20MCA24C DIGITAL IMAGE PROCESSING

UNIT III - COLOR IMAGE PROCESSING

FACULTY

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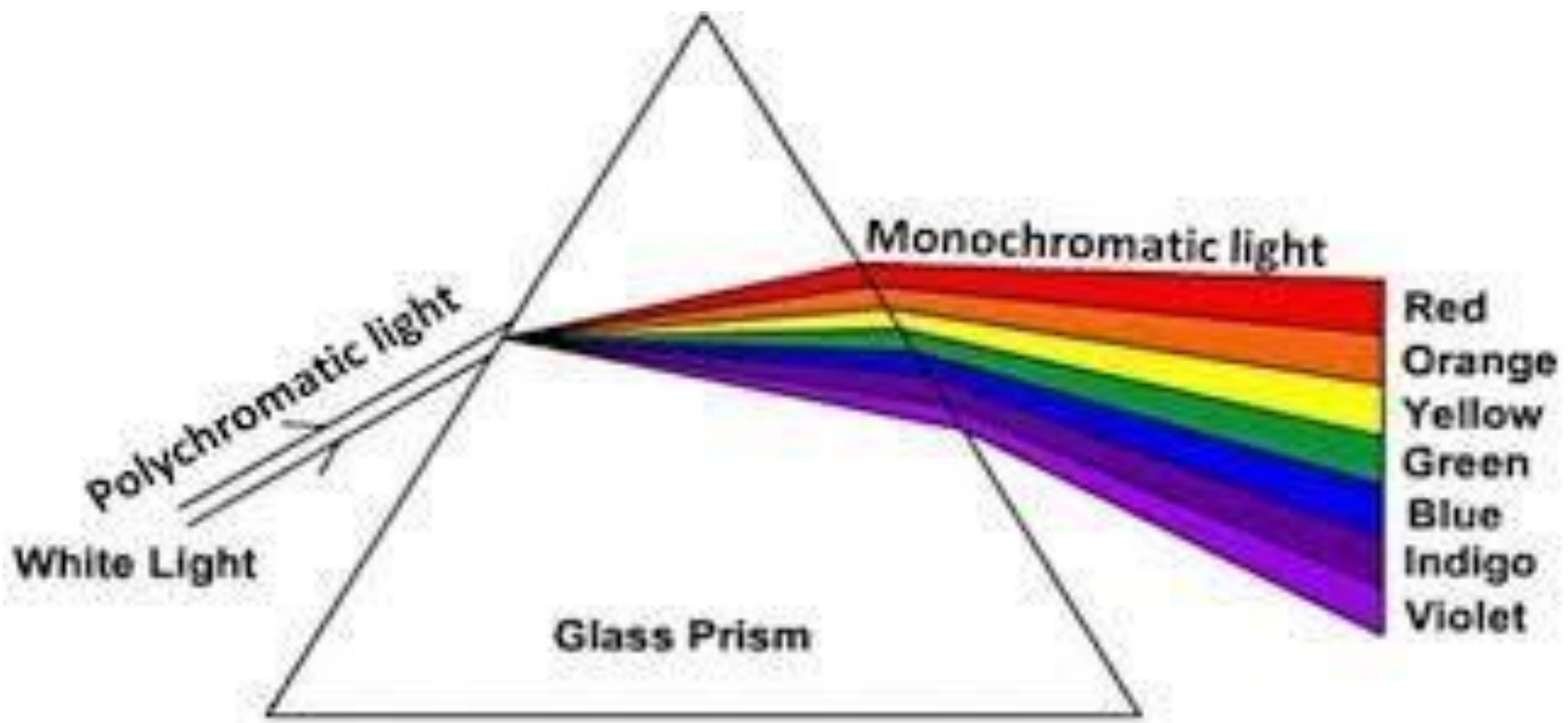
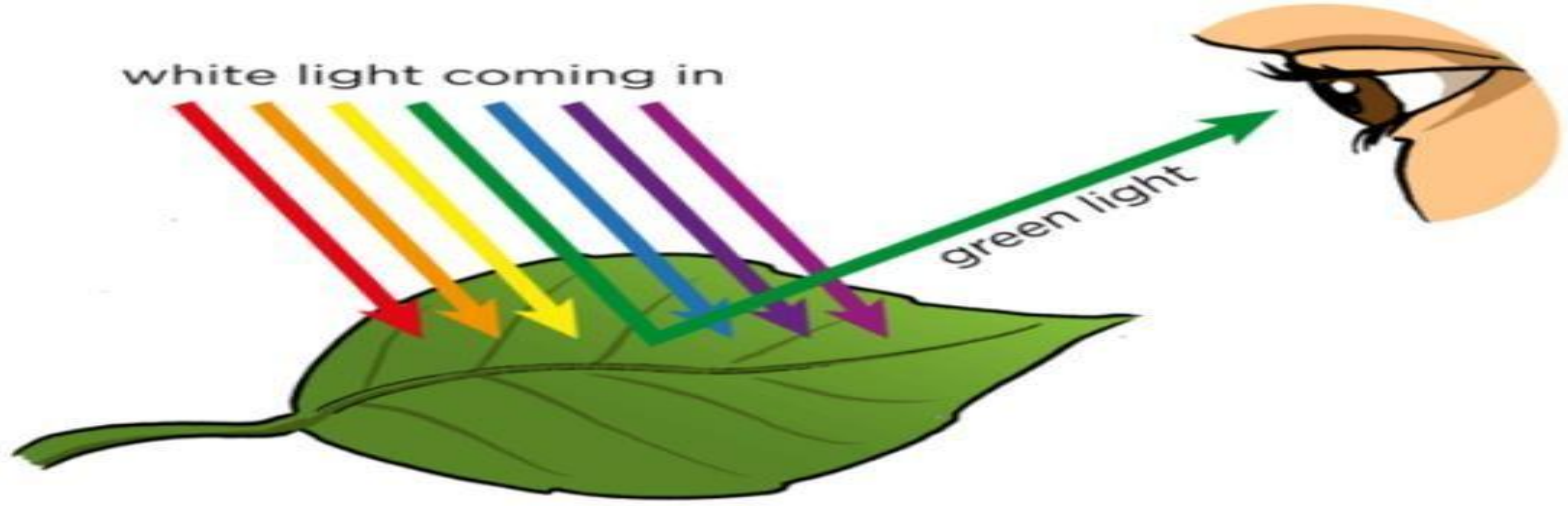
- ***Color Image Processing***
- Color image processing includes the following topics:
- Color fundamentals
- Color models
- Pseudocolor image processing
- Color image smoothing and sharpening
- Color edge detection
- Noise in color images
- Color perception models

Color Fundamentals

- In 1666 Sir Isaac Newton discovered that g (2002) when a beam of sunlight passes through a glass prism, the emerging beam is split into a spectrum of colors.


Monochromatic light
Polychromatic light
White Light
Glass Prism
Red
Orange
Yellow
Green
Blue
Indigo
Violet

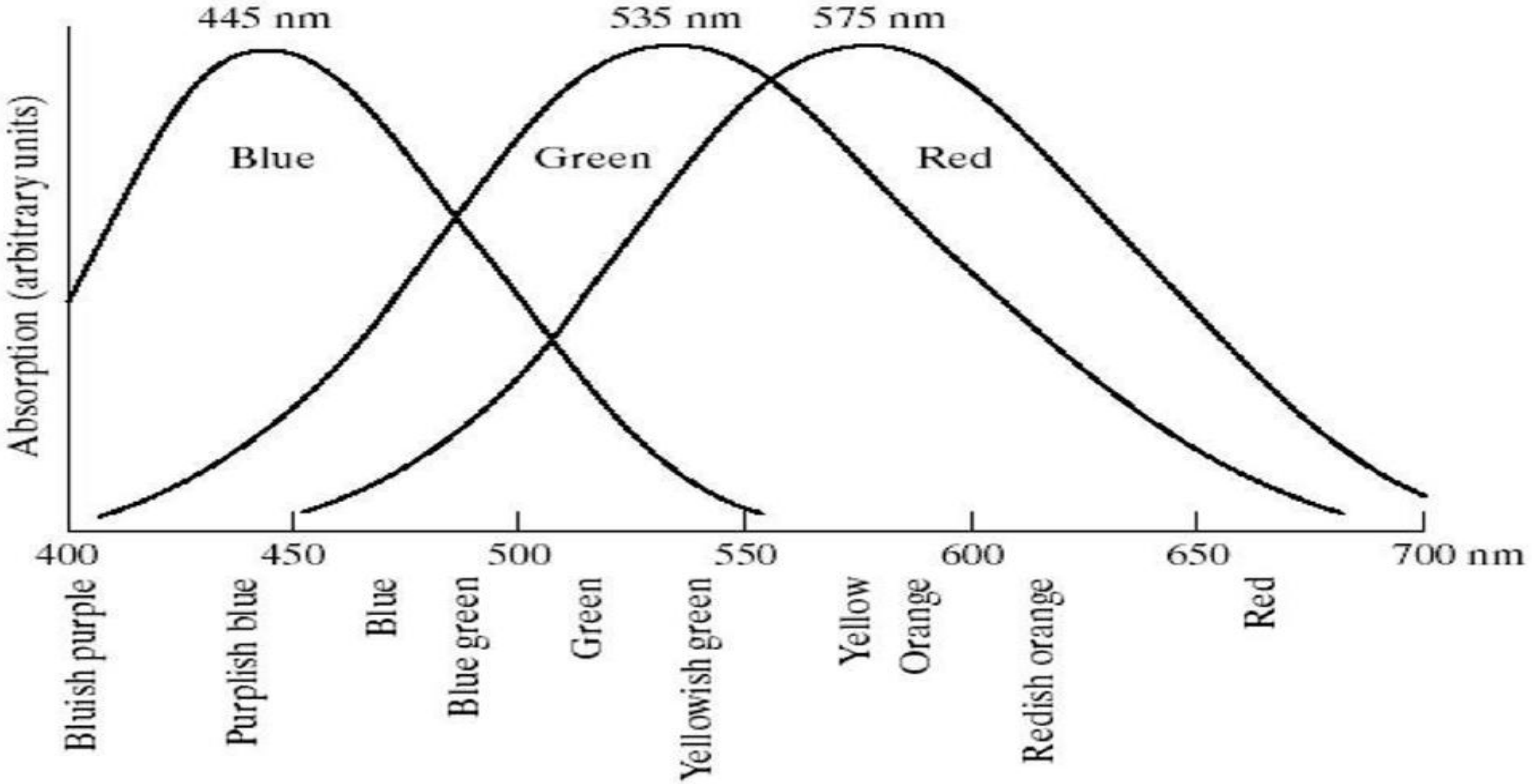
- The colors that humans and most animals perceive in an object are determined by the nature of the light reflected from the object
- For example, green objects reflect light with wave lengths primarily in the range of 500 – 570 nm while absorbing most of the energy at other wavelengths.



- Three basic quantities are used to describe the quality of a chromatic light source:
  - Radiance: the total amount of energy that flows from the light source (measured in watts)
  - Luminance: the amount of energy an observer perceives from the light source (measured in lumens)
    - Note we can have high radiance but low luminance
  - Brightness: a subjective (practically un-measurable) notion that embodies the achromatic notion of intensity of light
- Chromatic light spans the electromagnetic spectrum from approximately 400 to 700 nm.

- ➢ Human color vision is achieved through 6 to 7 million cones in each eye.
- ➢ Three principal sensing groups:
- –66% of these cones are sensitive to red light
- –33% to green light –2% to blue light.
- ➢ Absorption curves for the different cones have been determined experimentally.
- ➢ Strangely these do not match the CIE standards for red (700nm), green
- (546.1nm) and blue (435.8nm) light as the standards were developed before the experiments!

Images taken from Gonzalez & Woods, Digital Image Processing (2002)



➢The primary colors can be added to produce the secondary colors.

➢Mixing the three primaries produces white.

➢Mixing a secondary with its opposite primary produces white (e.g. red+cyan).

➢Primary colors of light (red, green, blue)

➢Primary colors of pigments (colorants)

A color that subtracts or absorbs a primary color of light and reflects the other two.

- These are cyan, magenta and yellow (CMY).
- A proper combination of pigment primaries produces black.
- How to Distinguish one color from another?

➢**Brightness:** the achromatic notion of intensity.

➢**Hue:** the dominant wavelength in a mixture of light waves.

Note :

The dominant color perceived by an observer, e.g. when we call an object red or orange we refer to its hue)

➢**Saturation**: the amount of white light mixed with a hue. Pure colors are fully saturated. Pink (red+white) is less saturated.

➢Hue and saturation are called chromaticity.

➢Therefore any color is characterized by its brightness and chromaticity.

➢The amounts of red, green and blue needed to form a particular color are called tristimulusvalues and are denoted by X, Y, Z.

- A color is then specified by its trichromatic coefficients:
- $x+y+z=1$

➢For any visible wavelength the tristimulus needed to produce that wavelength are obtained by curves compiled by extensive experimentation.

Color Models

- There are different ways to model color.
- Two very popular models used in color image processing:
  - RGB (Red Green Blue)
  - HSI (Hue Saturation Intensity)

RGB (Red Green Blue)

➢In the RGB model each color appears in its primary spectral components of red, green and blue.

➢The model is based on a Cartesian coordinate system.

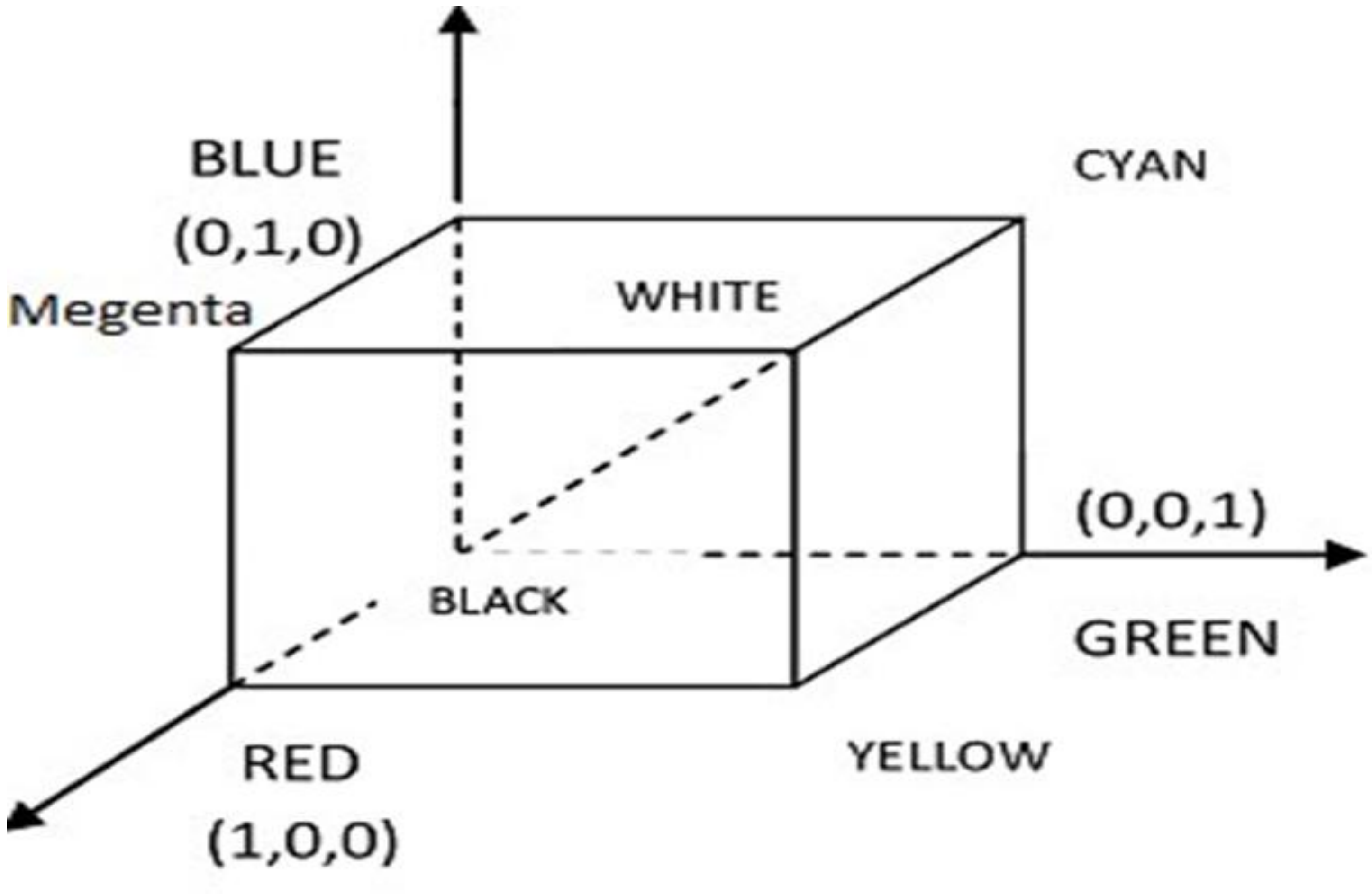
- RGB values are at 3 corners.

➢Cyan magenta and yellow are at three other corners.

➢Black is at the origin.

➢White is the corner furthest from the origin.

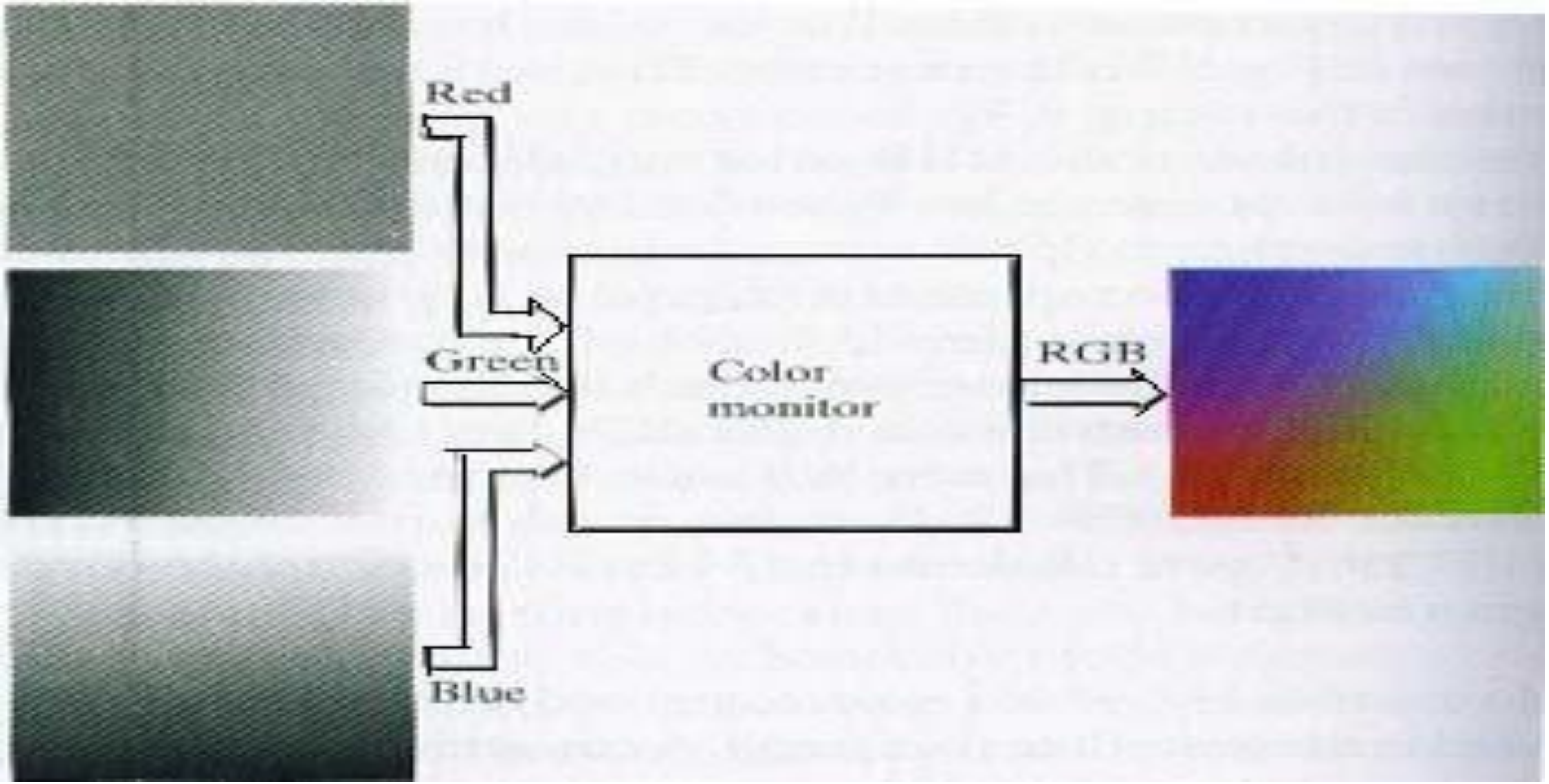
➢Different colors are points on or inside the cube represented by RGB vectors.


BLUE
(0,1,0)
CYAN
Megenta
WHITE
(0,0,1)
BLACK
GREEN
RED
YELLOW
(1,0,0)

Images represented in the RGB color model consist of three component images. – one for each primary color.

- ➢When fed into a monitor these images are combined to create a composite color image.
- ➢The number of bits used to represent each pixel is referred to as the color depth.
- ➢A 24-bit image is often referred to as a fullcolor image as it allows 16,777,216 colors.

Generating RGB image:


Red
Green
Blue
Color monitor
RGB

HSI Color Model

- RGB is useful for hardware implementations and is serendipitously related to the way in which the human visual system works.
- However, RGB is not a particularly intuitive way in which to describe colors.
- Rather when people describe colors they tend to use hue, saturation and brightness.
- RGB is great for color generation, but HSI is great for color description.

HSI Color Model

- Hue: A color attribute that describes a pure color (pure yellow, orange or red).
- Saturation: Gives a measure of how much a pure color is diluted with white light.
- Intensity: Brightness is nearly impossible to measure because it is so subjective. Instead we use intensity.
- Intensity is the same achromatic notion that we have seen in grey level images.
- Pseudocolor (also called false color) image processing consists of assigning colors to grey values based on a specific criterion.

Pseudocolor Image Processing

- The principle use of pseudocolor image processing is for human visualisation.
- o Humans can discern between thousands of color shades and intensities, compared to only about two dozen or so shades of grey.
- **Intensity Slicing :**
- Intensity slicing and color coding is one of the simplest kinds of pseudocolor image processing.
- First we consider an image as a 3D function mapping spatial coordinates to intensities (that we can consider heights).
- Now consider placing planes at certain levels parallel to the coordinate plane.

- If a value is one side of such a plane it is rendered in one color, and a different color if on the other side.
- In general intensity slicing can be summarised as:
- Let **[0, L-1]** represent the grey scale.
- Let $\mathbf{l_0}$ represent **black [f (x, y) = 0] and**
- let $\mathbf{l_{L-1}}$ represent **white [f (x, y) = L-1].**
- Suppose P planes perpendicular to the intensity axis are defined at **levels**

l1, l2, …, lp.

- Assuming that **0 < P < L-1** then the P planes partition the grey scale into

P + 1 intervals $\mathbf{V_1, V_2, \ldots, V_{P+1}}$

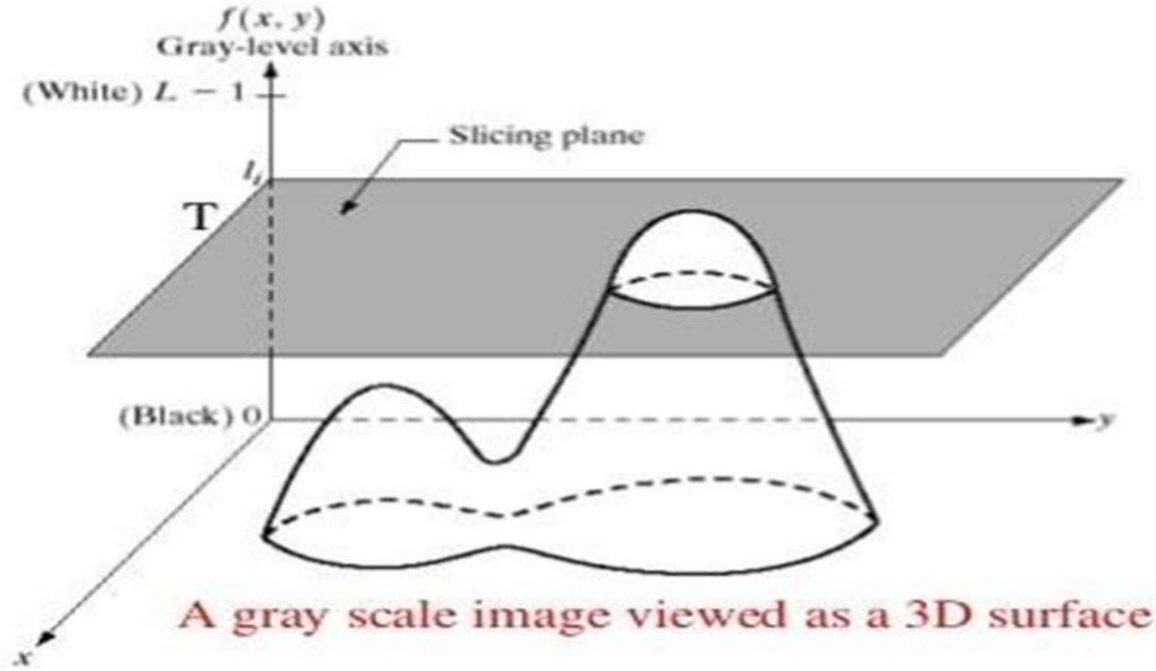
- Grey level color assignments can then be made according to the relation:

- **f (x, y) = ck , if f (x, y)   V**
- where ck is the color associated with the **kth intensity level Vk** defined by the partitioning planes at **l = k – 1 and l = k.**

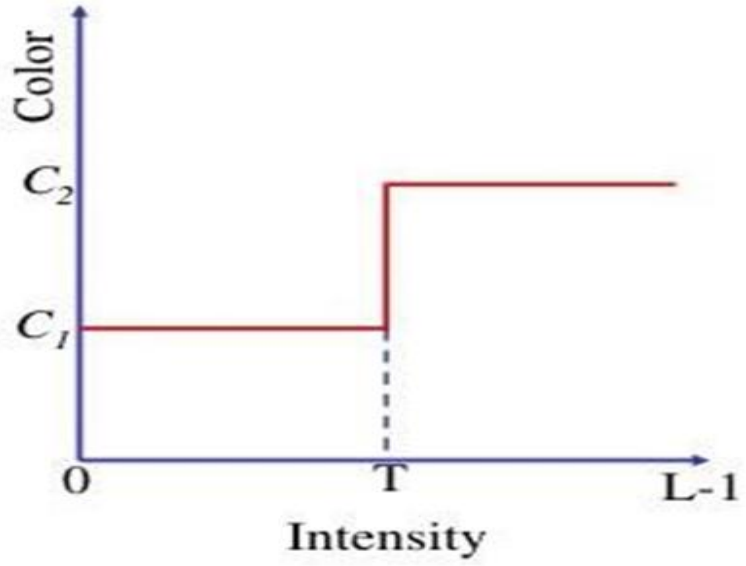
Formula:

$$g(x, y) = \begin{cases} C_1 & \text{if } f(x, y) \le T \\ C_2 & \text{if } f(x, y) > T \end{cases}$$

C_1 = Color No. 1
C_2 = Color No. 2

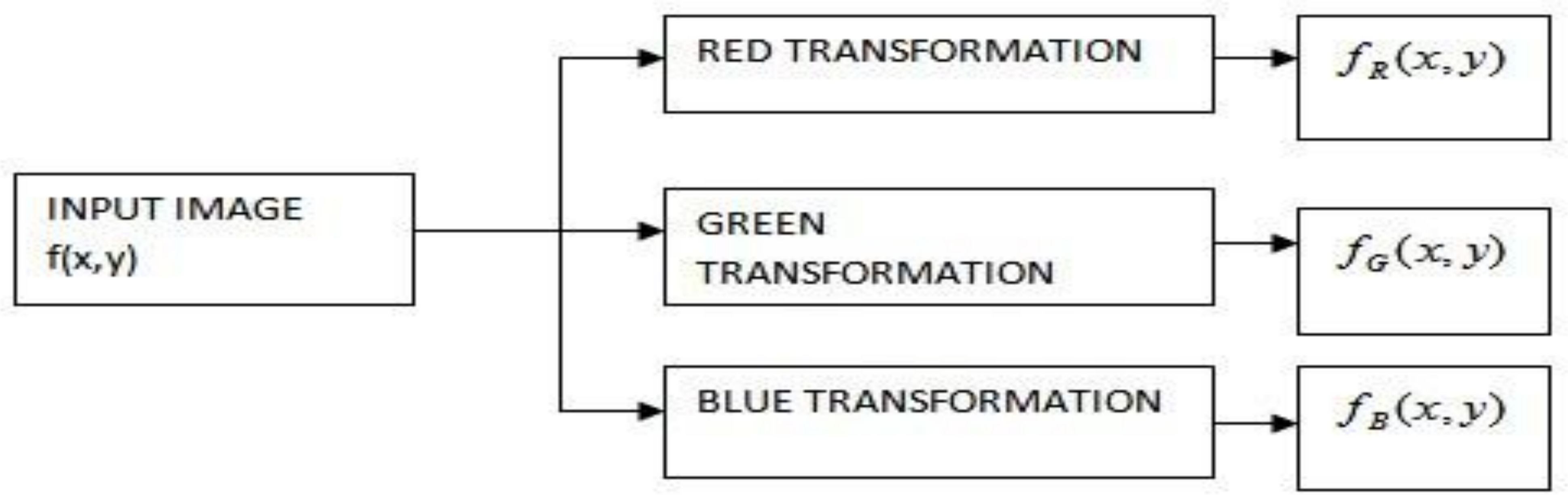


A gray scale image viewed as a 3D surface.



Pseudocolor Image Processing – Intensity to Color Transformation

- Three independent transformations of the intensity.
- The results are fed into the R, G, B channels.
- The resulting composite image highlights certain image parts.



- Sinusoidal transformation functions.
- Changing the phase or the frequency of the transformation functions can emphasize ranges in the gray scale.
- A small change in the phase between the transformations assigns a strong color to the pixels with intensities in the valleys.

ColorTransformation

- Gray scale image transformations may also be applied to each color separately. Color transformation operations are,
- Intensity adjustment
- Color complement
- Color slicing
- Tone Correction
- Correction of color imbalancies

Color Image Smoothing and Sharpening

- Color image smoothing and sharpening are two important Pre-Processing techniques within the computer vision field.
- Color image smoothing is part of pre-processing techniques intended for removing possible image perturbations without losing image information.
- Analogously, sharpening is a pre-processing technique that plays an important role for feature extraction in image processing.
- Sharpening is in charge of the improvement of the image visual appearance and enhance the details and borders of the image.
- There exists a lot of smoothing and sharpening methods that are able to improve visual quality of images. However the same does not happen with simultaneous approaches due to the opposite nature of these two operations.

- Typical spatial filters for color image smoothing are based on the convolution of the image with different kernels, depending on the intended result.
- These kernels could be of any size n × n, but usually 3 × 3.
- Commonly used filters for smoothing are based on averaging.
- Similarly, typical spatial techniques for sharpening images are based on kernels.
- Most common methods are based on derivatives, such as Laplacian filter.
- Smoothing intends to remove the high frequencies but Sharpening intends to increase the high frequencies.
- Both steps smoothing and sharpening are used to enhance the image. This is called two-step approach. In this approach, First performed either smoothing or sharpening.
- However this approaches usually leads too many problems.
- So, we used to prepare simultaneous approach.

Color edge detection

- **Color Edge detection** is one of the most important tasks in **image processing** and scene analysis systems.
- Therefore, one **edge detection** technique is to measure the gradient vector magnitude at pixel locations.
- Edge detection is one of the most commonly used operations in image processing and pattern recognition.
- Edges form the outline of an object.

- An edge is the boundary between an object and the background, and indicates the boundary between overlapping objects.
- This means that if the edges in an image can be identified accurately, all of the objects can be located and basic properties such as area, perimeter, and shape can be measured.

- Edge detection in color image is far more challenging task than gray scale images as color space is considered as a vector space.
- Almost 90% of edge information in a color image can be found in the corresponding grayscale image. However, the remaining 10% can still be vital in certain computer vision tasks.
- In Color edge detection, each pixel is represented by three channel values called Red, Green, and Blue.
- Each channel contain gray values. Gray edge detection techniques are applied on each channel to detect the edges, discriminate the objects and discriminate the objects and backgrounds.

Noise in color images

- **Image noise** is random variation of brightness or **color** information in **images**, and is usually an aspect of electronic **noise**. It can be produced by the **image** sensor and circuitry of a scanner or digital camera.
- The noise models discussed for grayscale images are also applicable to color images.
- However, in many applications, a color channel may be more or less affected than the other channels.

- For instance, using a red color filter in a CCD camera may affect the red component of the image (CCD sensors are noisier at low levels of illumination).
- The hue and saturation components are significantly degraded.
- This is due to the nonlinearity of the cos and min operations used in the transformation.
- The intensity component is smoother due to averaging of the three noisy RGB components.
- When only one channel is affected by noise, conversion to HIS spreads the noise to all HSI components images.
- This is due to the transformation that makes use of all RGB components to compute each HSI component. Different Noises are,
  - Salt and Pepper noise
  - Impulse noise
  - Gaussian noise

Color perception models

- Human visual system has three primary sensing groups for the cones $S_i(\lambda)$, i=1,2,3.
- The perception of a color with spectral energy distribution $C(\lambda)$ is described by the responses of the three primaries to that color:
- **Color perception** is a part of the larger visual system and is mediated by a complex process between neurons that begins with differential stimulation of different types of photoreceptors by light entering the eye.

THANK YOU

This content is taken from the text books and reference books prescribed in the syllabus.