# Color Image Processing

Chapter 6

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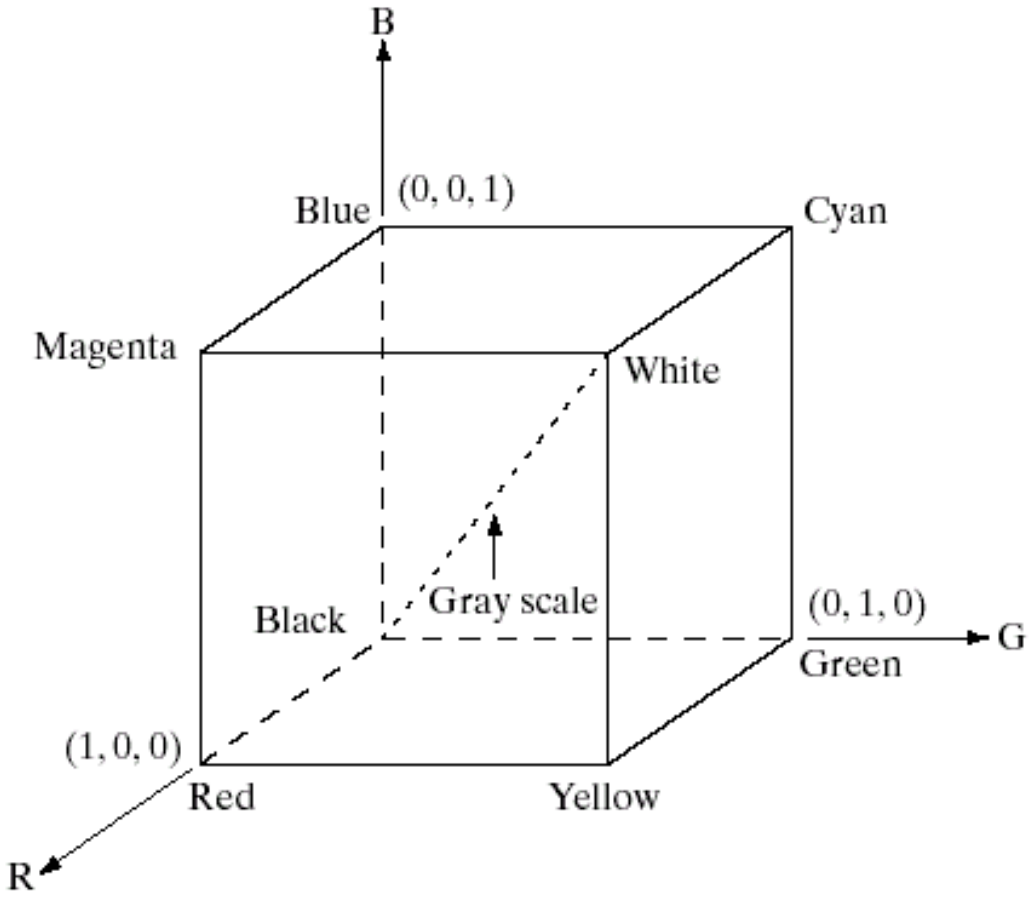
# Color Models

- Specification of colors in some standard generally accepted way
- We will consider two very popular models used in color image processing:
  - RGB (**R**ed **G**reen **B**lue)
  - HSI (**H**ue **S**aturation **I**ntensity)

# RGB Color Model

- In the RGB model each colour appears in 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 colours are points on or inside the cube represented by RGB vectors

# RGB Color Model



# RGB Color Model

- Images represented in the RGB color model consist of three component images – one for each color
- 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 full-color image as it allows $(2^8)^3$ = 16,777,216 colors

# HSI Color Model

- The HSI model uses three measures to describe colors:
  - **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:** Intensity is the same achromatic notion that we have seen in grey level images

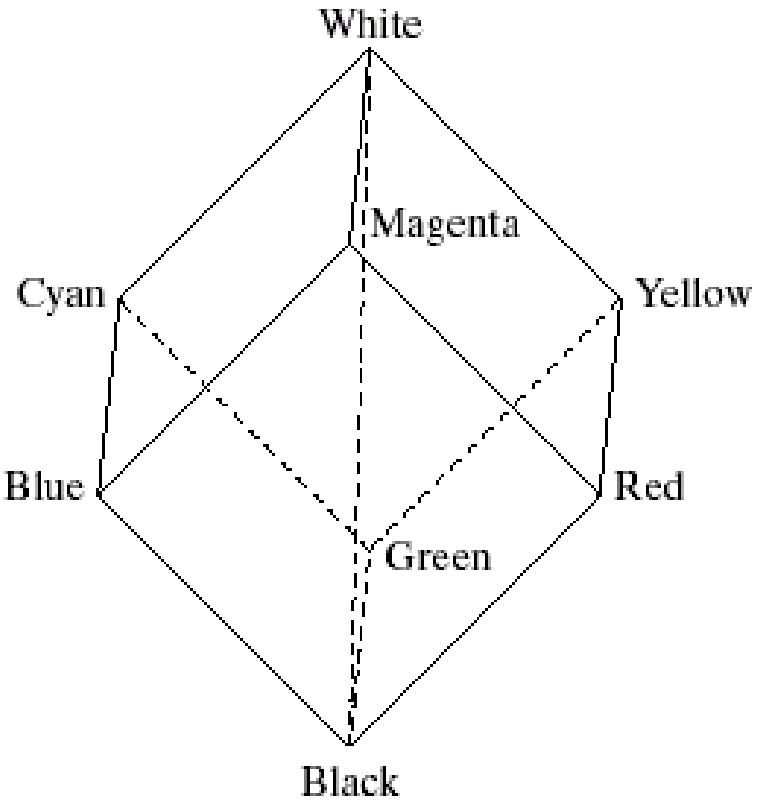
# HSI Color Model

- Intensity can be extracted from RGB images
- Remember the diagonal on the RGB color cube that we saw previously ran from black to white
- Now consider if we stand this cube on the black vertex and position the white vertex directly above it

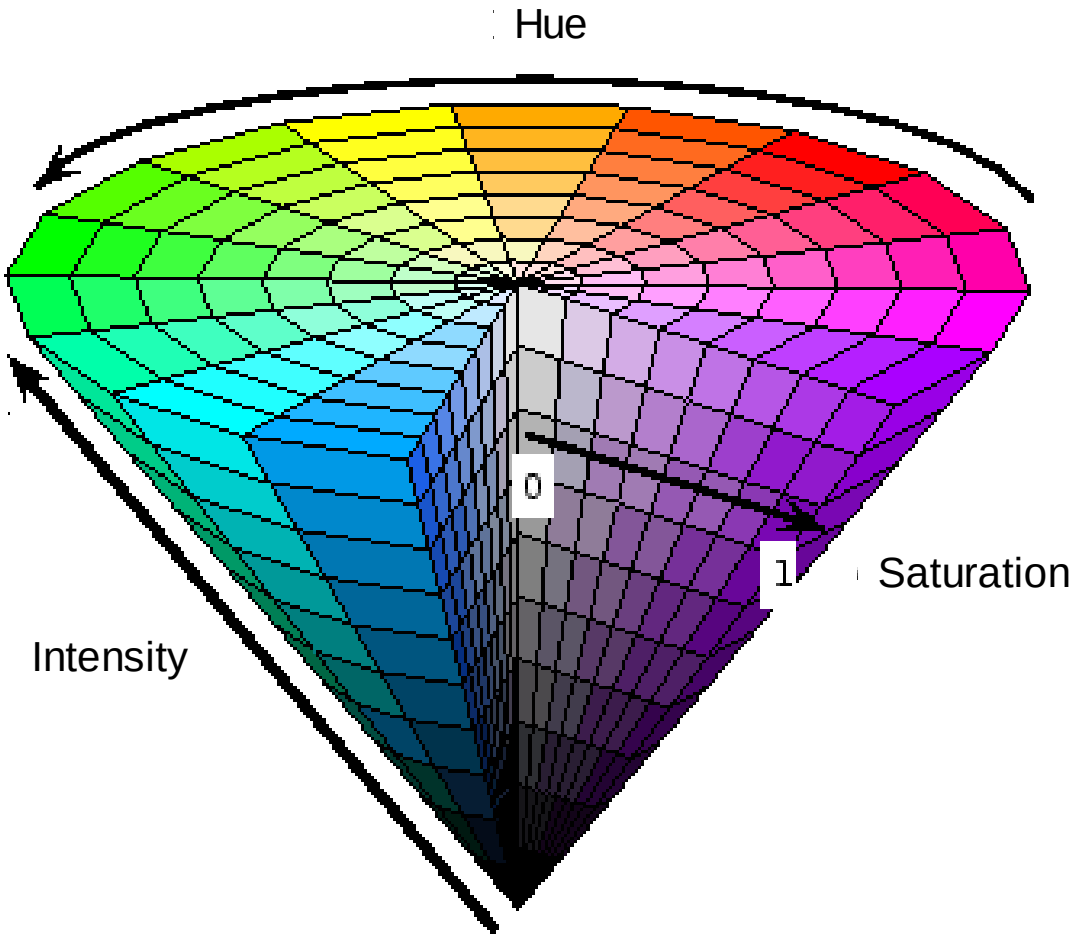
# HSI Color Model

- The intensity component of any color can be determined by passing a plane *perpendicular* to the intensity axis and containing the color point

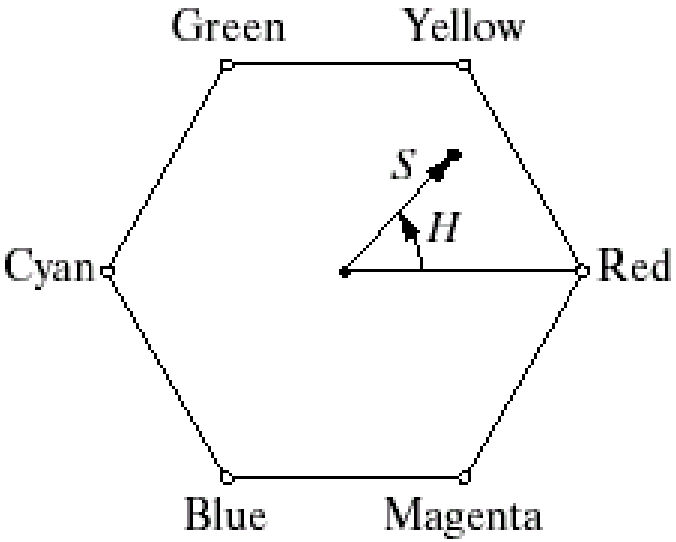
- The intersection of the plane with the intensity axis gives us the intensity component of the color



# HSI Color Model



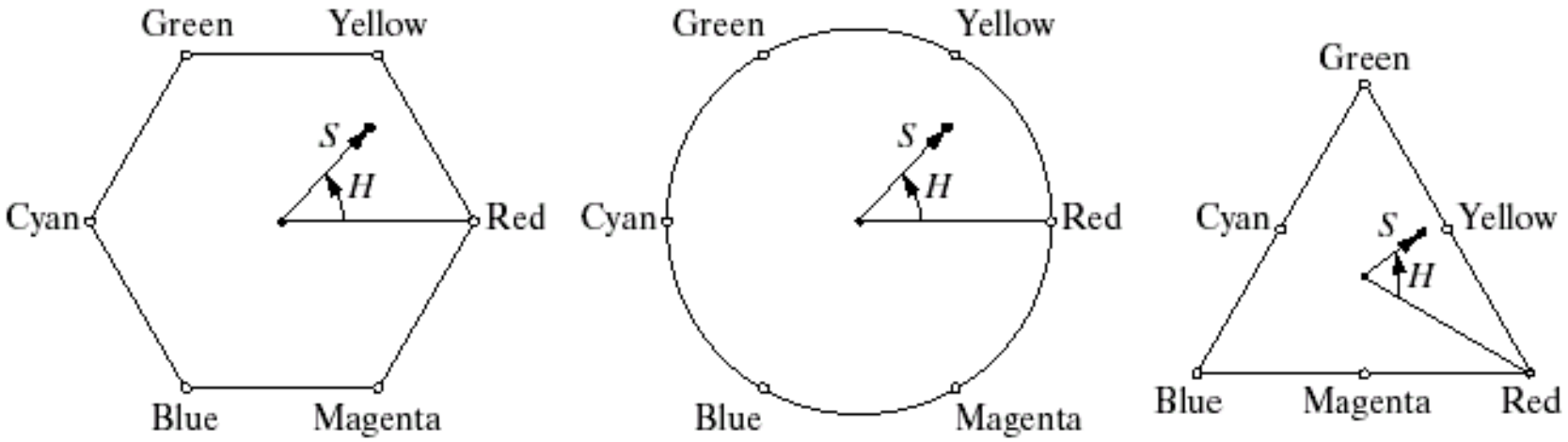
# HSI Color Model



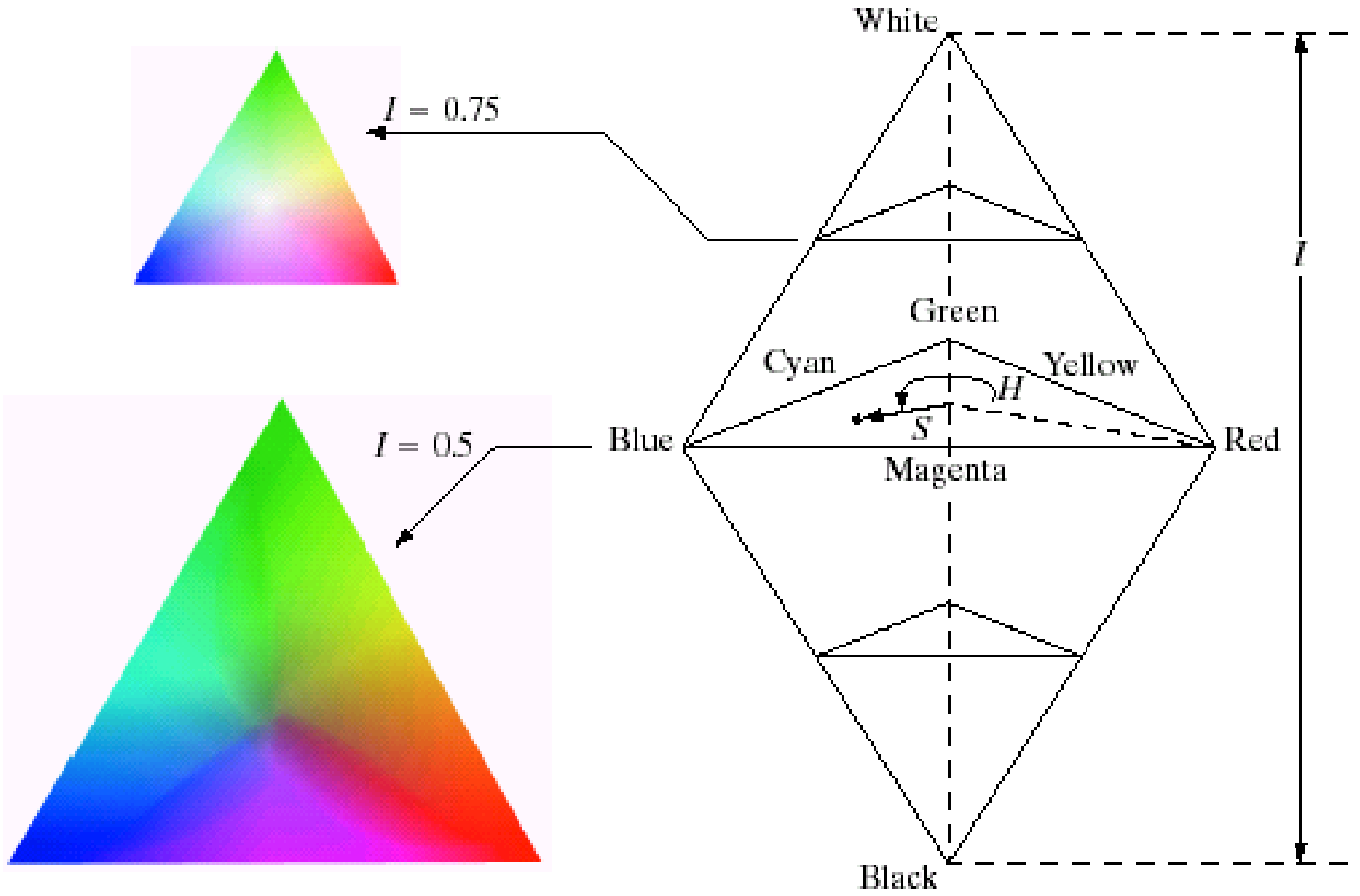

- An arbitrary color point
  - The hue is determined by an angle from a reference point, usually red
  - The saturation is the distance from the origin to the point
  - The intensity is determined by how far up the vertical intensity axis this hexagonal plane sits (not apparent from this diagram

# HSI Color Model

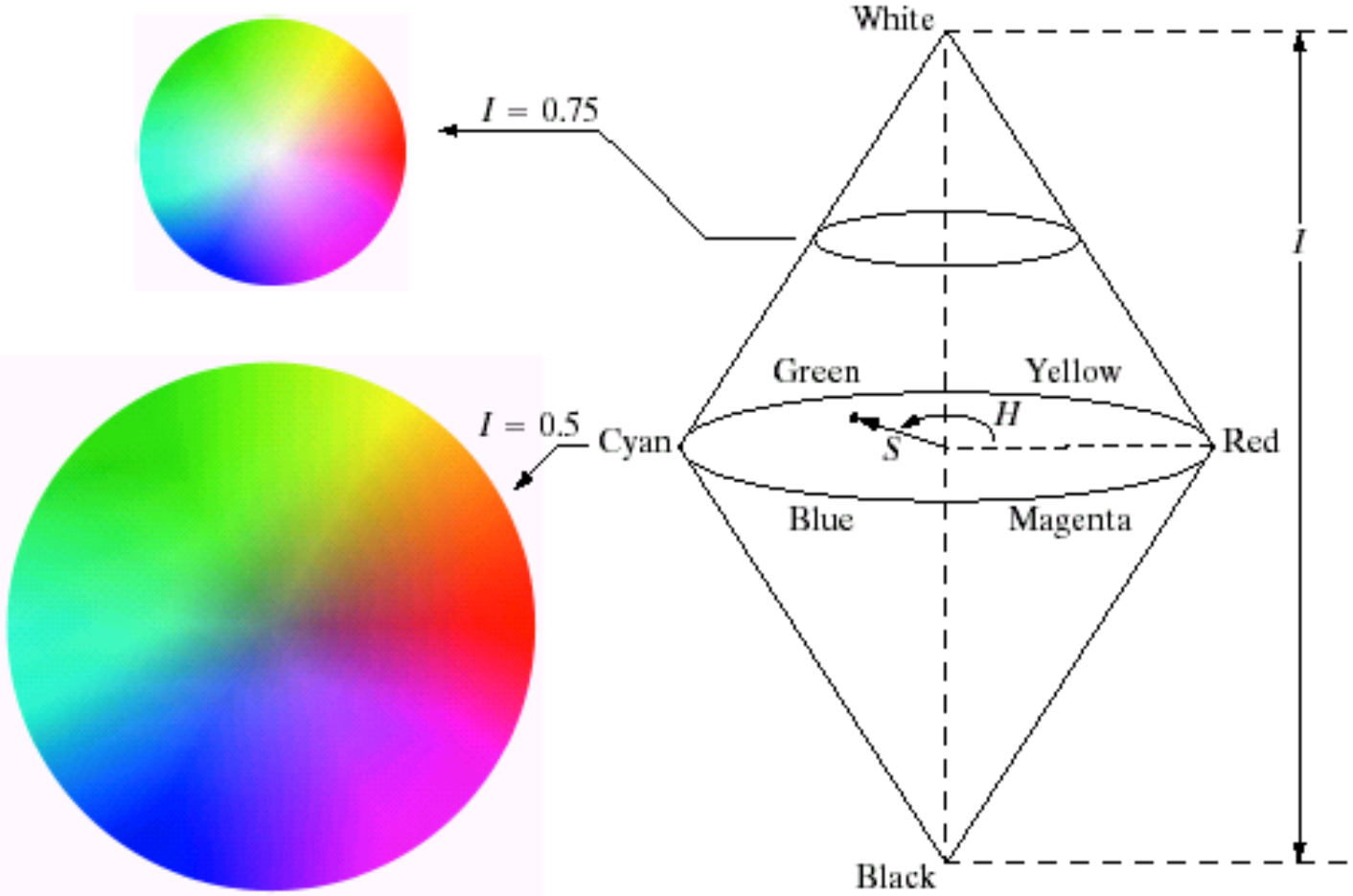
Because the only important things are the angle and the length of the saturation vector this plane is also often represented as a circle or a triangle



# HSI Color Model



# HSI Color Model



# Converting from RGB to HSI

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

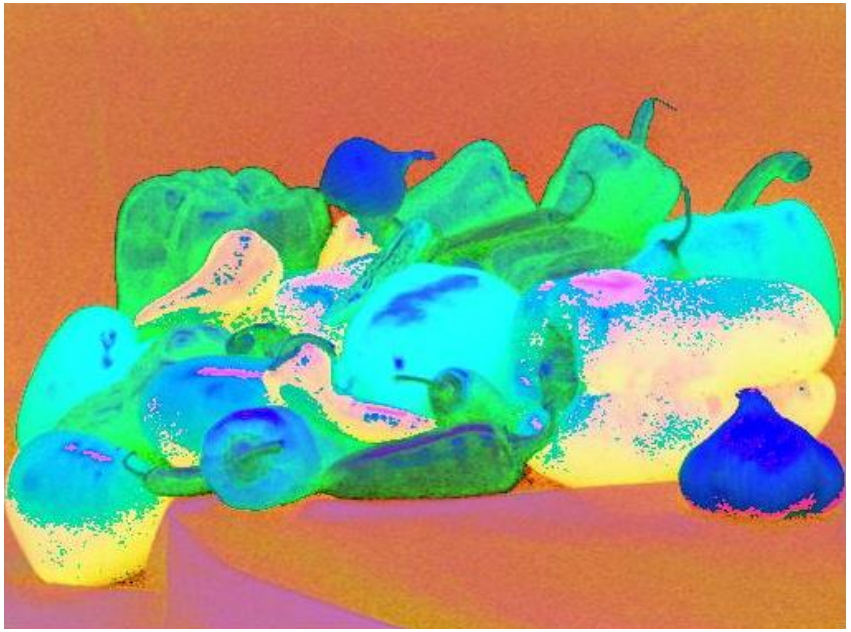
$$H = \begin{cases} \theta & if\ B \le G \\ 360-\theta & if\ B > G \end{cases}$$

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

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

# HSI Color Model

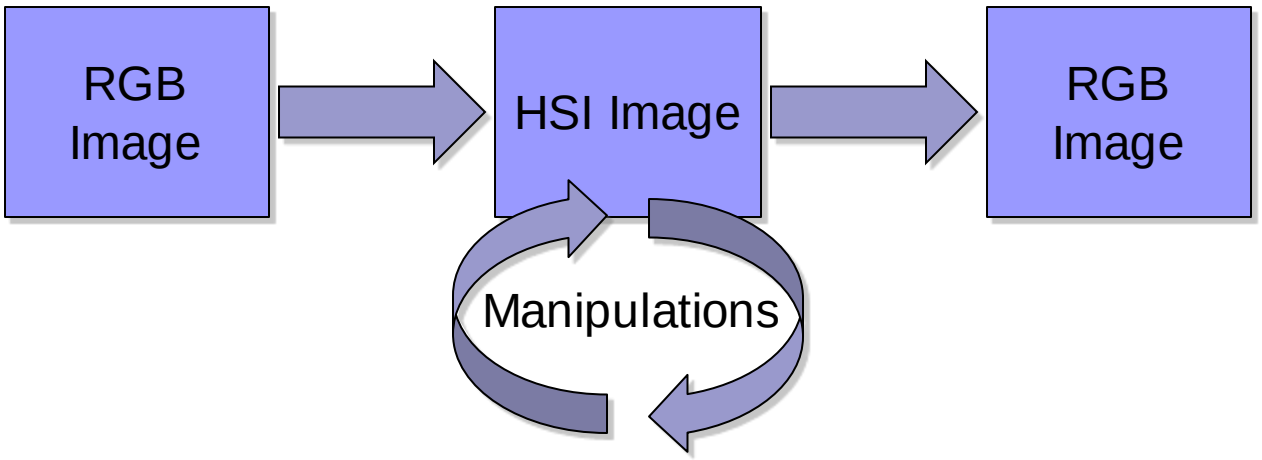
RGB



HSI

# Manipulating Images In The HSI Model

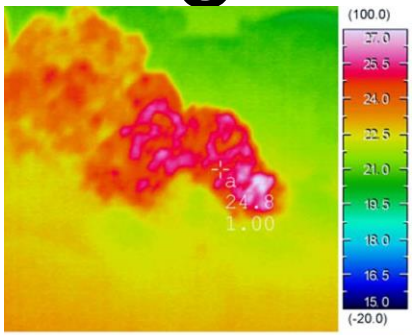
- In order to manipulate an image under the HSI model we:
  - First convert it from RGB to HSI
  - Perform our manipulations under HSI
  - Finally convert the image back from HSI to RGB

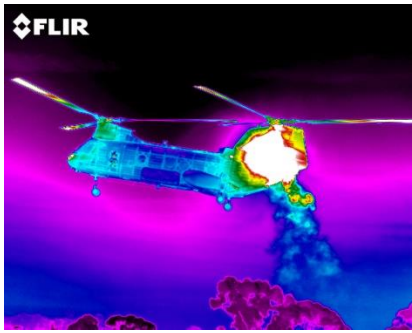


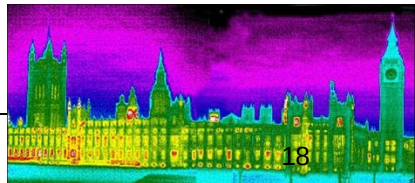
# Pseudocolor Image Processing

- Pseudocolor (also called false color) image processing consists of assigning colors to grey values based on a specific criterion

- The principle use of pseudocolor image processing is for human visualization



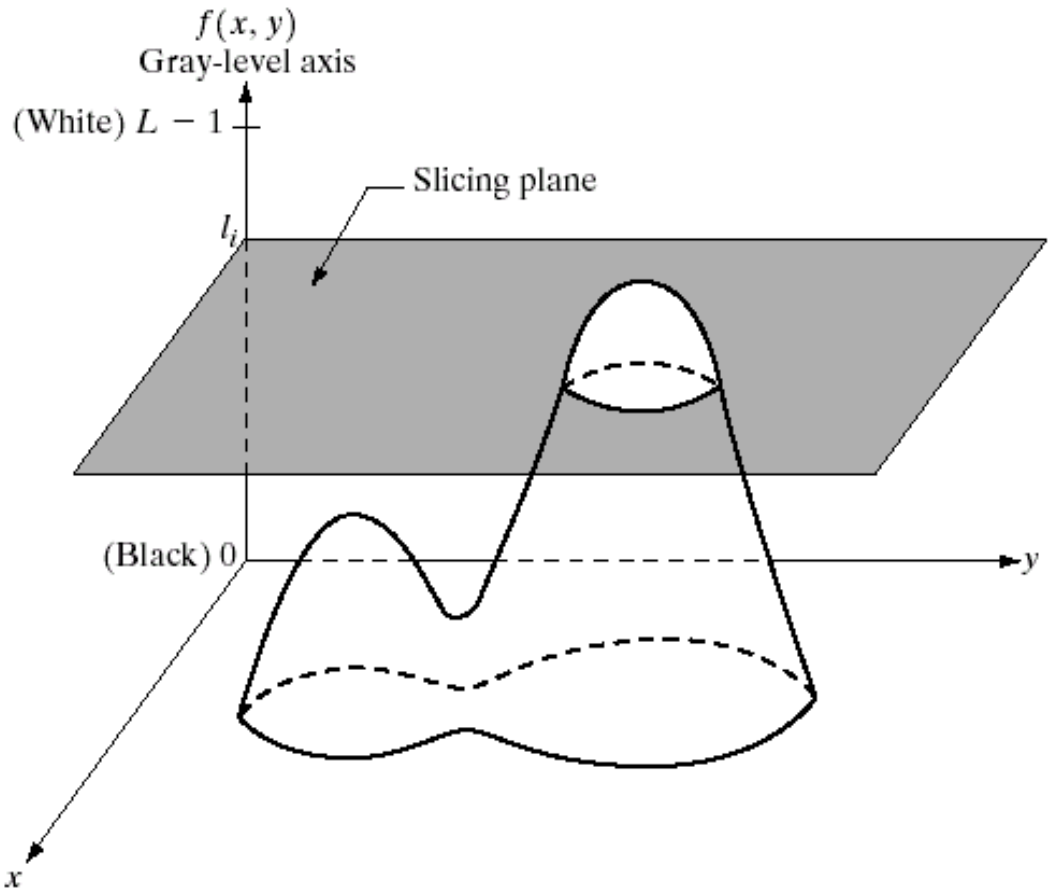



# Pseudo Color Image Processing – Intensity Slicing

- 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

# Pseudo Color Image Processing – Intensity Slicing



# Pseudo Color Image Processing – Intensity Slicing

- In general intensity slicing can be summarized as:
  - Let [*0, L-1*] represent the grey scale
  - Let $l_0$ represent black [$f(x, y) = 0$] and let $l_{L-1}$ represent white [$f(x, y) = L-1$]
  - Suppose $P$ planes perpendicular to the intensity axis are defined at levels $l_1, l_2, \ldots, l_p$
  - Assuming that $0 < P < L-1$ then the $P$ planes partition the grey scale into $P + 1$ intervals $V_1, V_2, \ldots, V_{P+1}$

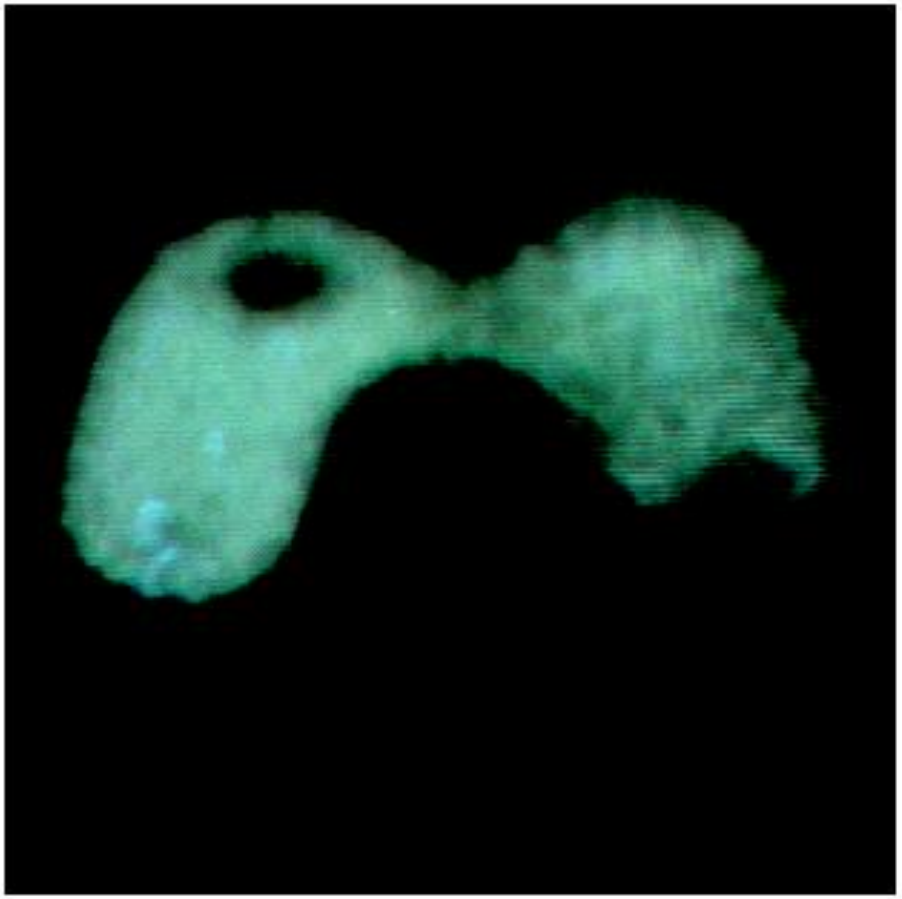
# Pseudo Color Image Processing – Intensity Slicing

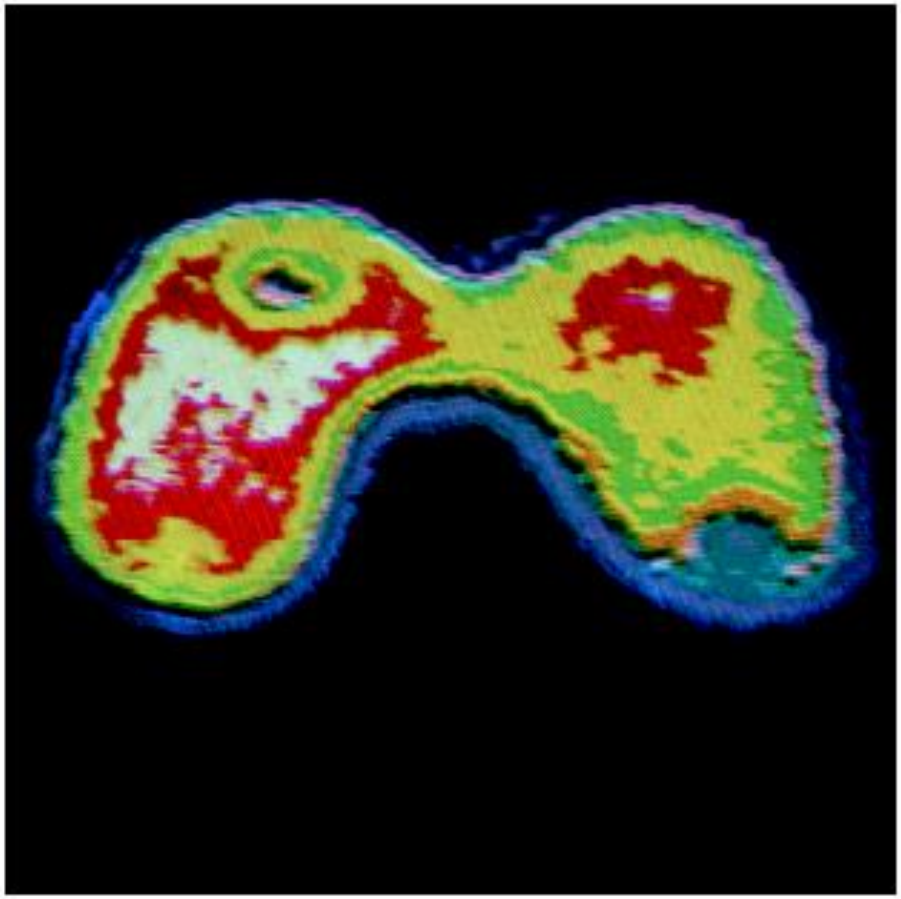
- Grey level color assignments can then be made according to the relation:

$$f(x,y) = c_k \qquad \text{if } f(x,y) \in V_k$$

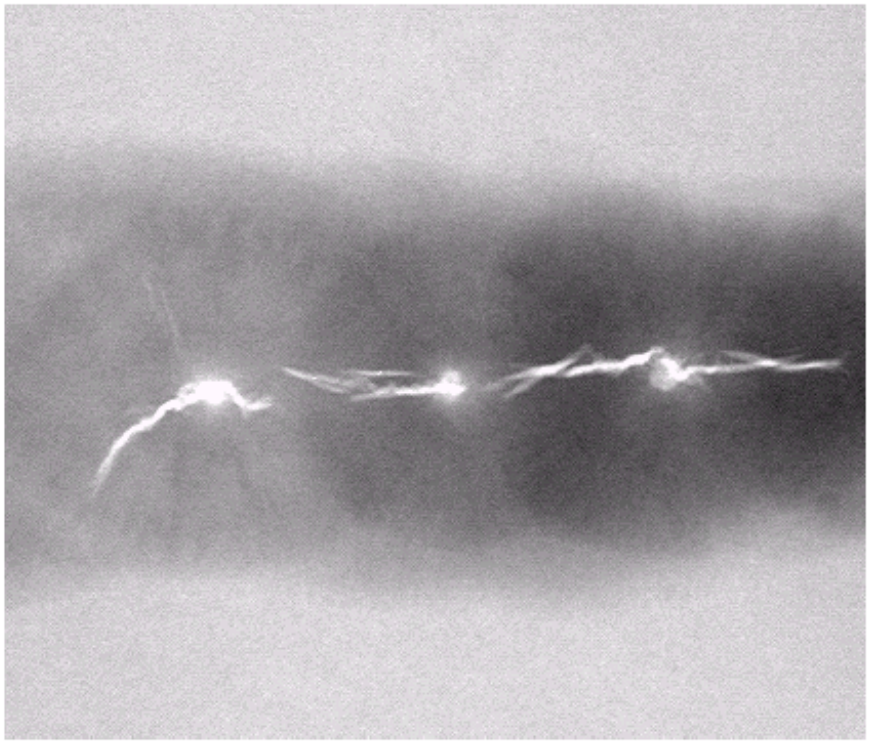
- where $c_k$ is the color associated with the $k^{th}$ intensity level $V_k$ defined by the partitioning planes at $l = k - 1$ and $l = k$

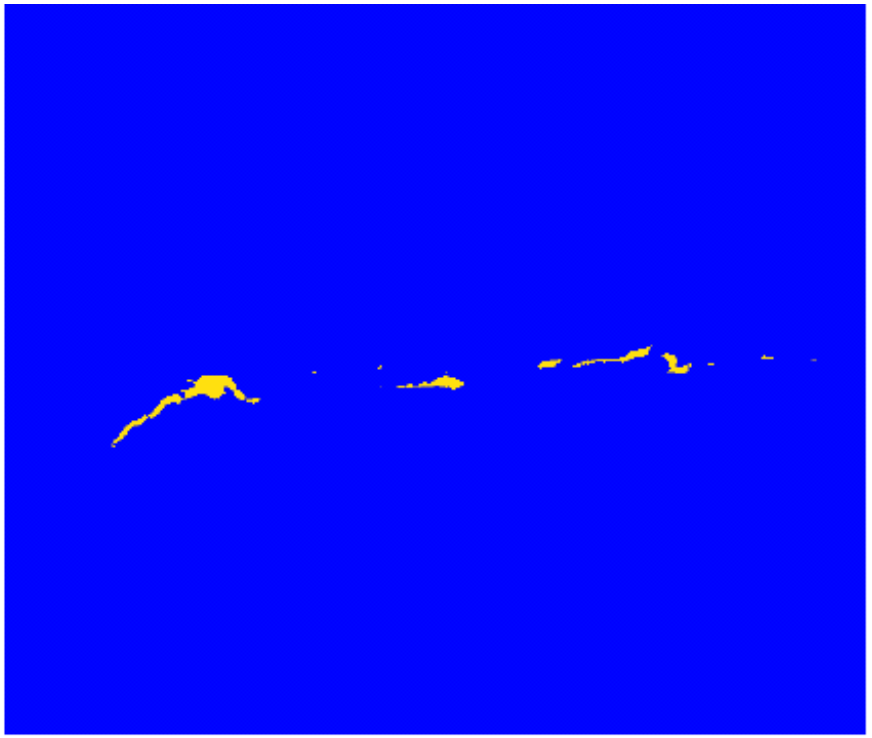
# Pseudo Color Image Processing – Intensity Slicing



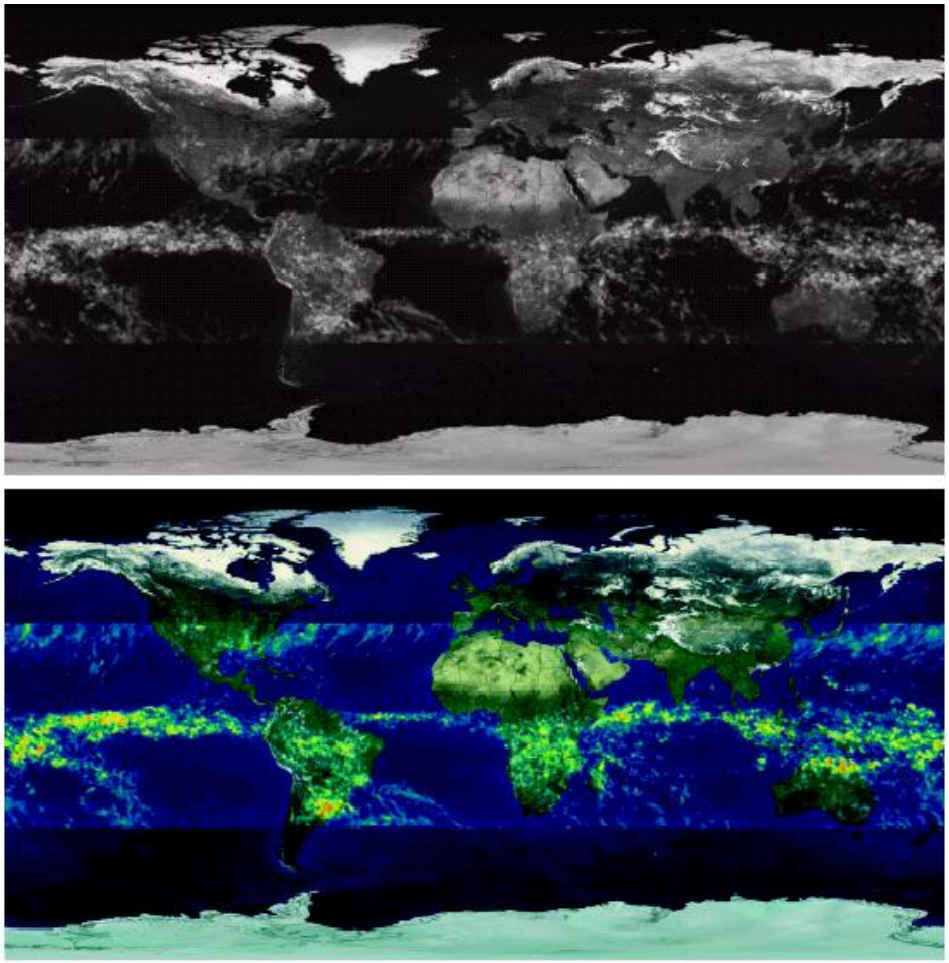


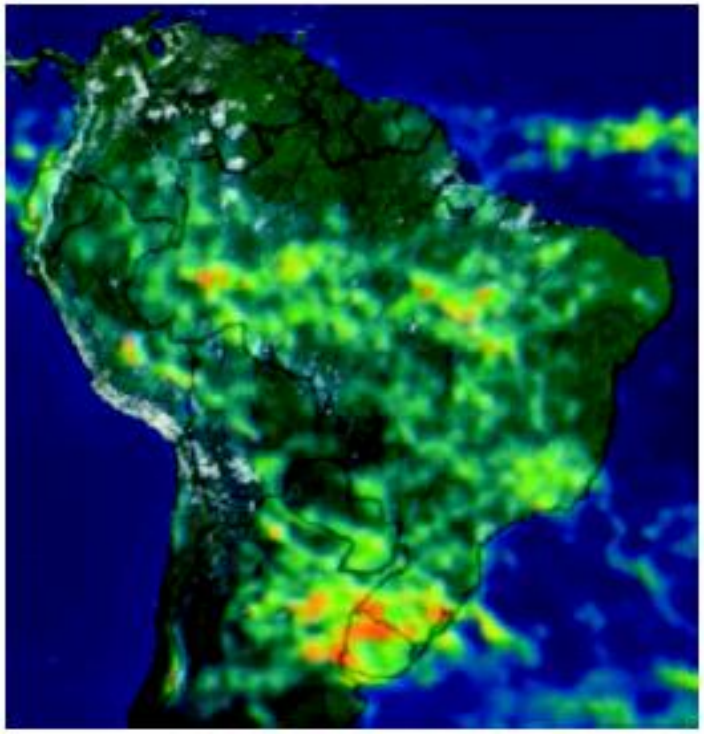
# Pseudo Color Image Processing – Intensity Slicing





# Pseudo Color Image Processing – Intensity Slicing





# References

- Chapter #6: Digital Image Processing by Rafael C. Gonzales & Richard E. Woods