# Color Questions

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1 Color mixing

a) Suppose additive color mixing. What is the result of mixing equal amount of red, green and blue?

b) Suppose subtractive color mixing. What is the result of mixing equal amount of red, green and blue?

c) Color printing is a mixture of additive and subtractive color mixing. Often, the CMYK color model is utilized. Which color corresponds to K?

d) Mention a media when additive color mixing occur and another media when subtractive color mixing occur. (2p)

e) Below is an illustration of additive and subtractive color mixing. Fill in the boxes with the following colors: yellow, green, red, blue, cyan, black, white and magenta. (3p)
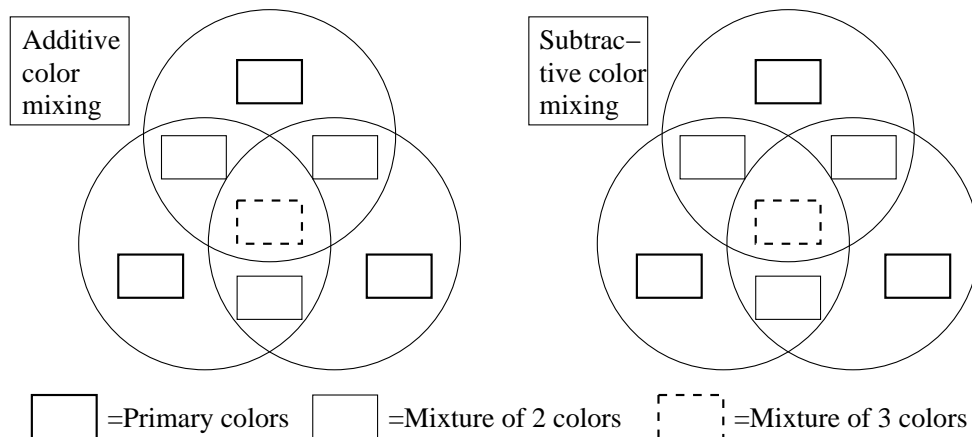

2 Eye color responce

a) See the figure below that shows the absorption of light by the cones in the human eye. Suppose that a person is exposed to light of wavelength 555nm. Which color hue does the person experience?

b) Suppose that a person is exposed to equal amount of light of wavelength 515nm and 595nm. Which color hue does the person experience? Is this color more or less saturated than the color in the previous question? Motivate your answer.

c) Suggest a combination of 2 wavelengths that give the experience of magenta.
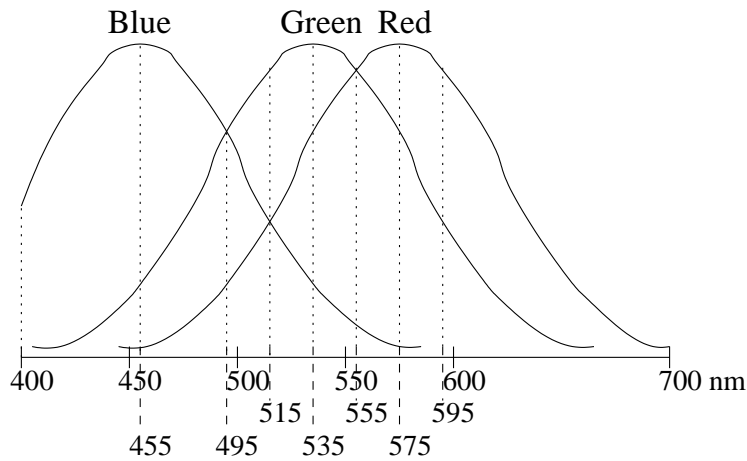
3   Colortables

a) An image is stored with pixel values between -128 and 127. (It could for example be the resulting image after applying a sobel filter.) First, the pixel undergo a linear transformation so that the range [-128,...,127] is converted to the range [0,...,255].

Construct the color table below, so that the image is shown in saturated blue for -128, white for 0 and saturated red for 127. The color will go from saturated blue linearly down by decreasing saturation too white and then go from white to red with linearly increasing saturation.
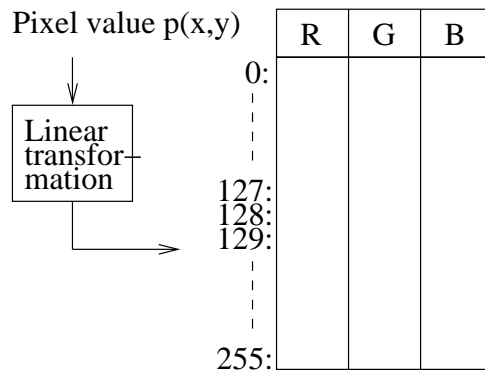
b) A rainbow colortable is shown below. It can be used for an image with pixel values between 0 and 7. Let 0 be the lowest value, corresponding to zero intensity and 10 be the highest value that corresponds to full intensity. Your task is to make three colortables.

- Make a fully saturated rainbow colortable. (2p)
- Make a colortable with the same **hues** but only half **intensity**. (1p)
- Make a colortable with the same **hues** but only half **saturation**. (2p)

		R	G	B
black	0:	0	0	0
red	1:			
orange	2:			
yellow	3:			
yellowgreen	4:			
green	5:			
cyan	6:			
blue	7:			

4 Chromaticity diagram

The chromaticity diagram is shown below. Around the thick border are the spectral colors located, red at 700nm, then yellow, green at 520nm and blue at 400nm. Suppose that we have an LCD screen with the three primary colors R, G and B as marked in the diagram.

a) Which approximate mixture of R, G and B will give us CYAN (also marked in the figure)?

b) Which approximate mixture of R, G and B will give us GOLD (also marked in the figure)?

c) Where is magenta? How can we experience magenta?
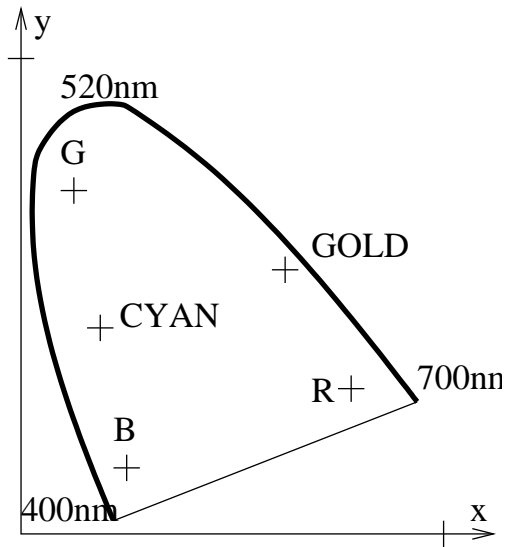
5 Color models transformation

The RGB color model is a simplified model consisting of a cube with corners at black: (0,0,0), white: (1,1,1), red: (1,0,0), green: (0,1,0), blue: (0,0,1), in a 3D coordinate system. Using this model, colors can be converted into other color models, like the CMYK color model or the HSI color model. Below are some equations for this.

Combine C,M,Y,K,H,S,I with the correct equation A,B2,C2,D,E,F,G2:

$$A = 1 - G$$

$$B2 = \frac{1}{3}(R + G + B)$$

$$C2 = 1 - B$$

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

$$E = \begin{cases} \theta, & B \le G, \\ 360 - \theta, & B > G, \end{cases} \quad \text{where}$$

$$\theta = \cos^{-1}\left\{ \frac{0.5[(R - G) + (R - B)]}{[(R - G)^2 + (R - B)(G - B)]^{0.5}} \right\}$$

$$F = 1 - R$$

$$G2 = (0, 0, 0)$$

6 Color transformations

The following intensity transformation of an image $f(x, y)$ to an image $g(x, y)$ corrects for a too dark image $f(x, y)$.
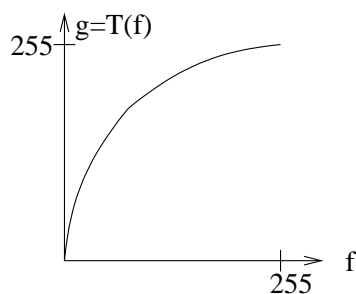
a) Sketch a curve that increase the contrast in the interval 192-255!

b) Sketch 3 curves (for R, G and B) that corrects for too much yellow.

c) Sketch 3 curves (for R, G and B) that corrects for too little cyan.

7 Color segmentation

See the figure below, left. It contains magenta pills in a mixed colored background. One pill (marked with a dashed line) has been investigated and the RGB mean m and standard deviation $\sigma = 0.1$ was calculated. What was the mean $m = (R, G, B)$? Choose among 0.1 and 0.9 for the values of R,G and B!
See further the figure below, right. It indicates how segmentation can be performed in the RGB vector space. Describe how you can use it for segmentation of your pill image. Suggest suitable values for c, the center of the sphere, and r, the radius of the sphere! (3p)