Color, Edge

2. Basic Image Features

low-level
mid-level
high-level

Eun Yi Kim

Artificial Inteligence
& Computer Vision
Laboratory

Color → 픽셀 단위로 정의

- Used heavily in human vision
- Color is a pixel property, making som e recognition problems easy
- Visible spectrum for humans is 400 n m (blue) to 700 nm (red)
- Machines can “see” much more;
  ex. X-rays, infrared, radio waves

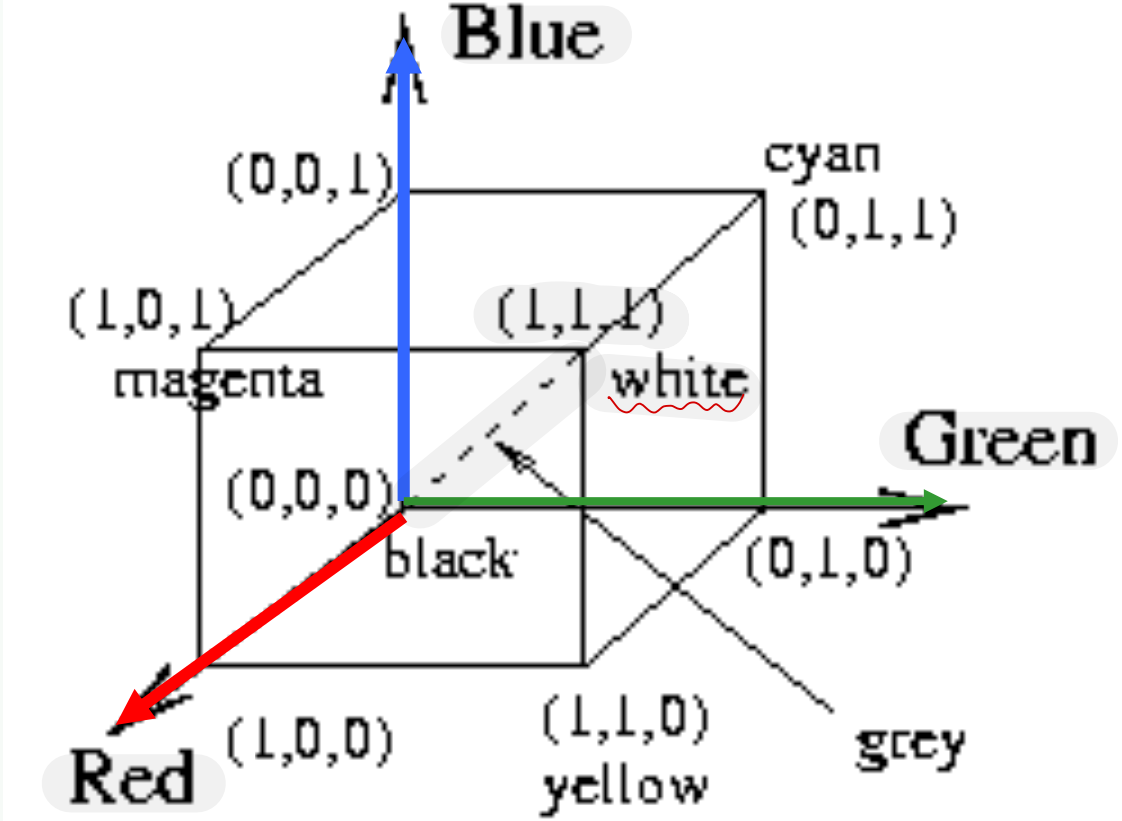
Artificial Inteligence & Computer Vision Laboratory

Coding methods for humans

- RGB is an additive system (add colors to black) used for displays.
- CMY is a subtractive system for printing.
- HSI is a good perceptual space for art, psychology, and recognition.
- YIQ used for TV is good for compression.

RGB color cube

= 어떤한 color space



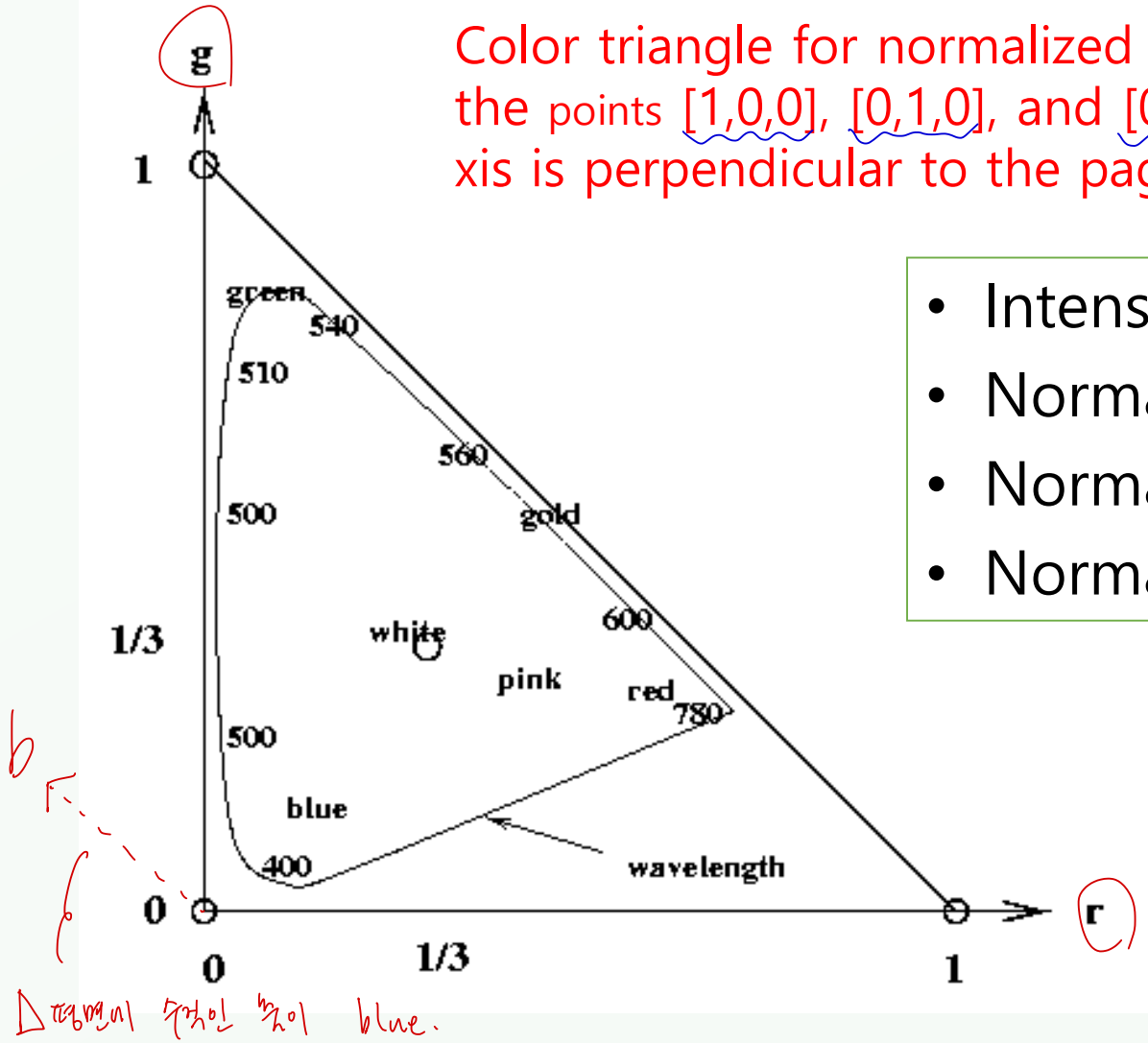
- R, G, B values normalized to (0, 1) int erval
- human perceives gray for triples on t he diagonal
- "Pure colors" on corners

RGB ⟷ CMY

"향상" "감산"

(1,1,1) − R(1,0,0) = C(0,1,1)

Color palette and normalized RGB



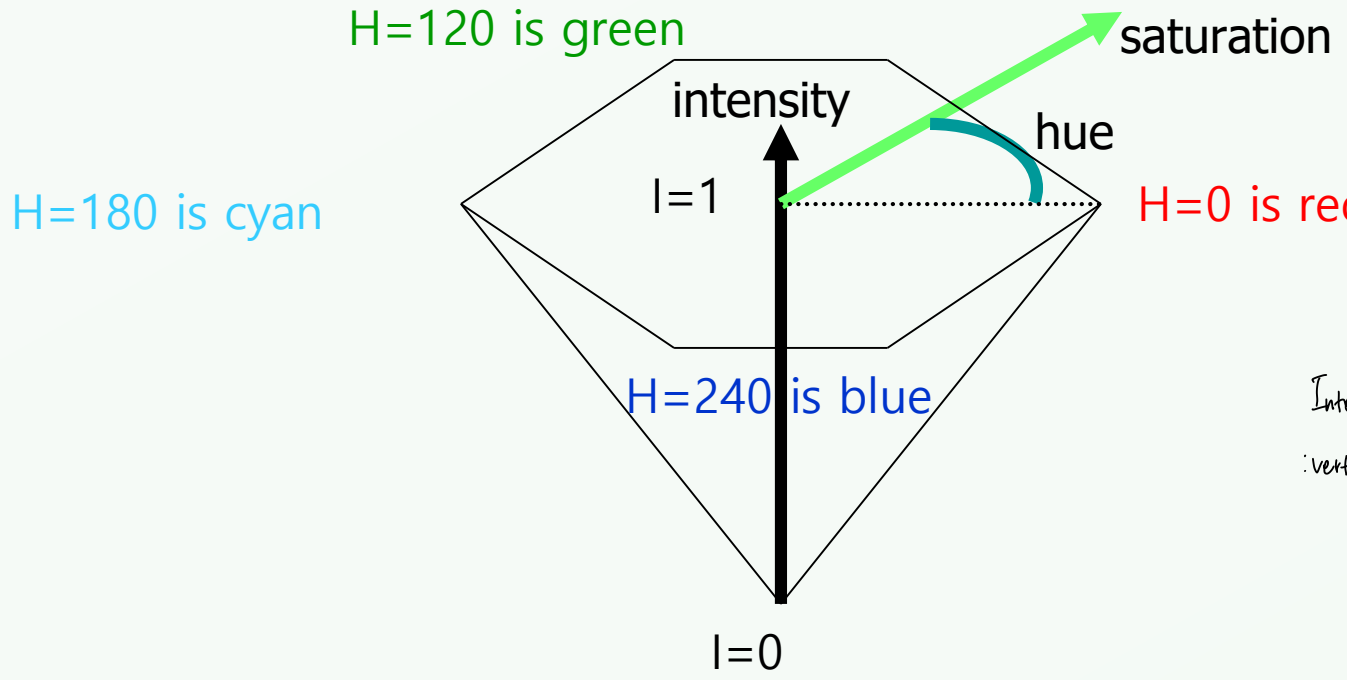
Color triangle for normalized RGB coordinates is a slice through the points [1,0,0], [0,1,0], and [0,0,1] of the RGB cube. The blue axis is perpendicular to the page.

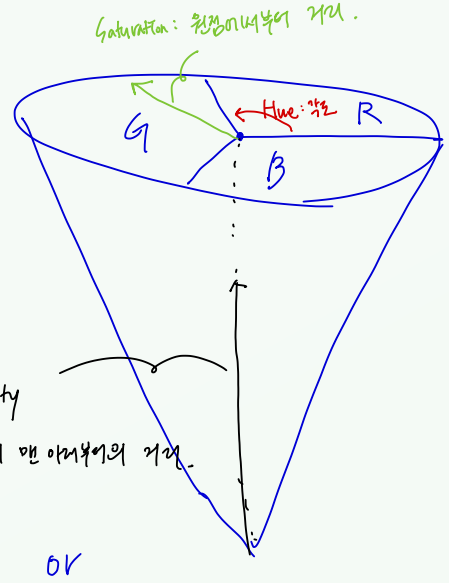
- Intensity $I = (R+G+B) / 3$
- Normalized red $r = R/(R+G+B)$
- Normalized green $g = G/(R+G+B)$
- Normalized blue $b = B/(R+G+B)$

In this normalized representation, $b = 1 - r - g$, so we only need to look at r and g to characterize the color.

Color hexagon for HSI (HSV)

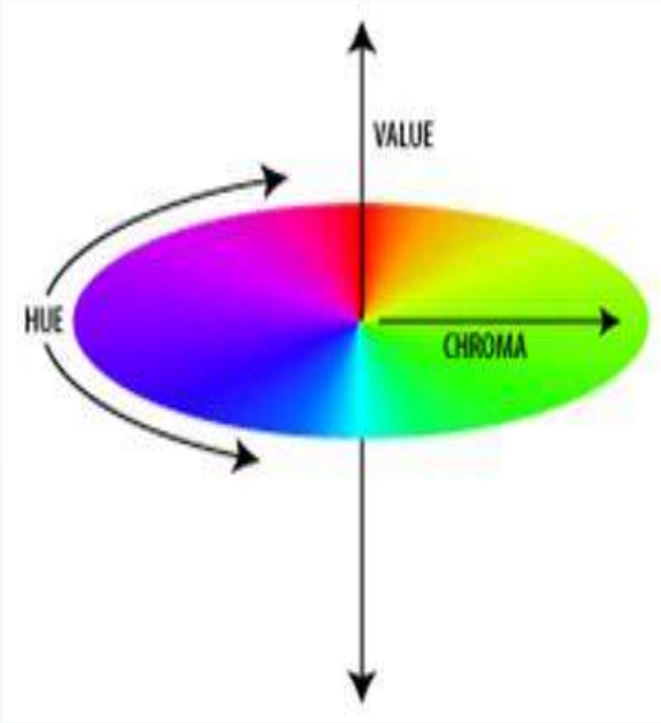
- Hue is encoded as an angle (0 to 2π).
- Saturation is the distance to the vertical axis (0 to 1).
- Intensity is the height along the vertical axis (0 to 1).





RGB to HSI Transform

- RGB → HSI



$$r = \frac{R}{R+G+B}, g = \frac{G}{R+G+B}, b = \frac{B}{R+G+B}$$

$$s = 1 - 3 \cdot \min(r, g, b); \quad s \in [0,1]$$

$$i = (R+G+B)/(3 \cdot 255); \quad i \in [0,1]$$

$$h = \cos^{-1}\left\{\frac{0.5 \cdot [(r-g)+(r-b)]}{[(r-g)^2+(r-b)(g-b)]^{1/2}}\right\} \quad h \in [0,\pi] \text{ for } b \le g$$

$$h = 2\pi - \cos^{-1}\left\{\frac{0.5 \cdot [(r-g)+(r-b)]}{[(r-g)^2+(r-b)(g-b)]^{1/2}}\right\} \quad h \in [\pi,2\pi] \text{ for } b > g$$

HSI to RGB Transform

Hue 범위에 따라 정의함.

- HSI → RGB
  - **RG area (0 ≤ H ≤ 120)**

$$b = \frac{1}{3}(1 - S)$$

$$r = \frac{1}{3}\left[1 + \frac{S\cos(H)}{\cos(60 - H)}\right]$$

$$g = 1 - (r + b)$$

  - **GB area (120 ≤ H ≤ 240)**

$$H = H - 120$$

$$g = \frac{1}{3}\left[1 + \frac{S\cos(H)}{\cos(60 - H)}\right]$$

$$r = \frac{1}{3}(1 - S)$$

$$b = 1 - (r + g)$$

- **Notes**
  - Saturation is not defined when intensity I = 0. → I=0이면 원판이 정의되지 X.
  - Hue is not defined when S = 0. → S=0이면 색깔이 정의 X.

예외에 항상 생각해봐야.

YIQ and YUV for TV signals

- Have better compression properties
- Luminance Y encoded using more bits than chrominance values I and Q; humans more sensitive to Y than I,Q
- Luminance used by black/white TVs
- All 3 values used by color TVs
- YUV encoding used in some digital video and JPEG and MPEG compression

Conversion from RGB to YIQ

RGB → YIQ

An approximate linear transformation from RGB to YIQ:

$$
\begin{aligned}
luminance \quad Y &= 0.30R + 0.59G + 0.11B \\
R - cyan \quad I &= 0.60R - 0.28G - 0.32B \\
magenta - green \quad Q &= 0.21R - 0.52G + 0.31B
\end{aligned}
$$

흑백이미지

We often use this for color to gray-tone conversion.

$$
\begin{pmatrix} 0.30 & 0.59 & 0.11 \\ 0.60 & 0.28 & 0.32 \\ 0.21 & 0.52 & 0.31 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix}
$$

이거 A라고하면,

역변이 A^{-1} 를 곱해서 계산함.

Histogram

→ Color의 개수 자체에 대한 개념.

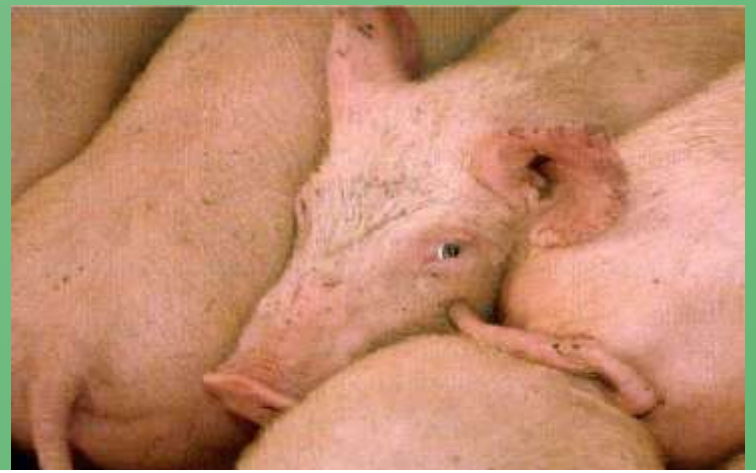
→ Color 가 어떻게이 몇번 나왔는지 보여주는 그래프.

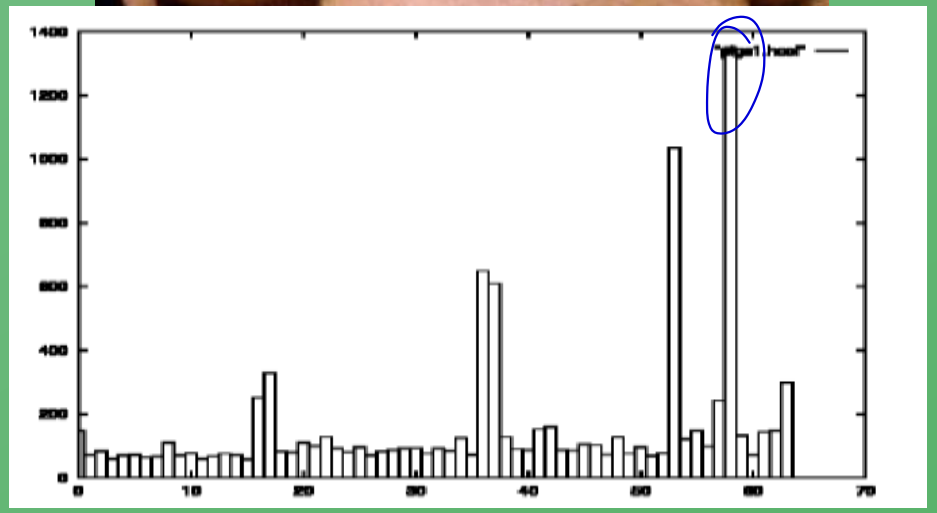
- Color histogram can represent an image
- Histogram is fast and easy to compute.
- Size can easily be normalized so that different image histo grams can be compared.
- Can match color histograms for database query or classifi cation.

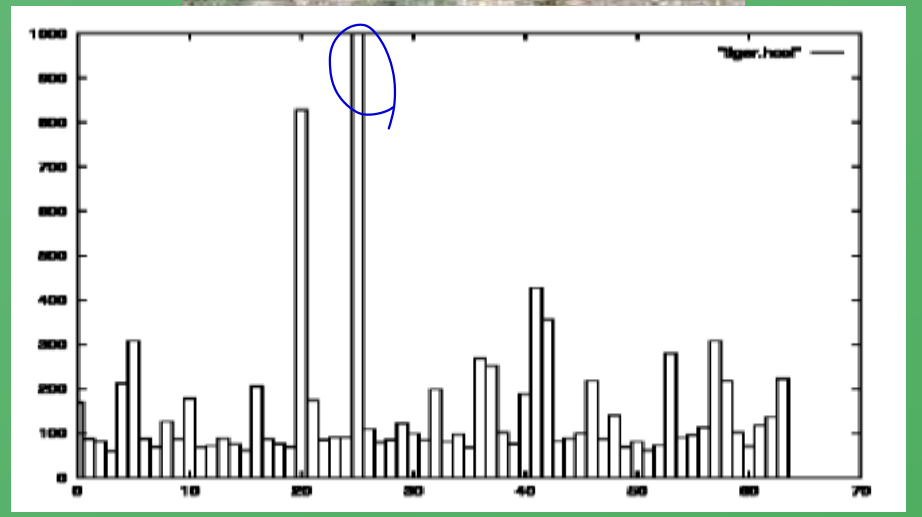
Histograms of two color images

↳ 색깔은 명암이 많지 않아서,

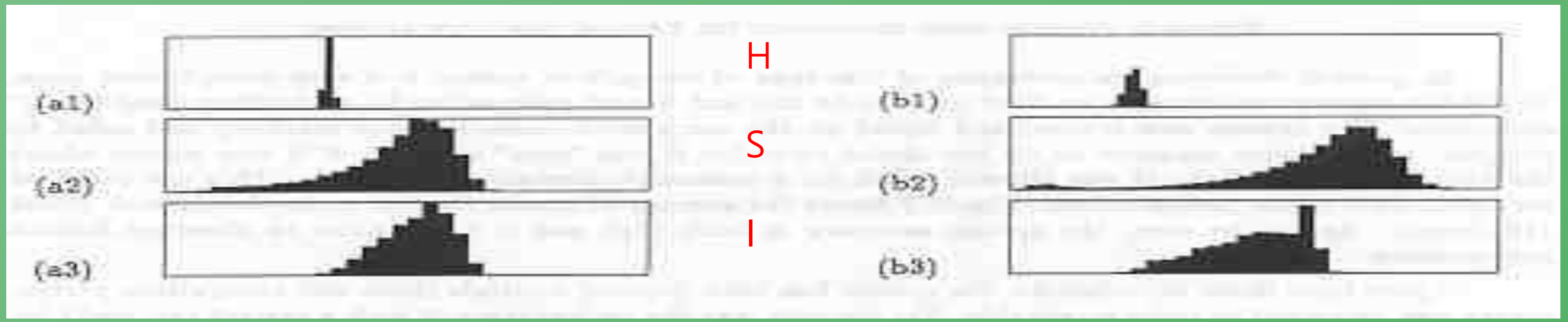
Histogram 만으로 차별 가능.







Apples versus Oranges



Separate HSI histograms for apples (left) and oranges (right) used by IBM's VeggieVision for r ecognizing produce at the grocery store checkout station.

Editing saturation of colors

origin

Saturation −20%

+40%

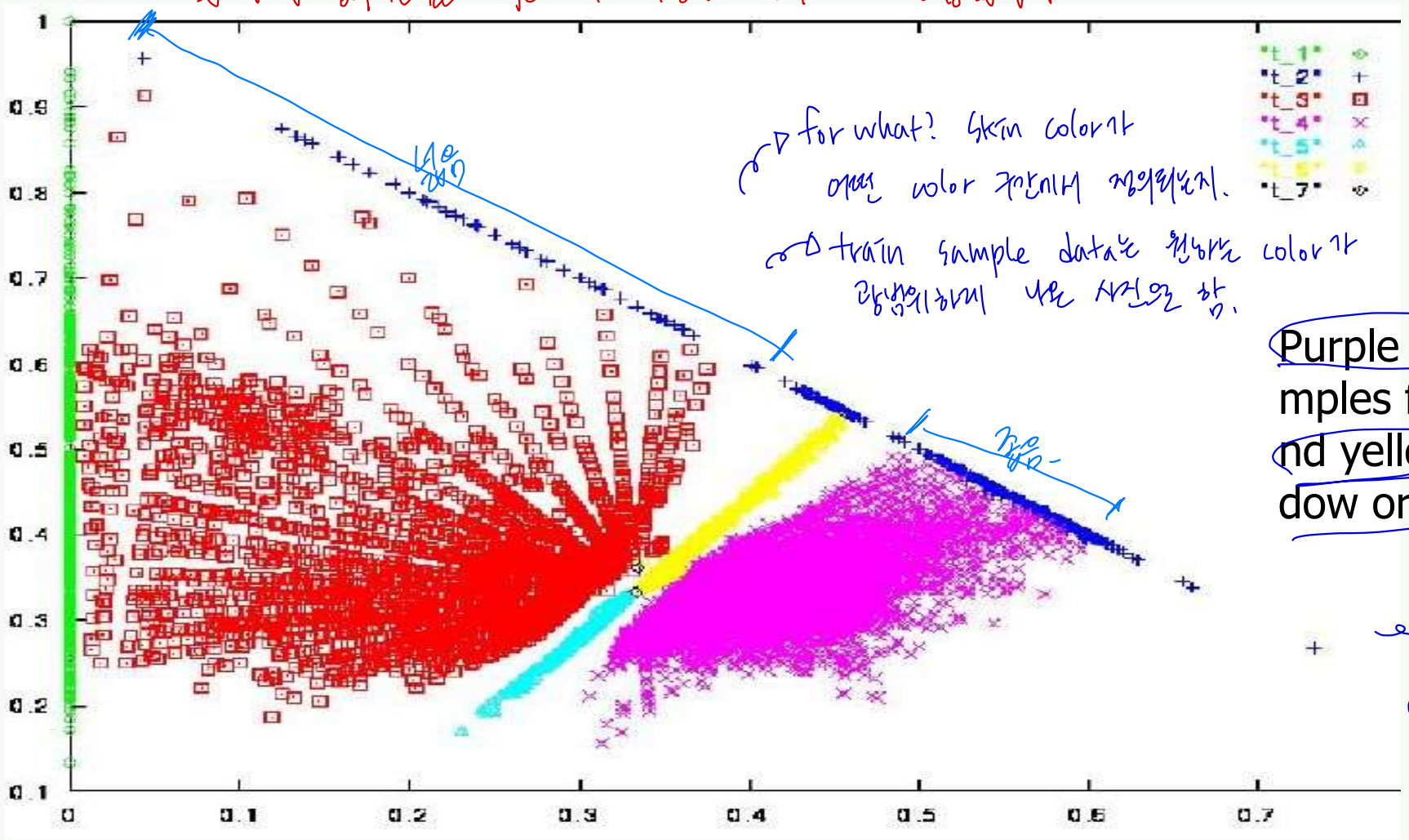
- (Left) Image of food originating from a digital camera;
- (center) saturation value of each pixel decreased 20%;
- (right) saturation value of each pixel increased 40%.

Skin color in RGB space
(shown as normalized red vs normalized green)

→ skin color를 normalized RGB color space에서 정의

Artificial Inteligence & Computer Vision Laboratory

☆☆☆ 정의하려는 object의 특성을 정의하는 방법 ☆☆☆



for what? skin color가 어떤 color 공간에서 정의되는지.

train sample data로 얻어진 color가 통계적하게 나온 결과임.

red region : non-skin color.

Purple region shows skin color samples from several people. Blue and yellow regions show skin in shadow or behind a beard.

어떻게 컴퓨터가 say to computer 방법.

① If : ≤ Nomalized Red ≤ & ≤ N.G ≤ 일때
skin의 color,
else
skin의 color가 아님.

②

Finding a face in video frame