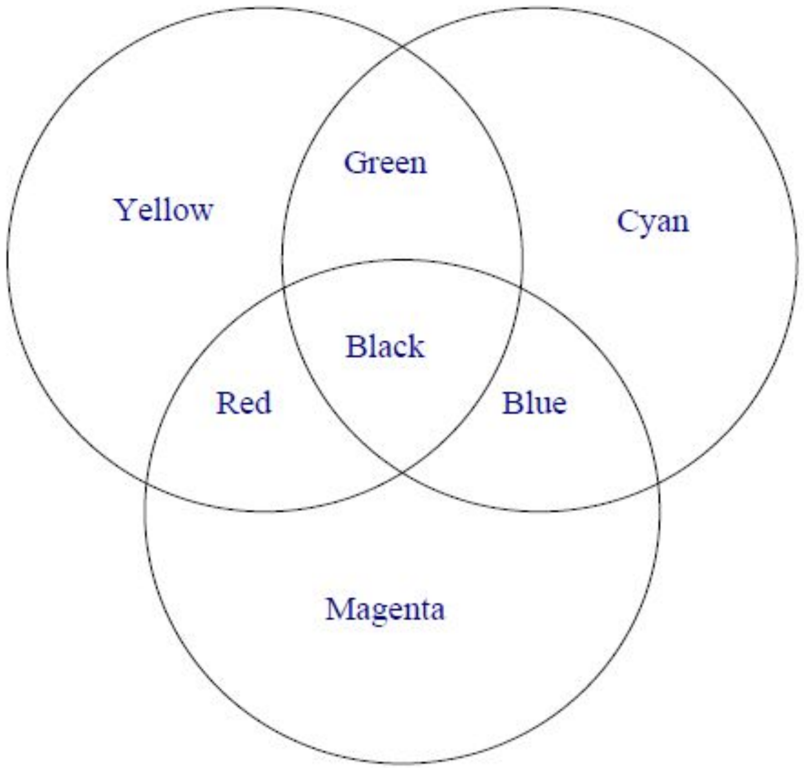
Subset of 3-D Cartesian space



Additive Colors : RGB



Subtractive Colors



The CMY Model

- Paint/ink/dye subtracts color from white light and reflects the rest
- Mixing paint pigments subtracts multiple colors
- The Cyan-Magenta-Yellow (*CMY*) model is the most common *subtractive model*
  - Same as RGB except white is at the origin and black is at the extent of the diagonal
- Very important for hardcopy devices

HSV Color Space

HSV = Hue Saturation Value

a.k.a. HSB = Hue Saturation Brightness