

Color in digital pictures

As was mentioned in class the pixel grey level reflects brightness. When dealing with colors there are many more terms that may be associated with a single pixel. Several of them are listed here:

brightness - the human sensation by which an area exhibits more or less light.

Hue - the human sensation according to which an area appears to be similar to one, or to proportions of two, of the perceived colors red, yellow, green and blue.

Colorfulness - the human sensation according to which an area appears to exhibit more or less of its hue.

lightness - the sensation of an area's brightness relative to a reference white in the scene.

chroma - the colorfulness of an area relative to the brightness of a reference white.

saturation - the colorfulness of an area relative to its brightness.

RGB

The most common representation of color in digital images is in terms of three colors: Red, Green and Blue. This is referred to as "The RGB Model". Most hardware systems require color to be represented in this way. In RGB, each pixel is represented by three numbers. For example, Red=200, Green=0, Blue=0, is a red pixel, and Red=0, Green=200, Blue=200, is a yellow pixel.

The human visual system cannot distinguish between more than approximately 64 levels of R,G, or B. Since these 64 levels are not equally spaced, they may require as many as 256 levels for accurate representation. Therefore, representing each one of the three colors in one byte enables a "true" color representation. The technical term for this representation which requires 24 bits for each pixel is "TRUE COLOR".

RGB is not the only possible way of representing color. In principle, any representation that enables one to one mapping to the RGB representation can be used. Mathematically, the simplest ones are linear maps. Let A be any 3×3 non singular matrix then we can define a representation in terms of X, Y, Z given by:

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix}$$

YIQ

The YIQ model is used in commercial color TV broadcasting. The idea is to use a linear transformation that separates the luminance component from the "color" information for the pixel. The equations are given by:

$$\begin{pmatrix} Y \\ I \\ Q \end{pmatrix} = \begin{pmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & 0.275 & -0.321 \\ 0.212 & -0.523 & 0.311 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix}$$

Digital YUV

The YUV model is similar to the YIQ. The important difference is the range of the values. The numbers are scaled in such a way that if the RGB values are all between 0 and 255 then the Y value is also in the 0-255 range, and the U,V values are in the -127 to +127 range.

$$\begin{pmatrix} Y \\ U \\ V \end{pmatrix} = \begin{pmatrix} 0.299 & 0.587 & 0.114 \\ -0.169 & -0.3316 & 0.5 \\ 0.5 & -0.4186 & -0.0813 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix}$$

The inverse matrix:

$$\begin{pmatrix} R \\ G \\ B \end{pmatrix} = \begin{pmatrix} 1 & 0 & 1.4 \\ 1 & -0.34 & -0.714 \\ 1 & 1.7 & 0 \end{pmatrix} \begin{pmatrix} Y \\ U \\ V \end{pmatrix}$$