

UNIT - V

↳ Color Processing:

The physics of colour

Human color perception

representing colour

Model for image colour

Surface color from image colour

↳ Range image processing:

active range sensor

Range data segmentation

Range image registration and model acquisition

Object recognition.

The physics of colours:

It describes that how matter and light interact to each other and produce colour each other that we see.

There are some key principles.

1. Light or Electromagnetic wave:

→ Visible light is the small portion of electromagnetic spectrum. It consists of wave with various wavelengths.

Red light has longer wavelength and violet has shorter.

2. Absorption and reflection:

→ When light fall on any object then that object absorbed some light ~~and reflect some~~ transmitts and reflect other light. For example A red Apple appears red because ~~to~~ it reflect red light and absorb the rest light.

3. Additive colour mixing:

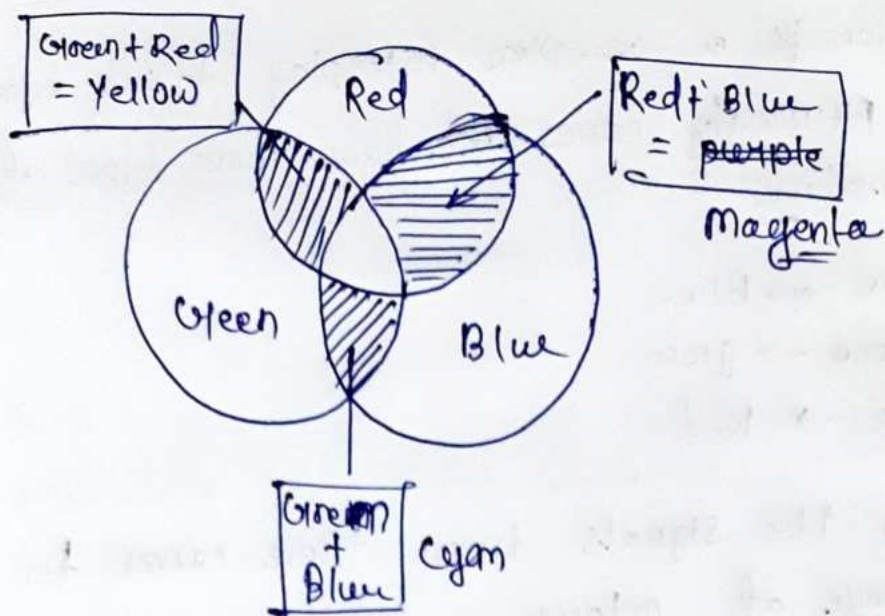
→ In additive colour mixing colour are created by combining different wave length of light. In this system red green and blue are primary colour mixing them in various proportion can create a wide range of colour. This is how computer screen and TVs can produces colour.

4. Subtractive colour mixing:

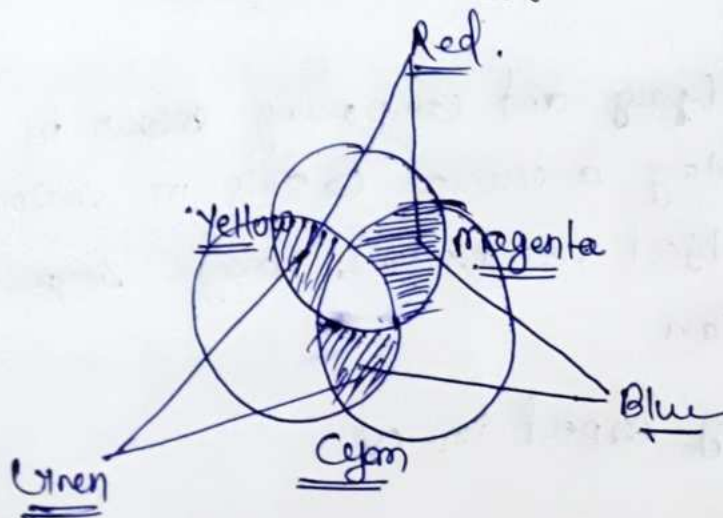
→ In subtractive colour mixing, colour are created by mixing pigment or dyes. Here the primary color are cyan magenta, yellow. When these colour combine they subtract certain wavelength of light. Resulting in the perception of specific colour like - Red, ^{green} ~~Yellow~~, Blue.

5. ~~Colour Temp.~~

→ Diagram for Additive colour mixing:



→ Diagram for Subtractive colour



5. Colour Temperature:

Higher temperature → correspond to → Blue light
 Lower temperature → correspond to → Reddish light.

Human colour perception:

→ Human colour perception is a complex interplay of our eyes
• Photoreceptor cell primarily cones. We have three types of cones that are sensitive

- (i) Short cone → Blue
- (ii) medium cone → green
- (iii) long cone → Red

Our brain processes the signals from these cones to receive a wide range of colour.

Colour matching:

→ The process of quantifying and comparing colour in the image or video. It plays a crucial role in various applications such as object recognition, image segmentation and color correction.

→ There are some key aspects in CV

(i) Color-space

(ii) Color-Histogram

(iii) Color-Based object recognition

(iv) Colour-segmentation

(v) Colour-correction

(i) colour-space:

The representation of color in the color-space

Common color-space - RGB (Red, ~~Blue~~, Green, Blue)

Color Histogram - HSV (Hue, Saturation, Value).

LAB

YUV

These colour-space provide different way to express and manipulate the colour information

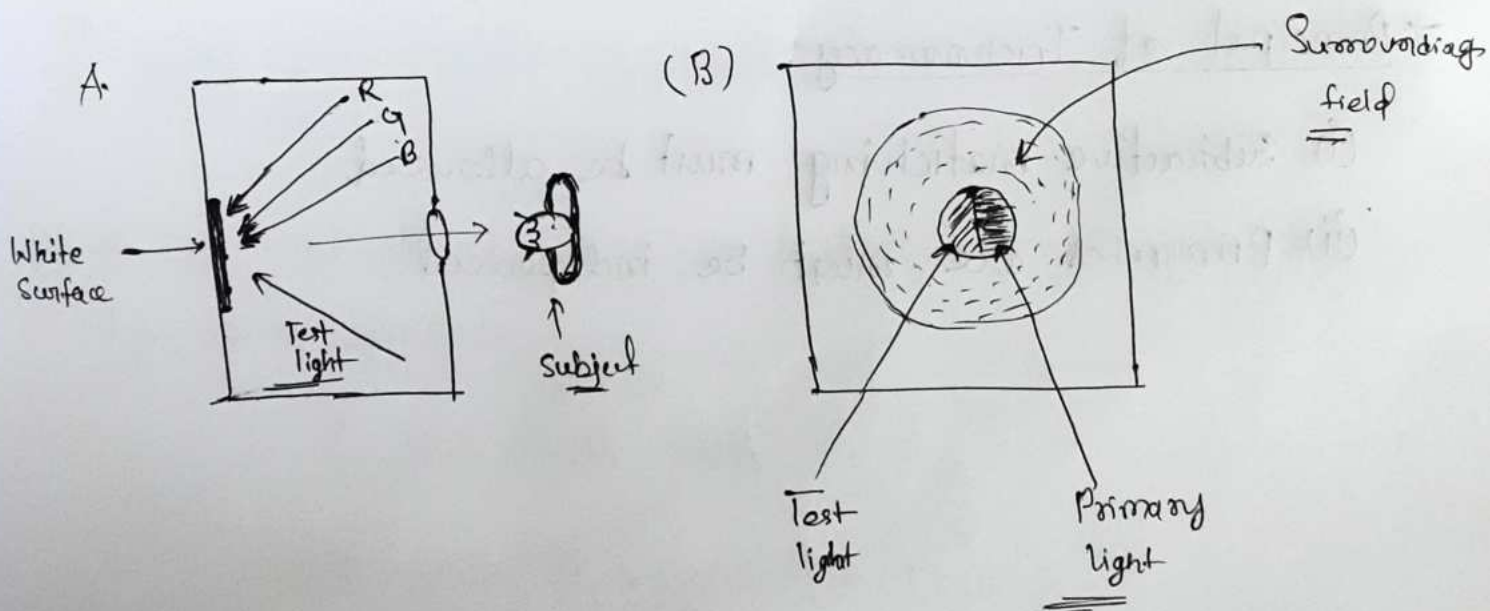
(ii) colour-Histogram:

→ It is a statistical representation of colour distribution in the image.

→ It quantify ~~that~~ how many pixels in the image having specific colour value within the defined colour space

(iii) Color-Based.

Colour matching experiment:



Trichromacy:

Trichromatic colour theory:

↳ Three number of colour are sufficient to make any number of colours.

Principle of trichromacy:

(i) Subtractive matching must be allowed

(ii) primaries must be independent: it means no mixture of two primary match to third.

~~iii~~

→ According to Trichromacy theory Human Eye can perceive three primary colour and (Red, Green, Blue) There are three color transducer in the human eye. and we can see a wide range of colour through this three color transducer.

~~From~~

Trichromatic vision is the most common vision in the human.

→ Principal of Trichromacy:

(i) Subtractive matching must be allowed.

(ii) Primaries are must be independent

Grassman's Law:

↳ Grassman's law states that colour matching appears to be linear.

(i) Suppose we have two test light with same weight of primaries then both the light match to each other or appear same.

$$A = u_1 P_1 + u_2 P_2 + u_3 P_3$$

$$B = u_1 P_1 + u_2 P_2 + u_3 P_3$$

Then

$$A = B.$$

(ii) If there are two test light of different weight are mixed to each other. Then its result colour ~~also~~ will be mixture the matches.

$$A = u_1 P_1 + u_2 P_2 + u_3 P_3$$

$$B = v_1 P_1 + v_2 P_2 + v_3 P_3$$

Then

$$(A+B) = (u_1+v_1) P_1 + (u_2+v_2) P_2 + (u_3+v_3) P_3.$$

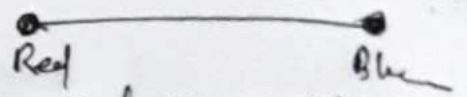
(iii) If we scaled the test light then matches get scaled by some amount.

$$A = u_1 P_1 + u_2 P_2 + u_3 P_3$$

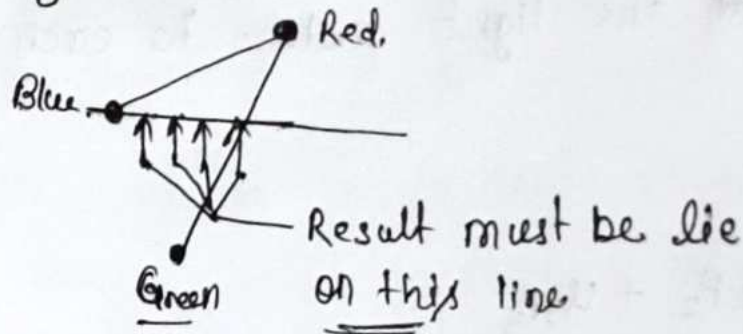
$$kA = (ku_1) P_1 + (ku_2) P_2 + (ku_3) P_3.$$

Linear - colour - space:

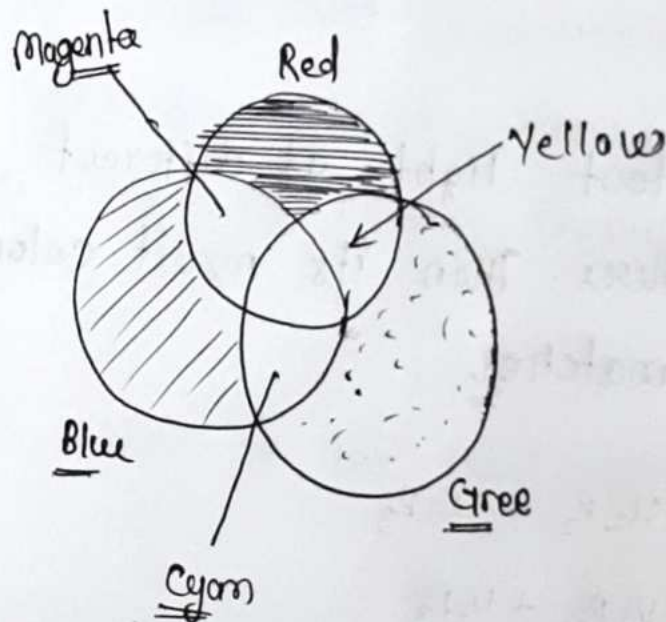
→ Mixing of two light produce colour that also lie on along straight line on the colour - space



→ Mixing of three light produce colour that lie within the triangle they defined in the colour space.

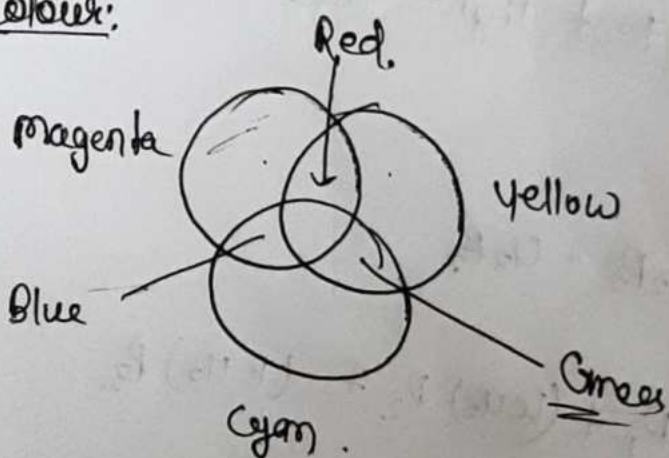


Additive and subtractive colour:



Additive colour

Subtractive colour:



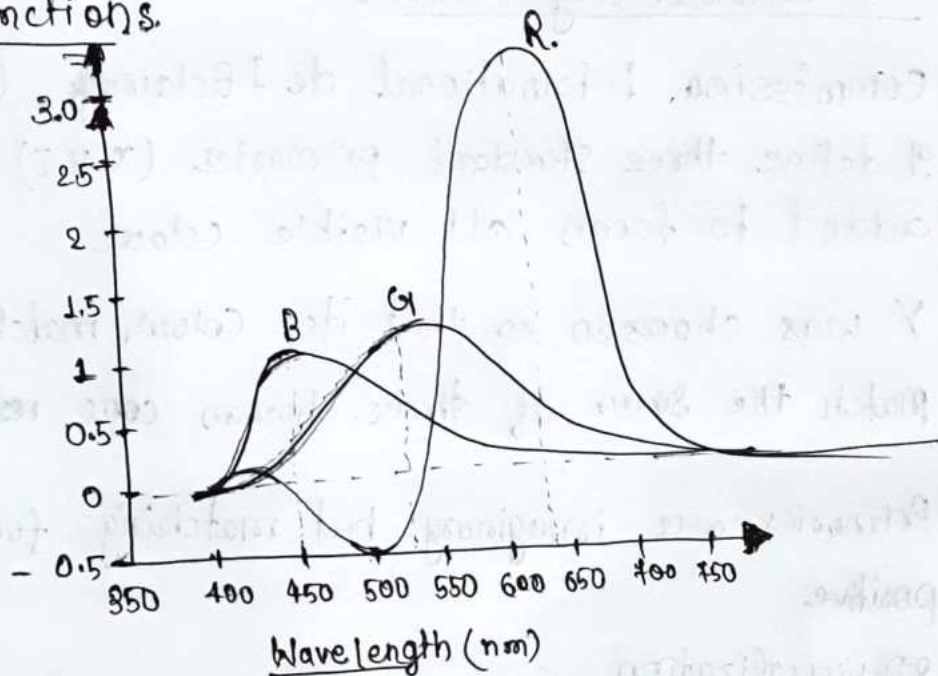
Linear Colour-space :

(i) RGB Colour-space :

Red = 645 nm
Green = 525 nm
Blue = 444 nm

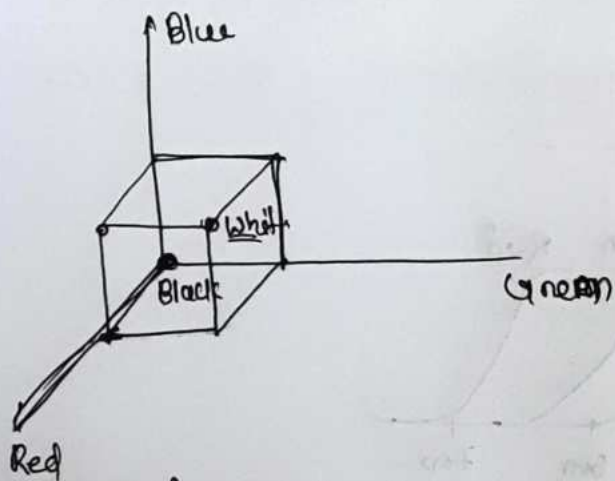
These all are primaries monochromatic light

RGB matching functions.



RGB Model :

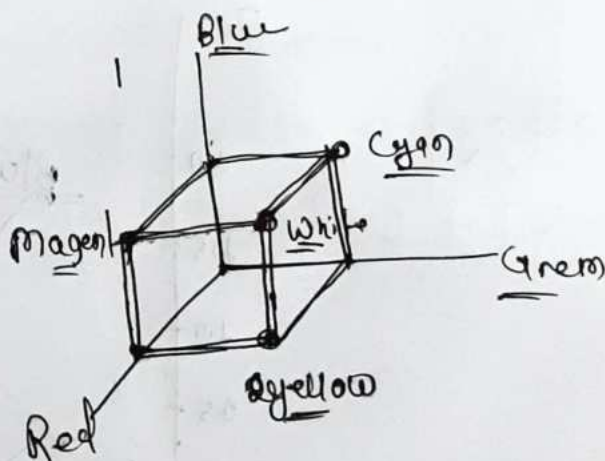
- Additive model
- Red, Green, Blue



→ Appropriate for image display

CMY Model

- Subtractive model
- Cyan, Magenta, Yellow



→ Appropriate for paper printing

White + Blue = Yellow
W + Red = Cyan
W + Green = Magenta

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

CIE Chromaticity Model's

→ Commission International de l'Eclairage (Est = 1931)

→ It define three standard primaries, (x, y, z) that can be added to form all visible colour

→ Y was choosen so that its colour matching function match the sum of three human cone responses

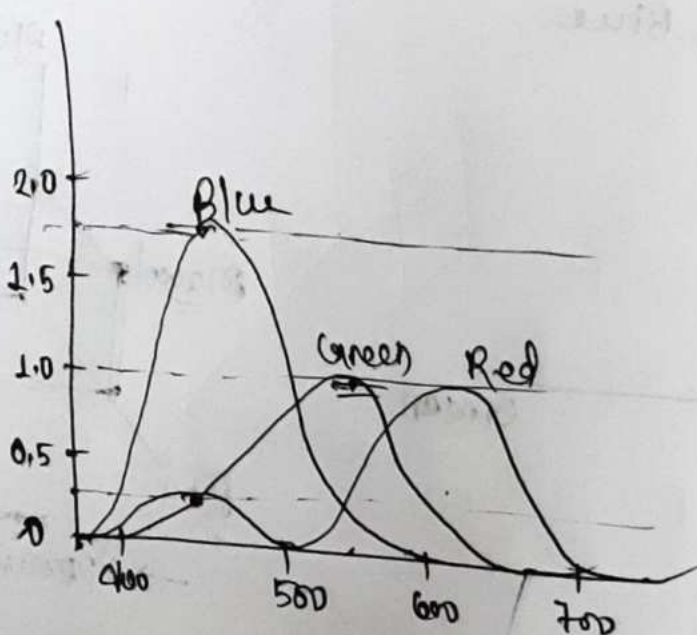
→ Primaries are imaginary but matching function are everywhere positive

→ 2D-Visualization

$$X = X / (x + y + z)$$

$$Y = Y / (x + y + z)$$

CIE matching function:



YIQ Model:

→

→ YIQ All three value used by colour TVs.

→ Y = Luminance which is use in black and white TVs

YCbCr Model:

$$\begin{bmatrix} 0.256 & 0.502 & 0.098 \\ 0.148 & 0.290 & 0.438 \\ 0.438 & 0.366 & 0.71 \end{bmatrix}$$

256	502	98
148	290	438
438	366	71

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 0.256 & 0.502 & 0.098 \\ 0.148 & 0.290 & 0.438 \\ 0.438 & 0.366 & 0.71 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} + \begin{bmatrix} 0 \\ 128 \\ 128 \end{bmatrix}$$

→ Having better compression properties

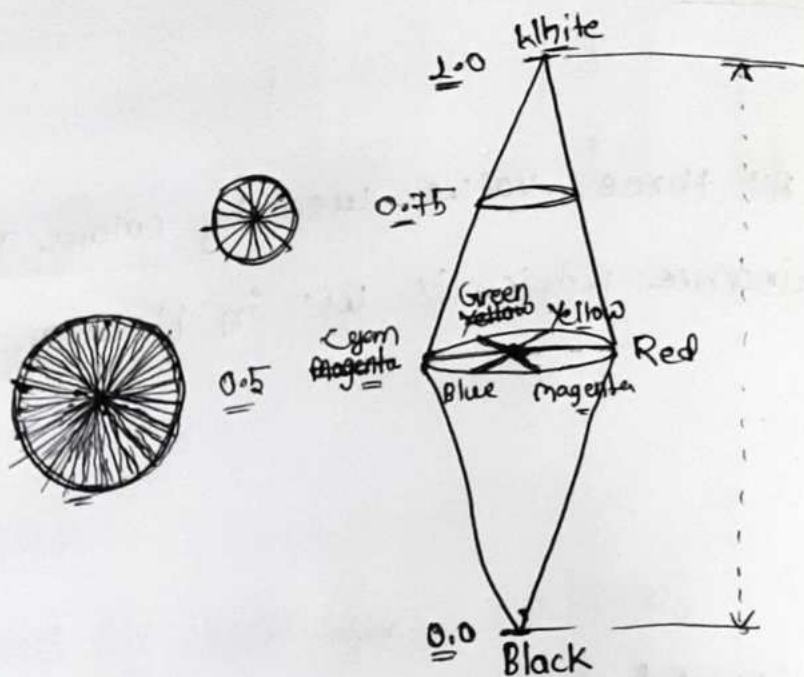
→ Used in image and video compression scheme

→ Cb and Cr translated to bring range 0 to 255.

(RGB) → 0 to 255

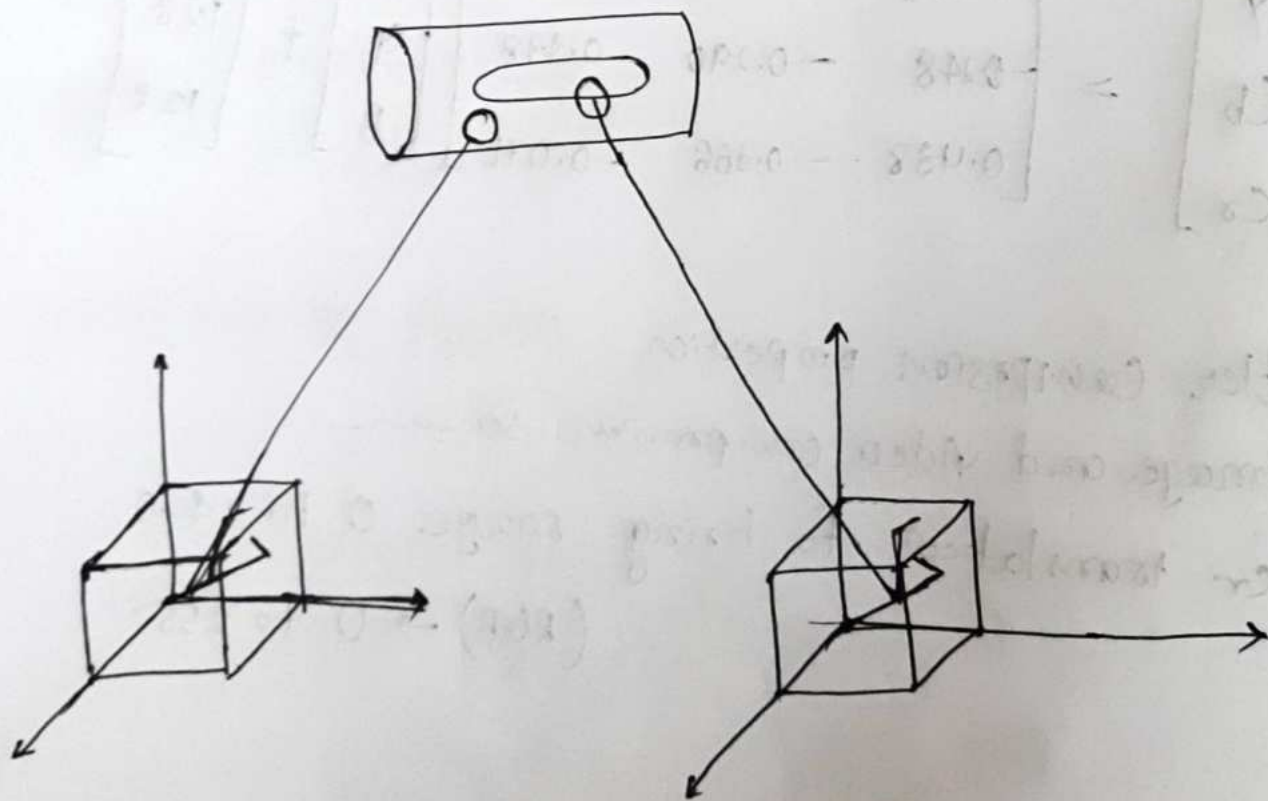
HSV-Colour Model :

- Hue, saturation, value
- Hue is encoded angle 0 to 2π
- Saturation is encoded distance to verticle axis (0 to 1)
- Intensity is ^{light} height along the verticle axis. (0 to 1)



Specularities :

- Specularities can have strong effect on an objects appearance.



→ Linear cluster produce by specularities on the plane object

The Eye : A Camera :

