Graphics File Format

- A graphics file format is the format in which graphics data – data describing a graphics image – is stored in a file.
- Graphics file formats have come about from the need to store, organize and retrieve graphics data in an efficient and logical way.
- Graphics files are just chunks of data.

Graphics File Formats

- GIF(Graphics Interchange Format)
- Microsoft Windows Bitmap (BMP)
- JPEG File Interchange Format
- TIFF (Tag Image File Format)
- PNG (Portable Network Graphic Format)

GIF

- GIF(Graphics Interchange Format) is a creation of CompuServe and is used to store multiple bitmap images in a single file for exchange between platforms and systems.
- In terms of number of files in existence , GIF is perhaps the most widely used format for storing multibit graphics and image data.

GIF

- Type
- Colors
- Compression
- Maximum size Image
- Multiple Images Per File
- Originator
- Platform

- Bitmap
- 1 to 8 bits
- LZW
- 64K * 64K pixels
- Yes
- CompuServe,Inc.
- MS –DOS ,
- Macintosh,
- UNIX,
- Amiga,
- others

Microsoft Windows Bitmap

- Also known as BMP, , Windows BMP
- The BMP file format is one of several file formats supported by the Microsoft Windows operating environment .BMP is the native bitmap format of Windows and is used to store virtually any type of bitmap data.

Microsoft Windows Bitmap

Type	Bitmap
Colors	1-,4-,8-,16-,32-bits
Compression	RLE
Maximum Image Size	32K * 32 K and 2G*2G pixels
Multiple Images per File	No

JPEG File Interchange Format

- Also known as JFIF,JFI,JPG,JPEG
- JPEG (**Joint Photographic Experts Group**) refers to standards organization , a method of file compression , and some times a file format.
- In fact , the JPEG specification itself does not define a common file interchange format to store and transport JPEG data between computer platforms and operating systems.

JPEG

Type	Bitmap
Colors	UP to 24-bits
Compression	JPEG
Maximum Image Size	64K * 64K pixels
Multiple Images per File	No

TIFF

- TIFF is an acronym for the Tag Image File Format .
- The TIFF specification was originally a standard method of storing black-and-white images created by scanners and desktop publishing applications.
- TIFF 4.0 added supports for uncompressed RGB color images and was quickly followed by the release of TIFF Revision 5.0.
- TIFF 5.0 was the first revision to add the capability of storing palette color images and support for the LZW compression algorithm.
- TIFF 6.0 new support added for CMYK and YCbCr color images and the JPEG compression method.

TIFF

- **Type** : Bitmap
- **Colors** : 1- to 24-bits
- **Compression** : Uncompressed, RLE, LZW, CCITT Group 3 and Group 4, JPEG
- **Maximum Image Size** : 2^{32}-1
- **Multiple Images Per File** : Yes
- **Originator** : Aldus
- **Platforms** : MS-DOS, Macintosh, UNIX, others
- **Supporting Applications** : Most paint, imaging, and desktop publishing programs

PNG

- PNG is an acronym for the **Portable Network Graphic Format .**
- PNG (pronounced "ping") is a bitmap file format used to transmit and store bitmapped images.
- PNG supports the capability of storing up to 16 bits (gray-scale) or 48 bits (true color) per pixel, and up to 16 bits of alpha data.
- It handles the progressive display of image data and the storage of gamma, transparency and textual information, and it uses an efficient and lossless form of data compression.

PNG

Type	Bitmap
Colors	1-bit to 48-bits
Compression	LZ77 variant
Maximum Image Size	2Gx2G pixels
Multiple Images Per File	No
Numerical Format	Big-endian
Originator	Thomas Boutell, Tom Lane, and many others
Platform	Any
Supporting Applications	Many shareware and commercial packages

PNG Vs GIF

- **The following PNG features are not found in GIF:**

- ✓ Storage of true color images of up to 48 bits per pixel
- ✓ Storage of gray-scale images of up to 16 bits per pixel
- ✓ Full alpha channel
- ✓ Gamma indicator
- ✓ CRC method of data stream corruption detection
- ✓ Standard toolkit for implementing PNG readers and writers
- ✓ Standard set of benchmark images for testing PNG readers

PNG Vs GIF

- **The following GIF features are not found in PNG v1.0:**

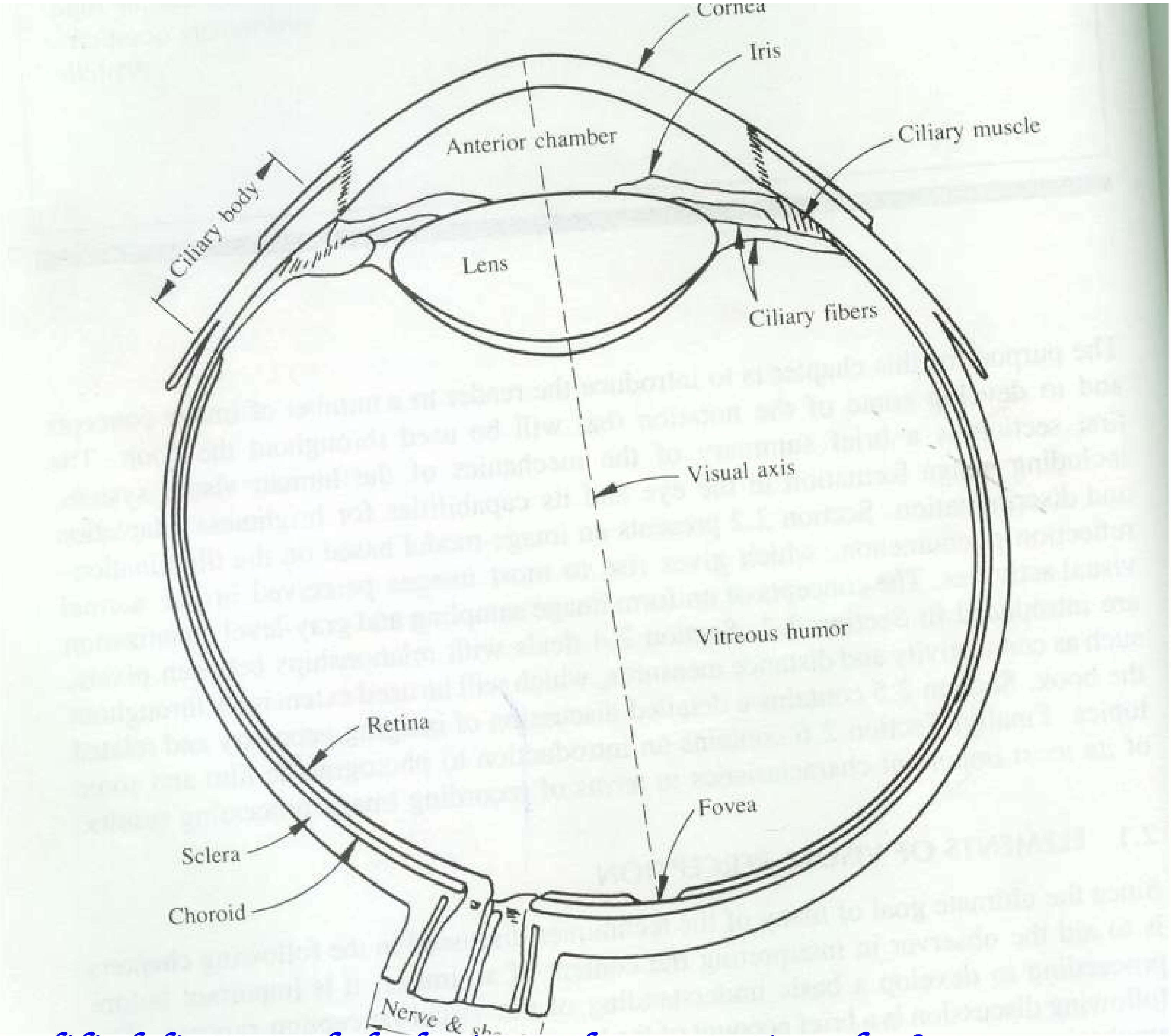
- ✓ Capability of storing multiple images
- ✓ Support of storage of animation sequences
- ✓ Payment of a licensing fee required to sell software that reads or writes the GIF file format

PNG Vs GIF

- Unlike most file formats, which are created by one or two programmers without much thought for the future expansion of the format, PNG was authored by a committee of interested implementers and GIF detractors (revision 1.0 of the PNG specification lists 23 authors) headed by Thomas Boutell.

- PNG also holds the distinction of being one of the better-designed file formats, allowing additional features to be added to the format without compromising existing functionality, and without forcing modifications to existing PNG-using software.

Visual Preliminaries



Simplified diagram of the horizontal cross-section of Human Eye

- The shape of the eye is nearly spherical with a radius of 11 mm(approx.).
- The outer most layer, called sclera, is 1 mm thick opaque membrane and merges in to the transparent Cornea.
- The cornea is a tough, transparent tissue that covers the anterior surface of the eye.

- The sclera is continuous with the cornea; it is an opaque membrane that enclosed the remainder of the optic globe.
- At the rare, the optic nerve penetrates the sclera on the nasal side.
- The choroids lies directly below the sclera. This membrane contains a network of blood vessels that serve as the major source of nutrition of the eye.

- The choroids coat is heavily pigmented and hence helps to reduce the amount of extraneous light entering the eye and the backscatter of light within the optical globe.
- At its anterior extreme, the choroids is divided into the ciliary body and the iris diaphragm.
- The iris is nearly circular aperture which constitutes the pupil.
- It contracts and expands to control the amount of light entering the eye.

- The innermost membrane of the eye is the retina.
- When the eye is properly focused , light from an object outside the eye is imaged on the retina.
- Pattern vision is afforded by the distribution of discrete light receptors over the surface of the retina.
- The retinal surface contains a mosaic of photoreceptor cells called rods and cones.

- The number of cones in each eye is between 6 and 7 million.
- The number of rods ranges from 75 to 150 million.
- Cones are located primarily in the central portion of the retina, called fovea and are sensitive to color.

- The cones are responsible to acute vision and the cone vision is known as photopic or bright-light vision.
- The rods give an overall appearance of the scene but are not involved in color vision. They are sensitive to low-levels of illumination. So the rod vision is known as scotopic or dim-light vision.

- The double convex lens is made up of concentric layers of fibrous cells is suspended directly behind the pupil.
- The shape of the lens can be changed to vary the effective focal length, and thus variable viewing distance can be achieved by a single lens.

- The shape of the lens is controlled by the fibres of the ciliary body.
- To focus on the distant objects the lens is made relatively flat. When an eye is looking at an object shape of the lens is controlled by appropriately such that a sharp and reverse image is formed on the retinal surface.

- The photoreceptors convert light energy into electrical pulses through some photochemical reaction. These pulses are transmitted to the visual cortex through the optical nerve.
- The information reaching the visual cortex are finally decoded by the brain.

Image Processing & Analysis

Introduction

- A major portion of information received by a human from the environment is visual.
- The process of receiving and analyzing visual information by the human is referred to as sight, perception or understanding.
- The process of receiving and analyzing visual information by digital computer is called

  digital image processing and image analysis.

Introduction

- Modern digital technology has made it possible to manipulate multi-dimensional signals with systems that range from simple digital circuits to advanced parallel computers.

The goal of this manipulation can be divided into three categories:

- Image Processing

image in -> image out

- Image Analysis

image in -> measurements out

- Image Understanding

image in -> high-level description out

Digital Images (DIs)

- Computer images can be divided into two classes: Natural and Artificial.
- Artificial images are created exclusively by computer processes and are usually called graphic images.
- A natural image is one digitized from an analog image such as a photograph, drawing, painting, television and motion pictures, schematics, maps and so on.
- DIs are a very important medium for representing information.

Digital Images

- A digital image is a picture that may be stored in, displayed on, or otherwise processed by a computer.
- A PIXEL is the basic unit of a digital image.
- A pixel by itself does not convey much info. The context in which the pixel is found or its arrangement in the overall image is what determines what it depicts.
- Each pixel is a discrete sample of the continuous signal of an analog image.
- i.e each pixel contains one or more numbers that measure the value of the signal for that portion of the image.

Digital Images

- Most images depict how things look as a function of light reflecting from the objects.
- Even so images may be derived from other names of the electromagnetic spectrum like x-ray, radar etc.
- Pixels are usually arranged as rectangular units in 2-D grid.

Image : Image is a two-dimensional light-intensity function, denoted by $f(x, y)$, where the value or amplitude of f at coordinates (x, y) gives the intensity of the image at that point.

$$0 < f(x, y) < \infty \text{ (because light is a form of energy)}$$

Nature of $f(x, y)$ is characterized by

1. The amount of source light incident on the scene being viewed

   illumination component i(x, y) , determined by light source

2. The amount of light reflected by the objects in the scene,

   reflectance component r(x, y), characteristics of the object in a scene

$\mathbf{f(x, y) = i(x, y)\ r(x, y)}$ *where* $0 < i(x, y) < \infty$ *and* $0 < r(x, y) < 1$

Digital image

- We may consider a digital image as a matrix whose row and column indices identify a point in the image and the corresponding matrix element value identifies the gray level at that point.
- A digital image is an array of real and complex numbers represented by a finite number of bits.

$$f(x,y) = \underbrace{\begin{bmatrix} f(0,0) & f(0,1) & \cdots & f(0,M-1) \\ f(1,0) & f(1,1) & \cdots & f(1,M-1) \\ \vdots & \vdots & & \vdots \\ f(N-1,0) & f(N-1,1) & \cdots & f(N-1,M-1) \end{bmatrix}}_{\text{Digital Image}} \quad \text{N x M}$$

A digital image is composed of *pixels* which can be thought of as small dots on
the screen.

Applications

- Office automation
  - optical character recognition;
  - document processing;
  - cursive script recognition;
  - logo and icon recognition;
  - identification of address area on envelop;

  etc.

Applications

- Industrial automation
  - Automatic-inspection system;
  - non-destructive testing;
  - automatic assembling;
  - process related to VLSI manufacturing;
  - robotics;
  - oil and natural gas exploration;
  - seismography;
  - process control applications;

    etc.

Applications

- Bio-Medical
  - ECG, EEG, EMG analysis;
  - cytological, histological and stereological applications;
  - automated radiology and pathology;
  - X-ray analysis; m
  - ass screening of medical images such as chromosome slides for detection of various diseases,
  - mammograms,
  - cancer smears;
  - CAT, MRI, PET, SPECT, USG and other tomographic images;
  - routine screening of plant samples;
  - 3-D reconstruction and analysis;

  etc.

Applications

- Criminology
  - finger print identification;
  - human face registration and matching;
  - forensic investigation;

  etc.
- Astronomy and space applications
  - Restoration of images suffering from geometric and photometric distortions;
  - computing close-up picture of planetary surfaces;

  etc

Applications

- Remote sensing
  - Natural resources survey and management;
  - estimation related to agriculture,
  - hydrology,
  - forestry,
  - mineralogy;
  - urban planning;
  - environment and pollution control;
  - cartography, registration of satellite images with terrain maps;
  - motoring traffic along roads, docs and airfields;

  etc.
- Meteorology
  - Short term weather forecasting,
  - long-term climatic change detection from satellite and other remote sensing data;
  - cloud pattern analysis; etc.

Applications

- Information technology
  - Facsimile image transmission,
  - videotext; video-conferencing and videophones;
  - etc.
- Entertainment and consumer electronics
  - HDTV;
  - multimedia and video editing
  - etc.
- Printing and Graphics art:

  color fidelity in desktop publishing, art conservation and dissemination, etc

Applications

Military applications:

- Missile guidance and detection,
- target identification, navigation of pilotless vehicles,
- reconnaissance and range finding

etc.

Components of Image Processing system.

- Image Sensor
- Digitizer
- Processor
- Display Unit

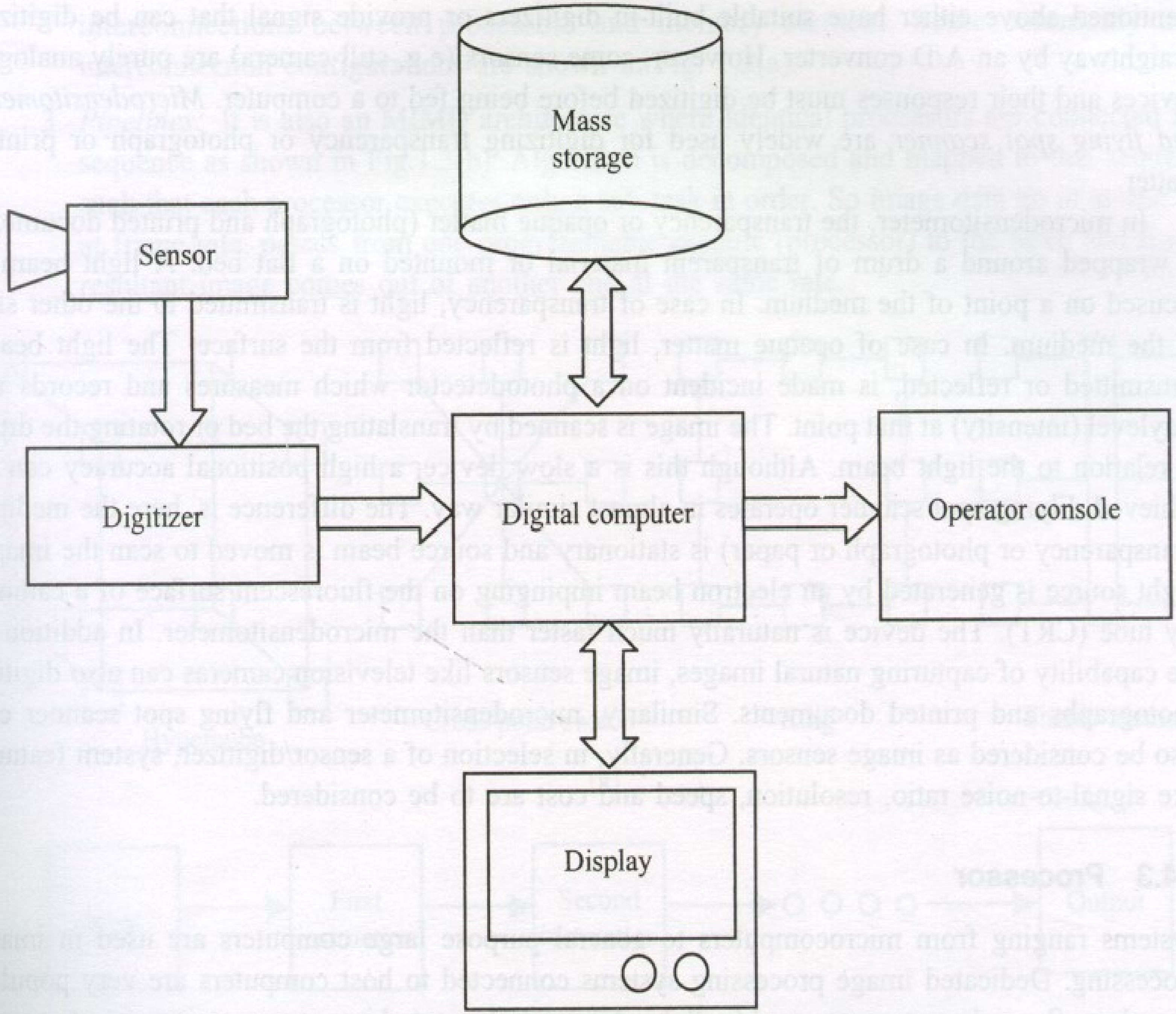
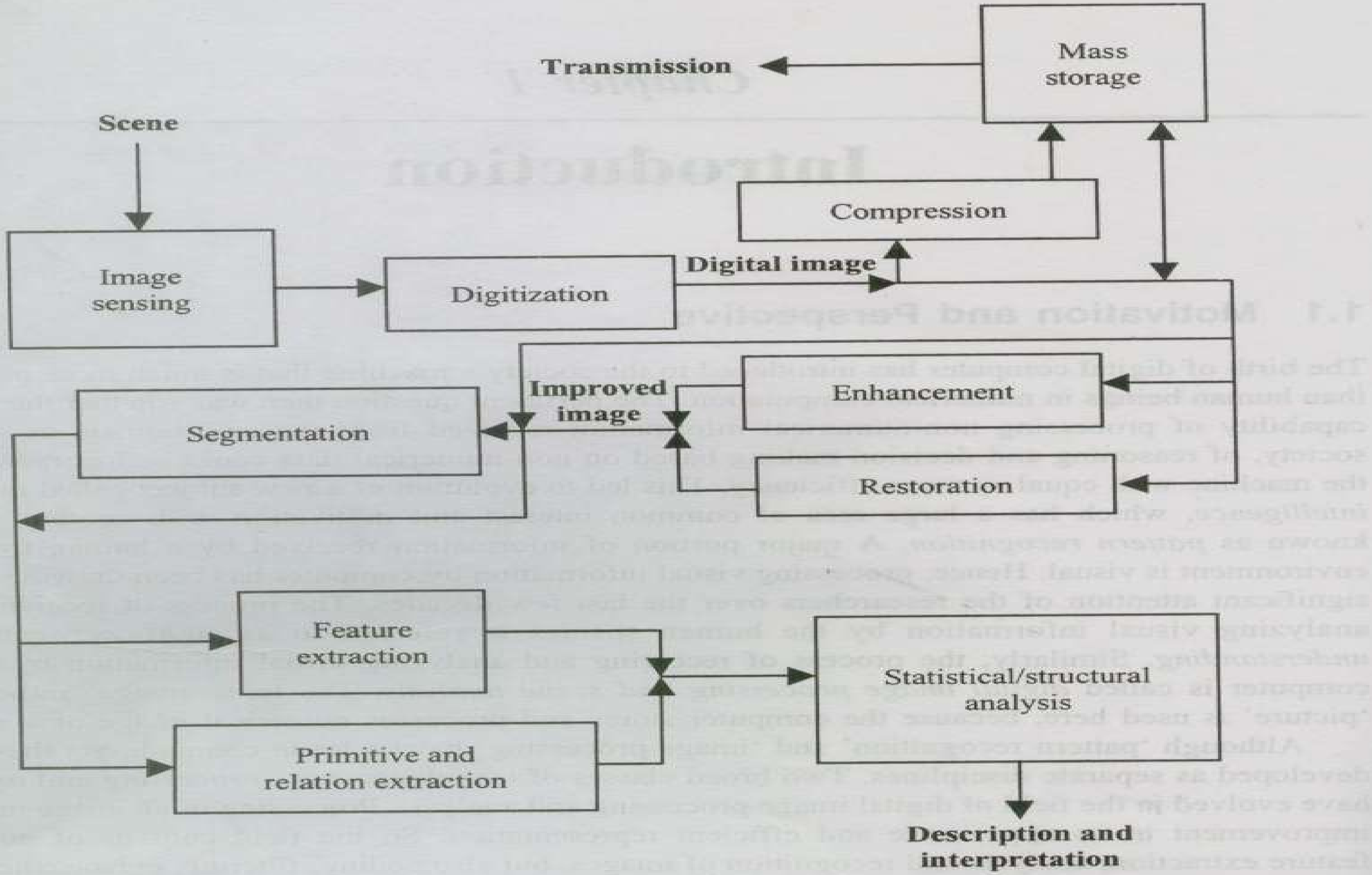


Fig. 1.2 A general-purpose image processing system.

Components of Image Processing system.

- **Image Sensor:** Image sensor intercepts the radiant energy propagating from the scene and transforms it to produce an intensity image.
- **Digitizer:** is required input images to a digital computer, produces digital image composed of intensity values at discrete positions.
- **Processor**: systems ranging from microcomputers to purpose large computers are used in image processing.
- **Display UNIT:** A display device produces and shows a visual form of numerical values stored in computer as image array.

Stages of Image Processing & Analysis System



ig. 1.1 Different stages of image processing and analysis scheme. Information flow along the outgoing link from each block.

Digitizing

- Digitizing is the process of converting a continuous signal (such as sound or video, etc) into distinct units that the computer or other electronic equipment can process.
- There are many ways to digitize things. E.g. microphone, which digitizes sound.
- The scanner can digitize photos and other images
- A digital camera is able to bring video into the computer.
- Using 3D digitizer one can also digitize 3D objects.

Image Digitization

- An image g(x,y) that is detected and recorded by a sensor is primarily a continuous tone intensity pattern formed on a 2-dim. Plane.
- This image must be converted into a form which is suitable for computer programming.
- The method for converting an image which is continuous in space as well as in its value, into a discrete numerical form is called image *digitization*.

Digitization

This conversion may be considered as two step process.

✓Taking measurements at regularly spaced intervals, called ***Sampling*** and

✓Mapping the measured intensity to one of finite number of discrete levels called ***quantization.***

Digitization

Sampling is a process by which image formed over a patch in continuous domain is mapped into a discrete point with integer coordinates.

This process involves two important choices:

✓***Sampling interval***

✓***Tessellation*** *(the spatial arrangement of the sample points)*

- The sampling theorem provides a mathematical basis for the first one.
- The second choice is influenced by the connectivity and the metric to be used in the discrete domain.

Digitization

- Image sampling may be defined as the selection of a set of discrete locations in the continuous two-dim space and intensity at these locations only will be considered for processing by computer.

Quantization.

- The values obtained by sampling a continuous function usually comprise an infinite set of real numbers ranging from a minimum to a maximum depending on sensor’s calibration.
- These values must be represented by a finite number of bits to store and to process.

Quantization.

- The mapping from the real numbers to finite range of integers or in other words the process of amplitude digitization is called ***quantization***.
- The transformation is increasing but non-reversible.
- A single image can be sampled and quantized at different rates at different parts of the image. This is known as non-uniform sampling and non-uniform quantization.

Visual detail in the Digital Image

- The people working with digital images come across the parameter called ***resolution.***
- The resolution is of **TWO** kinds:

✓ ***Spatial resolution***

(related to the sampling interval)

✓ ***Graylevel (Intensity) resolution***

(related to the quantization levels)

Spatial resolution

- Spatial resolution is related to the resolving power to distinguish image detail.
- As image processing is a multidisciplinary field, there are many ways to specify spatial resolution, each one is application oriented.

Spatial resolution

- In remote sensing, it is common to specify the **spatial resolution as the size each pixel represents in the real world by the terms *ground resolution element* and *ground resolution distance***.
- As an example the LANDSAT has resolution ranging from 30 m to 120 m.
- In this case as smaller the resolution distance, the better one can resolve image spatial contents.

Spatial resolution

- In medical imaging, the resolution is also used as in remote sensing, but using millimeters as their standard unit.
- Typical CT (Computer Tomography) Scanners have pixel size of 1 mm.
- In document industry, the resolution is used as number of pixels per world dimension.
- As an example desktop scanners has resolution of 600 dpi (dots per inch).

Image Processing

- Improvement in the quality of degraded images can be achieved by the application of ***restoration*** and/or ***enhancement*** technique.
- ***Image Restoration*** may defined as an attempt to estimate the original image by applying effective inversion of the degrading phenomenon.
- This requires an priori model of the degradation process.
- When no such knowledge is available the quality may be improved for specific application by some adhoc processes called ***image enhancement.***

Image Processing

- When ever an image is converted from one form to another, such as, digitizing, transmission etc. some form of degradation occurs in at the output.
- Process to improve quality of the image so that it gets the appropriate form for specific application is called ***Image Enhancement***

i.e. improvement of the appearance of an image by increasing dominance of some features or by decreasing ambiguity between different regions of the image.

Image Processing

- Improvement in the quality of degraded images can be achieved by the application of ***restoration*** and/or ***enhancement*** technique.
- ***Restoration*** may defined as an attempt to estimate the original image by applying effective inversion of the degrading phenomenon.
- This requires an priori model of the degradation process.
- When no such knowledge is available the quality may be improved for specific application by some adhoc processes called ***image enhancement.***

Image Enhancement

- In Image enhancement the goal is to accentuate certain image features for subsequent analysis or for image display.

  e.g. Contrast, edge enhancement, pseudocoloring, noise filtering, sharpening, magnifying, etc.

- The enhancement of certain features may be achieved by the cost of suppressing others.

Image Enhancement

- The enhancement techniques can be divided into *THREE* categories:

✓Contrast Intecification

✓Noise reduction or Smoothing

✓Edge Sharpening or crispening

- The algorithms are developed using one of the two basic approaches :

✓**Spatial-domain techniques**

✓**Frequency-domain techniques.**

Contrast Intensification

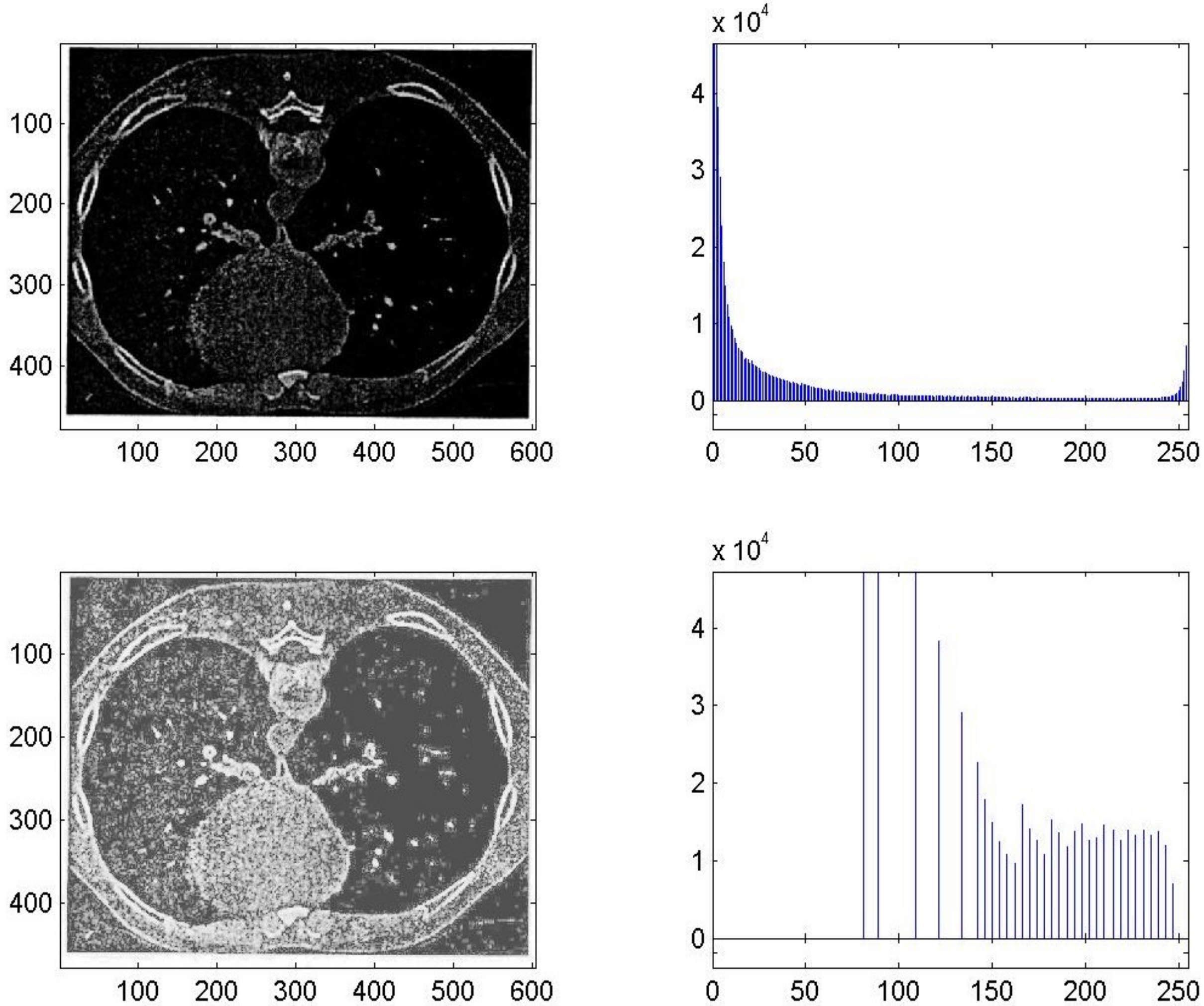
- One of the most common defect found in the recorded image is its **POOR CONTRAST**.
- The effect of such defect is reflected on the range and shape of the gray level histogram of the recorded image
- Contrast can be improved by scaling the gray level of each pixel, so that image gray level occupy entire dynamic range available
- This operation is called **HISTOGRAM STRETCHING.**

Histogram :

Histogram of an image is to compute an array *H[0,1,2,…,k-1]* *(k = No. of gray-levels in the image)* such that *H[i]* is the number of pixels in the image with gray level *i*. *(k is assumed to be power of 2)*

Why Histogramming ?

- Histogram gives the global description of the appearance of the image.
- It is very much useful in many areas of image processing and Analysis.
- One of its application is in *image enhancement*.


100
200
300
400
100 200 300 400 500 600
x 10^4
0 1 2 3 4
0 50 100 150 200 250
100
200
300
400
100 200 300 400 500 600
x 10^4
0 1 2 3 4
0 50 100 150 200 250

To carry out this task we can apply transformations to the each pixel.

The transformation function $l = T(m)$ must satisfy the following conditions :

1. $T(m)$ must be monotonically increasing in the interval $[m_{min}, m_{max}]$,

$$\text{i.e. } m_1 < m_2 \Rightarrow l_1 = T(m_1) \leq l_2 = T(m_2)$$

That means that transformed graylevel l must preserve the order from black to white.

2. $l_{min} \leq l \leq l_{max}$ i.e. transformed graylevel must lie within the allowed range of graylevel.

Where $[l_{min}, l_{max}]$ $\rightarrow$ Available graylevel range and
$[m_{min}, m_{max}]$ $\rightarrow$ Graylevel range in the given image

- Various type of stretching can be applied
  Depending upon the **appearance** of recorded image and the **application** in which we want to use this image.

Linear Stretching :-

Here the Transformation function can be represented by

$$l = T(m) = \frac{l_{\max} - l_{\min}}{m_{\max} - m_{\min}}\{m - m_{\min}\} + l_{\min}$$

e.g.

Suppose m is the graylevel of input image which has to be transformed to l by linear stretching. Let n_i & n_i' are numbers of pixel having i^th graylevel input & output images reply. Suppose for an 8-level image we have the following frequency table for the input graylevels.

i	0	1	2	3	4	5	6	7
n_i	0	0	a	b	c	d	e	0

Here $m_{min}=2$ and $m_{max} = 6$ and , $l_{min}= 0$ and $l_{max}= 7$.

$$l = \frac{7}{4}(m-2)$$

for $m=3$; $l = 1.75 \approx 2$ and for $m = 4$ we have $l = 3.5 \approx 4$ and so on. The final table will look like

i	0	1	2	3	4	5	6	7
$N_{i''}$	a	0	b	0	c	d	0	e

<u>Non-linear Stretching</u> : -

This type of transformation function can be illustrated by

$$l = l_{\max} \frac{\ln(m - m_{\min} + 1)}{\ln(m_{\max} - m_{\min} + 1)} + l_{\min}$$

e.g.

i	0	1	2	3	4	5	6	7
n_i	a	b	c	d	e	f	g	h

Here $m_{min}=0$ and $m_{max} = 7$ and , $l_{min}= 0$ and $l_{max}= 7$

$$l = 7\frac{\ln(m+1)}{\ln 8}$$

for m=1 ; l = 2.3 ≈ 2 and for m = 2 we have l = 3.7 ≈4 and so on. The final table will look like

i	0	1	2	3	4	5	6	7
n_i'	a	0	b	0	c	$d+e$	f	$g+h$

Exponential Transforms

• If the Histogram shows high population of pixels in the High gray level zone of the gray scale

• One should use Exponential or Power Law Transformation.

• These functions cancels the effect of logarithmic response of the sensor to the irradiation.

$$l = l_{\max}\left(\frac{l_{\max}}{l_{\min}}\right)^{\frac{m-m_{\min}}{m_{\max}-m_{\min}}}$$

e.g.

i	0	1	2	3	4	5	6	7
n_i	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*

Here m_{min}=0 and m_{max} = 7 and , l_{min}= 0+1 = 1 and l_{max}= 7+1 = 8. There for

$$l = 8^{\frac{m}{7}} \quad 1$$

for m=1 ; l = 0.34 ≈ 0 and for $m = 2$ we have $l = 0.81$ ≈ 1 and so on. The final table will look like

i	0	1	2	3	4	5	6	7
n_i'	$a+b$	$c+d$	e	f	0	g	0	h

Smoothing

- ✓ This operation is used primarily to diminish the effect of spurious noise and to blur the false contours that may be presented in a digital image.
- ✓ This unwanted effect may be due to detection and recording error or transmission channel noise or digitization error or some combination of these factors.
- ✓ During removal of noise, smoothing techniques may degrade the sharp content details.

Smoothing Techniques

✓ Image Averaging

✓ Mean filter

✓ Ordered statistic filters

- Median filter
- Max-min and Min-max filters
- Morphological filter

etc.

Smoothing Techniques

✓ Image Averaging

✓ Mean filter

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- Median filter
- Max-min and Min-max filters
- Morphological filter

etc.

Smoothing Techniques

Common masks used for noise cleaning by moving average filtering :

3 X 3

5 X 5

Smallest symmetric mask (2 X 2)

Mask for weighted averaging

$\frac{1}{4}$

1	1
1	1

$\frac{1}{16}$

1	2	1
2	4	2
1	2	1

$\frac{1}{81}$

1	2	3	2	1
2	4	6	4	2
3	6	9	6	3
2	4	6	4	2
1	2	3	2	1

0	1	0	6	7
2	0	1	6	5
1	1	<u>7</u>	5	6
1	0	6	6	5
2	5	6	7	6

Smooth the image for a pixel (2,2) (underlined pixel

1. mean filter in a special domain using 3 X 3
2. Weighted average filter using mask 3 X 3
3. Median filter,

Image Sharpening

6.4 Image Sharpening

We have already explained that image degradation generally involves blurring. Being an integration operation blurring attenuates high spatial frequency components which suggests that observed/recoded image can be enhanced by differentiation in spatial domain. So, using spatial domain technique, the graylevel of sharpened image $g'(r, c)$ may be obtained as

$$g'(r, c) = \nabla^2 g(r, c) \quad (6.66)$$

where ∇^2 is Laplacian which is linear, rotation invariant, second-order derivative operator. In discrete domain, $\nabla^2 g$ is approximated in different types of connectivity as under:

Using 4-connectivity,

$$
\begin{aligned}
g'(r, c) &= \nabla^2 g(r, c) \\
&= \frac{1}{4}[g(r-1, c) + g(r+1, c) + g(r, c-1) \\
&\quad + g(r, c+1) - 4g(r, c)] \qquad (6.67) \\
&= g_{b4} - g(r, c) \qquad (6.68)
\end{aligned}
$$

and using 8-connectivity,

$$
\begin{aligned}
g'(r, c) &= \nabla^2 g(r, c) \\
&= \frac{1}{8}[g(r-1, c-1) + g(r-1, c) + g(r-1, c+1) \\
&\quad + g(r, c-1) + g(r, c+1) + g(r+1, c-1) \\
&\quad + g(r+1, c) + g(r+1, c+1) - 8g(r, c)] \qquad (6.69) \\
&= g_{b8} - g(r, c) \qquad (6.70)
\end{aligned}
$$

where g_{bn} represents the average graylevel of n-nearest neighbours. However, problem due to simple application of the Laplacian operator is that the ...

Example Consider the following figure where each small rectangle represents a pixel and the value inside it is graylevel at that pixel. Hence whole array represents a digital image $g(r, c)$ of size 5 × 5. The centre pixel $g(2, 2)$ is marked by underline.

	0	1	2	3	4
0	0	1	0	6	7
1	2	0	1	6	5
2	1	1	7	5	6
3	1	0	6	6	5
4	2	5	6	7	6

$= \frac{1}{4}\left((1,2) + (3,2) + (2,1) + (2,3) - 4 \times (7)\right)$

$= \frac{1}{4}\left\{1 + 6 + 1 + 5 - 4 \times 7\right\}$

Suppose we sharpen the image in spatial domain using Laplacian. Then, due to Equation (6.67):

$$g'(r, c) = \frac{1}{4}(1 + 1 + 5 + 6 - 4 \times 7) = -3.75 \approx -4$$

due to Equation (6.69):

$$g'(r, c) = \frac{1}{8}[0 + 1 + 6 + 1 + 5 + 0 + 6 + 6 - 8 \times 7] = -3.875 \approx -4$$

Image Compression

- Image compression techniques are concerned with reduction of the number of bits required to store or transmit images without any appreciable loss of information.

Image Compression

- In general, there are two forms of image compression: *loss less* and *lossy*.
- Loss less image compression means that the compressed image is identical to the uncompressed image. Because all the data in the image must be preserved, the degree of compression, and the corresponding savings, is relatively minors.

Image Compression

- Lossy compression, on the other hand, does not preserve the image exactly, but does provide a much higher degree of compression.
- With lossy compression, the image quality is compromised for a smaller byte count. Because the human eye may barely notice the loss, the trade-off may be acceptable.

Processing of color images

- *Pseudo and False coloring*

The process of assigning different color to every intensity value available in a grayscale image is known as pseudo-color processing. Many image features and their comparisons could readily be done using pseudo-colors; e.g.gray scale satellite image.

False coloring, as its name goes, assigns a true color to a wavelength band which does not correspond to that color in reality.

Multi-Valued Image Processing

Two-major areas:

Multi-spectral:

As the name suggests measurements correspond to different spectral bands of frequencies (or wavelengths) of electromagnetic waves.

e.g. different spectral bands correspond to red, blue and green lights in color images.

Multi-Valued Image Processing

Multi-modal

The measurements of different physical properties of any single object or its parts are the concept of multi-modal imaging.

Different sensors are employed to extract multi-modal characteristics.

e.g. X-ray, Computed tomography (CT) scan, Magnitic resonance Imaging (MRI), Ultrasonography (USG), single Photon Emission Computed Tomography(SPECT) are examples of imaging systems of various modalities.

Image Fusion

- Image fusion means to fuse more than one image and to make one.
- Clinical Diagnosis and Treatment of radio therapeutic patients usually requires exhaustive exploration of biomedical images with varieties of signal modalities.
- Single modality does not provide a complete set of information and this inadequacy of information makes biomedical image insufficient for use in clinical interpretation and diagnosis of disease.
- A computed tomography(CT) image, for example is suitable for visualization of ventricular systems, and skull and bone like hard structures; whereas a Magnetic resonance (MR) image is more suitable for visualizing cerebral tissues accurately.

Image Analysis

- *Segmentation*

  Divide the whole image into meaningful parts.
- *Edge and Line detection*
- *Feature extraction*
- *Description*
- *Recognition*

Edge Detection

- Edge detection plays an important role in recognition of an object
  - ✓ **Prewitt Operator**
  - ✓ **Sobel Operator**
  - ✓ **Laplace Operator**

Image Analysis

- *Examine image data to facilitate solving a vision problem.*
- *This can be done by feature extraction or pattern classification.*
- *Feature extraction is a process of acquiring high-level image information like shape or color information.*
- *Pattern classification is the act of taking this high-level information and identifying objects within the image.*

Example(s) (Image analysis)

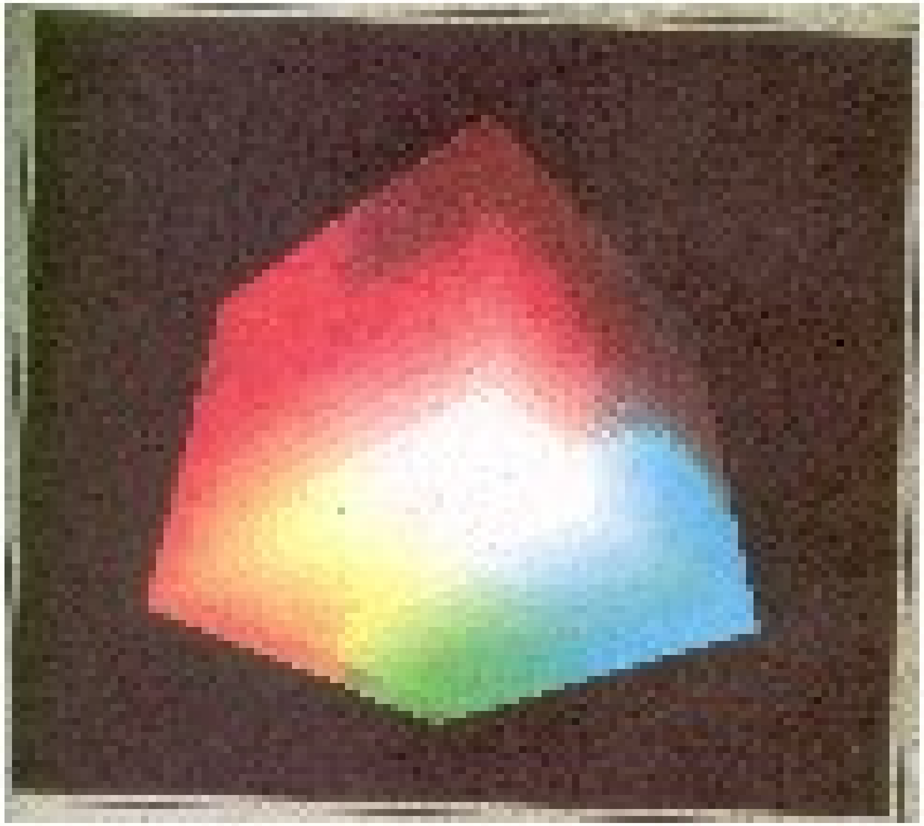
- Assume that we want to filter some color from a given image and find out the percentage of filter color.
- We may want to find ,how much portion of the given leaf image is dry? Or burned?
- We may want that in given endoscopic image how much percent of the image has ulcer?

etc……

Image understanding

- *Image understanding is a process of discovering, identifying, and understanding patterns that are relevant to the performance of an image-based task.*
- *One of the principal goals of image understanding by computer is to endow a machine with a capability to approximate, in some sense, a similar capability in human beings.*

Color Models.



A **color model** is a method for explaning the properties and behavior of color within some particular context.

Several color models are existing.

Some models are used to describe color output on printers and plotters, and other models provide a more intuitive color-parameter interface for the user.

No single color model can explain all aspects of color, so we make use of different models to help describe the different perceived characteristics of color

PROPERTIES OF LIGHT

- Light or different colors, is a narrow frequency band within the electromagnetic spectrum.
- A few of the other frequency bands within this spectrum is called radio waves, microwaves, infrared waves, x-rays etc.

PROPERTIES OF LIGHT

- Each frequency value within the visible band corresponds to a distinct color.
- At the low-frequency end is a red color ($4.3 * 10^{14}$ Hz)and highest frequency is a violet color ($7.5 * 10^{14}$ Hz).
- Figure below shows the approximate frequency ranges for some of the electromagnetic bands.

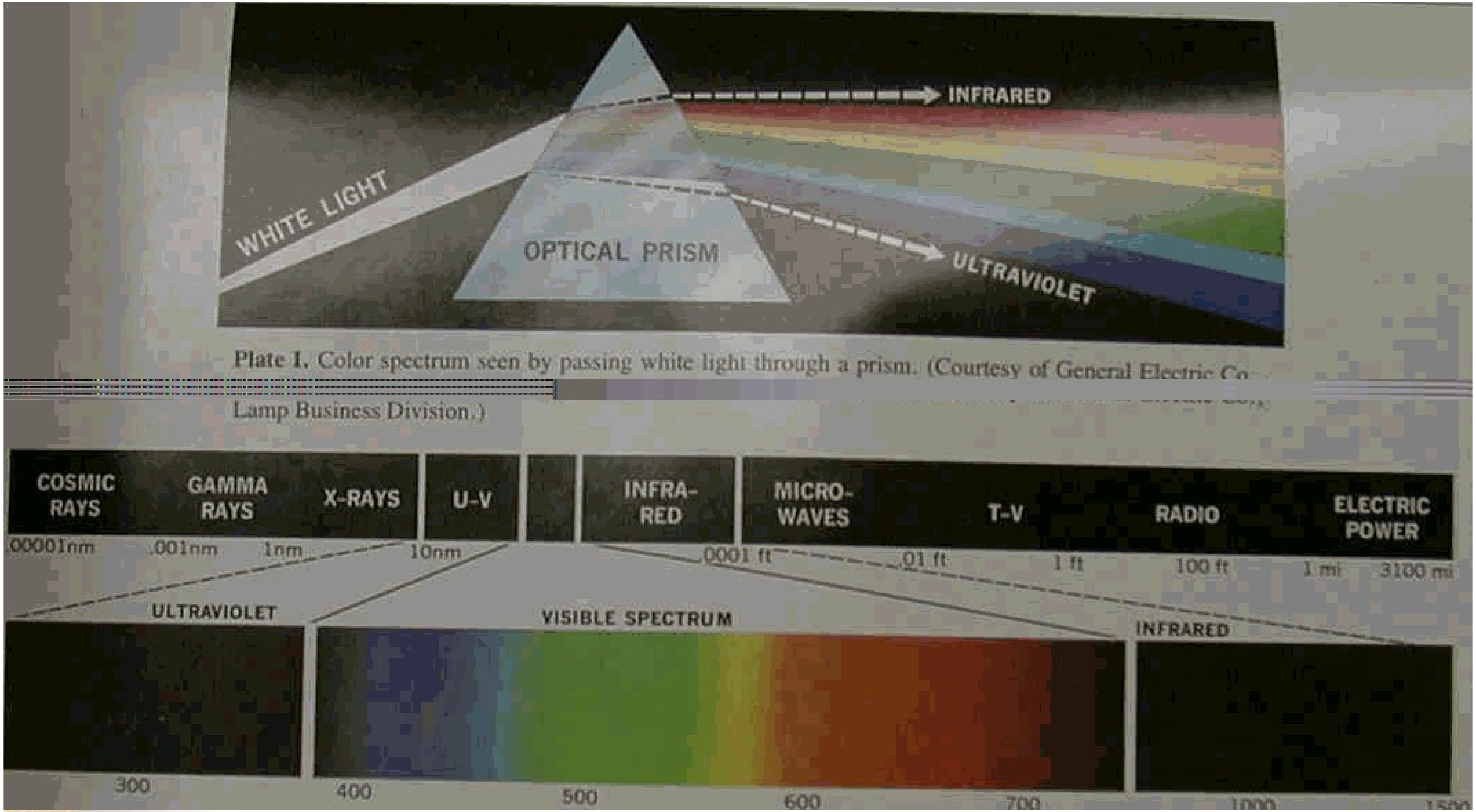


Figure shows the approximate frequency ranges of the electromagnetic bands

STANDARD PRIMARIES AND THE CHROMATICITY DIAGRAM

- Since no finite set of color light sources can be combined to display all possible colors, three standard primaries were defined in 1931 referred to as the CIE(Commission International del'Eclairage).

XYZ COLOR MODEL

- The set of CIE primaries is generally referred to as the XYZ color model where X,Y,Z represent vectors in a three-dimensional, additive color space. Any color $c\lambda$ is expressed as,
- $$c\lambda = xX + yY + zZ$$
- Where x,y,z are designate the amounts of the standard primaries needed.
- Normalized amount are thus calculated as ,

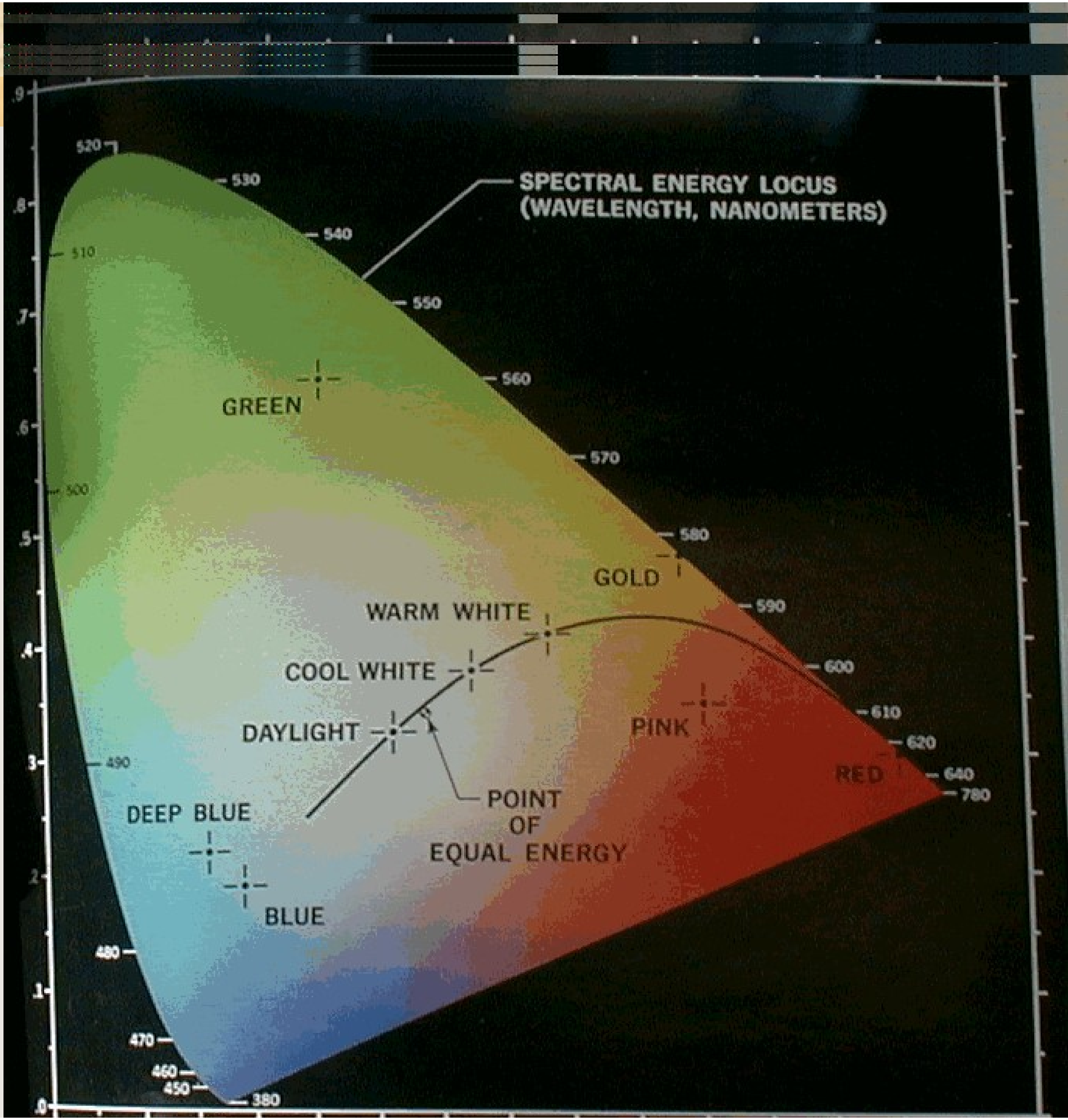
Where x+y+z =1.

$$x = \frac{X}{X + Y + Z}$$

$$y = \frac{Y}{X + Y + Z}$$

$$z = \frac{Z}{X + Y + Z}$$

obviously, **x + y + z = 1**


SPECTRAL ENERGY LOCUS
(WAVELENGTH, NANOMETERS)
520
530
540
510
550
560
570
500
580
590
600
610
620
640
780
490
480
470
460
450
380
GREEN
GOLD
WARM WHITE
COOL WHITE
DAYLIGHT
PINK
RED
POINT
OF
EQUAL ENERGY
DEEP BLUE
BLUE
.9
.8
.7
.6
.5
.4
.3
.2
.1
.0

Color Models

- A color model is a method for explaining the properties and behavior of color within some particular context.
- Several color models are available. Some models are used to describe color output on printers and plotters, and other models provide a more intuitive color parameter interface for the user.
- No single color model can explain all aspects of color, so we make use of different models to help describe the different perceived characteristics of color

Color models

- **Hardware oriented**

RGB, CMY, YIQ, YCbCr

. Intitutive

HSI

RGB COLOR MODEL

- Based on the tristimulus theory of vision, our eyes perceive color through the stimulation of the three visual pigments in the cones of the retina. These visual pigments have a peak sensitivity at wavelengths of about 630 nm (red), 530 nm(green) and 450 nm(blue). By comparing intensities in a light source, we perceive the color of the light.

This theory of vision is the basis for displaying color output on a video moniter using the three color primaries red,green and blue referred to as the RGB color model.

Thus the color $c\lambda$ expressed in RGB components as,

$c\,\lambda = rR + gG + bB$

YIQ Color model

- The NTSC color system , is used in television in the US, uses YIQ color model.
- Data consists of three components luminance (Y), hue (I) and saturation(Q).
- The luminance component represents gray-scale information and other two carry another color information of a TV signal.

RGB TO YIQ

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.274 & -0.322 \\ 0.211 & -0.523 & 0.312 \end{bmatrix} \times \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

YIQ TO RGB

$$\begin{matrix} R \\ G \\ B \end{matrix} = \begin{bmatrix} 1.000 & 0.956 & 0.621 \\ 1.000 & -0.272 & -0.647 \\ 1.000 & -1.106 & 1.703 \end{bmatrix} \times \begin{bmatrix} Y \\ I \\ Q \end{bmatrix}$$

YCbCr COLOR MODEL

- It is used in digital video. In this format, luminance information is represented by a single component Y, and color information is stored as two color difference components, Cb and Cr.
- Cb = diff. Between the blue component and a reference value and
- Cr = difference between red component and a reference value.

RGB TO YCbCr

$$\begin{bmatrix} Y \\ C_b \\ C_r \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 65.481 & 128.553 & 24.966 \\ -37.797 & -74.203 & 112 \\ 112 & -93.876 & -18.214 \end{bmatrix} \times \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

YCbCr TO RGB

$$R = Y + 1.403*(Cr - 0.5)$$

$$G = Y - 0.344*(Cr - 0.5) - 0.714 * (Cb - 0.5)$$

$$B = Y + 1.773*(Cb - 0.5)$$

CMY to RGB

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} C \\ M \\ Y \end{bmatrix}$$

RGB to CMY

$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

INTUTIVE COLOR CONCEPTS

- An artist creates a color painting by mixing color pigments with white and black pigments to form the various shades,tins and tones in the scene. Starting with the pigment for a ‘pure color’ the artist adds a black pigment to produce different shades of that color.The more black pigments, the darker the shade. Similarly different tints of color are obtained by adding a white pigment to the original color,making it lighter as more white is adding. Tones of the color are produced by adding both black and white pigments.

HSI COLOR MODEL

- To give a color specification, a user selects a spectral color and the amounts of white and black that are to be added to obtain different shades,tins and tones. Color parameters in this model are hue(H), saturation(S) and Intensity value (I).
- Hue is the term of dominant frequency used to describe combinations of light.
- The three dimension representation of the HSV model is derived from the RGB cube. We see an outline of the cube that has the hexagon shape as shown in the below figure.

Converting Colors from RGB to HSI

$$H = \begin{cases} \theta & \text{if } B \leq G \\ 360 - \theta & \text{if } B > G \end{cases}$$

with

$$\theta = \cos^{-1}\left\{ \frac{\frac{1}{2}[(R-G)+(R-B)]}{\left[(R-G)^2+(R-B)(G-B)\right]^{1/2}} \right\}$$

The saturation component is given by

$$S = 1 - \frac{3}{(R+G+B)}\left[\min(R, G, B)\right].$$

Finally, the intensity component is given by

$$I = \frac{1}{3}(R+G+B).$$

Converting Colors from HIS to RGB

RG sector $(0^\circ \le H < 120^\circ)$:

$$B = I(1 - S)$$

$$R = I\left[1 + \frac{S\cos H}{\cos(60^\circ - H)}\right]$$

$$G = 1 - (R + B).$$

Converting Colors from HIS to RGB

GB sector $(120^\circ \leq H < 240^\circ)$:

$$H = H - 120^\circ.$$

Then the RGB components are

$$R = I(1 - S)$$

$$G = I\left[1 + \frac{S\cos H}{\cos(60^\circ - H)}\right]$$

and

$$B = 1 - (R + G).$$

Converting Colors from HIS to RGB

GB sector $(120° \leq H < 240°)$:

$$H = H - 120°.$$

Then the RGB components are

$$R = I(1 - S)$$

$$G = I\left[1 + \frac{S \cos H}{\cos(60° - H)}\right]$$

and

$$B = 1 - (R + G).$$

Converting Colors from HIS to RGB

BR sector $(240^\circ \le H \le 360^\circ)$:

$$H = H - 240^\circ.$$

Then the RGB components are

$$G = I(1 - S)$$

$$B = I\left[1 + \frac{S \cos H}{\cos(60^\circ - H)}\right]$$

and

$$R = 1 - (G + B).$$

Conversion of one Color model to other Color model is possible.

RGB ⟺ YIQ

RGB ⟺ YCbCr

RGB ⟺ CMY

RGB ⟺ HSI