

CS 331

Computer Vision

09 / 14 / 2026

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Today's Topics

- Questions? / Comments?
- Visible light
- Definitions of various kinds of images
- HSV Color model
- One use of HSV to select pixels of a range of Hues

Electromagnetic radiation

- Physically, color is electromagnetic radiation in the visible light frequency range.

Electromagnetic radiation

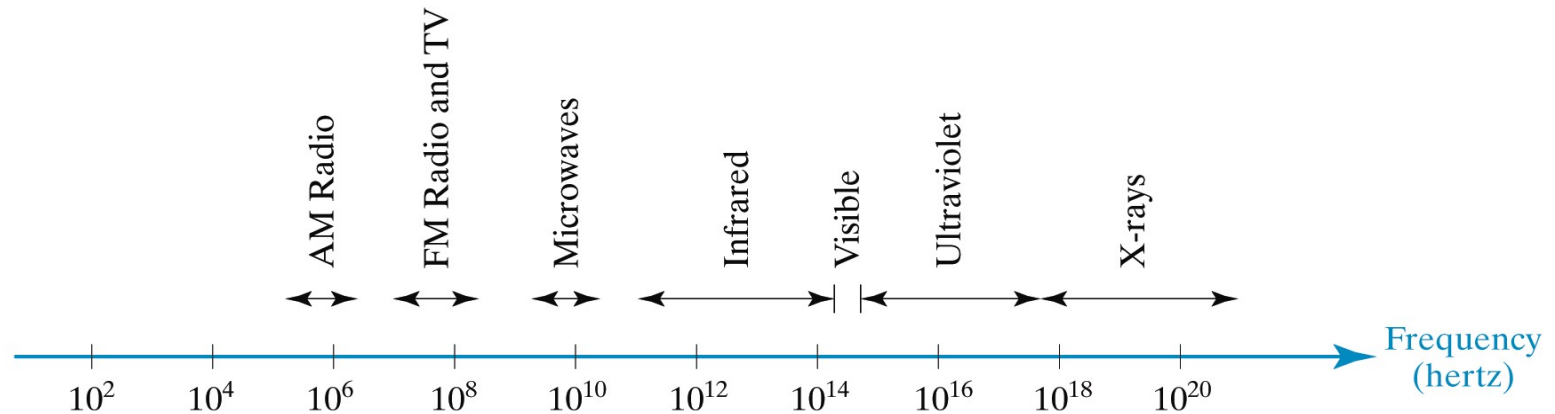


Figure 12-1

Electromagnetic spectrum.

- Frequency range of visible light is approx. from:
 - 4.3×10^{14} Hz up to 7.9×10^{14} Hz

Computer Graphics with Open GL, Third Edition, by Donald Hearn and M. Pauline Baker.
ISBN 0-13-0-15390-7 © 2004 Pearson Education, Inc., Upper Saddle River, NJ. All rights reserved.

Electromagnetic radiation

- Frequency and wavelength are inversely proportional to each other. $c = \text{wavelength} * \text{frequency}$
- Human eye senses radiation wavelengths between approx. 380-700 nanometers (that is the visible light)
- radiation with wavelengths less than visible light
 - Ultraviolet, X-rays
- radiation with wavelengths greater than visible light
 - Infrared, Microwaves, TV, Radio
- Sensors exist to detect these various non-visible wavelengths

Imaging devices

- x-ray images
 - can penetrate the human body/bones
- infrared (IR) images (higher temperatures emit higher infrared radiation)
- film camera
- digital camera
 - usually a CCD (charge-coupled device) with cells in a rectangular grid or CMOS (Complementary metal–oxide–semiconductor) sensors see section 2.3 for details
- For digital image processing and computer vision to be done on the images, we need a digital image.
- Also, if the device does not detect visible light, typically the different values captured by the devices are converted to visible colors for human interpretation.

Imaging devices

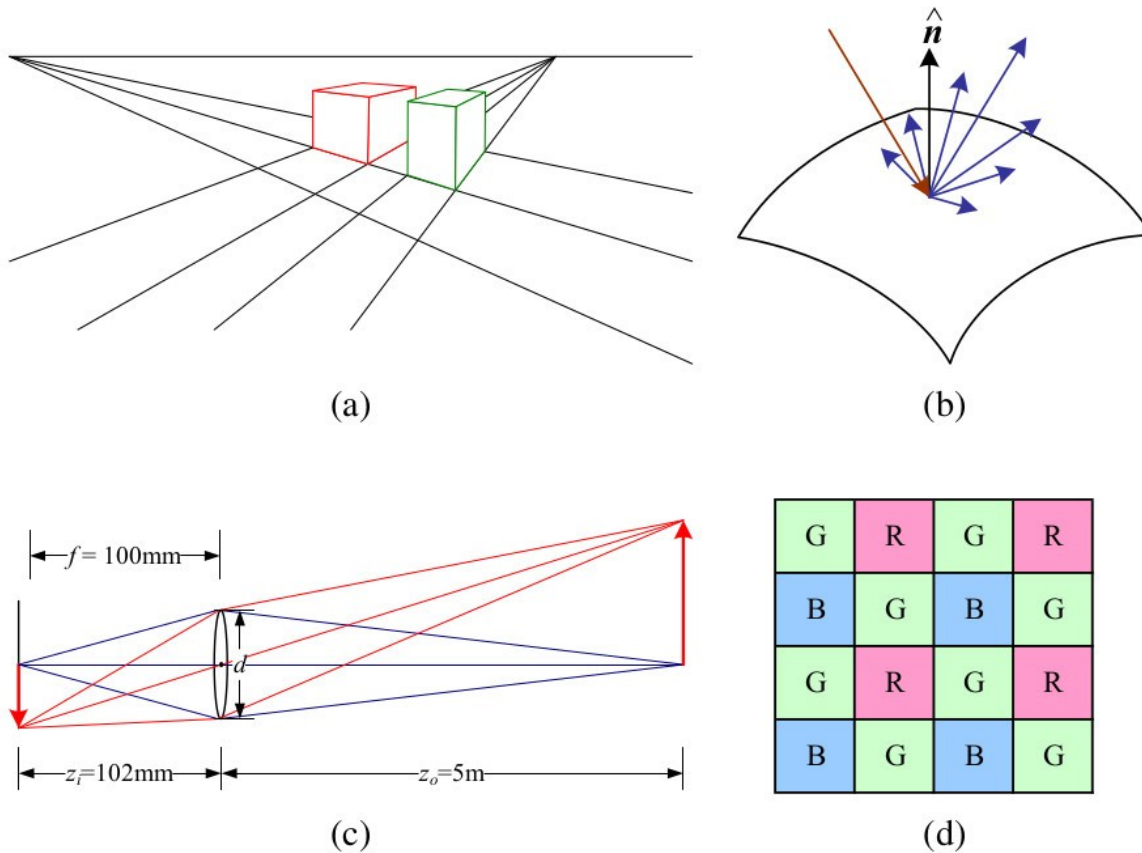
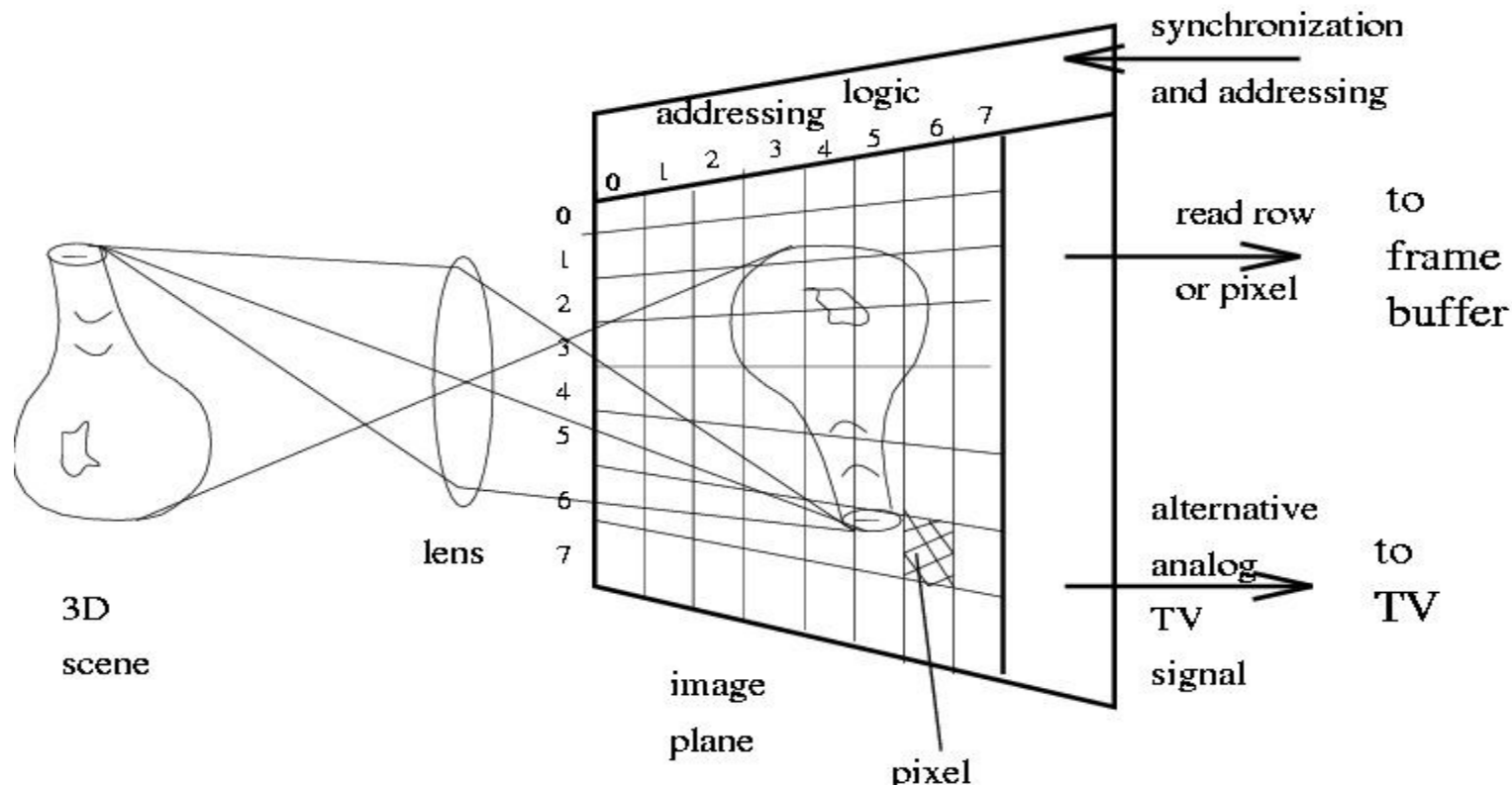


Figure 2.1 A few components of the image formation process: (a) perspective projection; (b) light scattering when hitting a surface; (c) lens optics; (d) Bayer color filter array.

CCD cameras



- image figure 2.2 in “Computer Vision” by Shapiro and Stockman
- discrete cells convert light energy into electrical charges and they integrate the light energy falling on them during the time the shutter is open

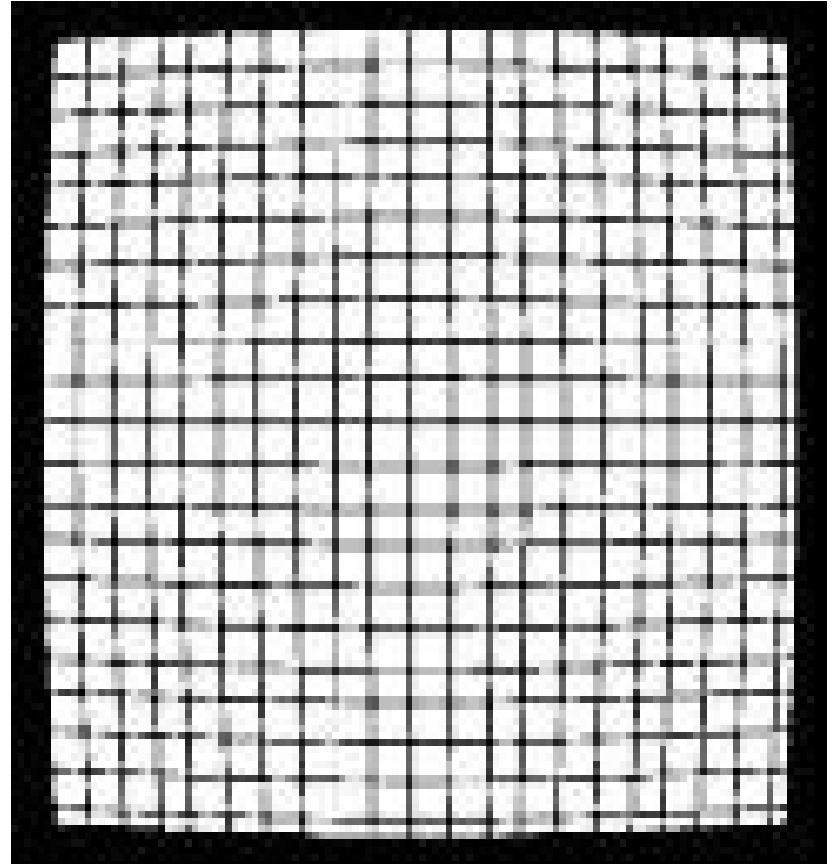
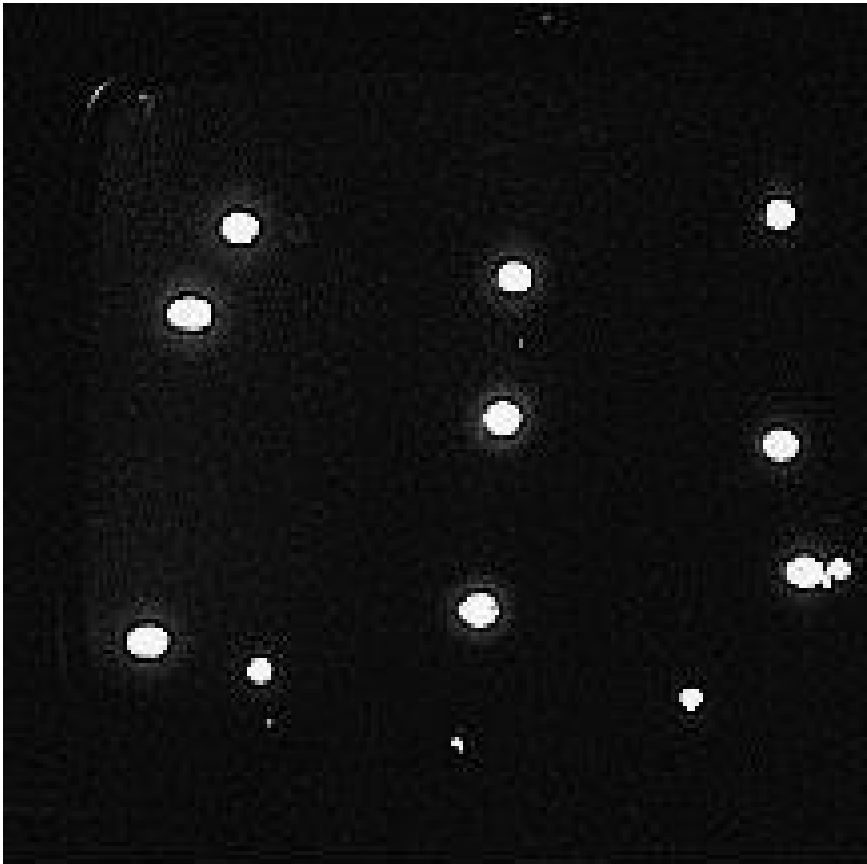
Problems in digital images

- geometric distortion
 - due to an imperfect lens the light beams don't travel on the correct path
 - e.g. barrel distortion for small focal lengths
- scattering
 - When the medium that the light travels through is not a vacuum, the light bends (e.g. air, water, other liquids ...) (see Snell's law)
 - Example: spoon in a glass of water
- blooming
 - each CCD cell is close to its neighbors so, light can leak between neighboring cells
- CCD variations
 - some cells might not be all equally sensitive due to variations in the manufacturing process

Problems in digital images

- clipping
 - when an analog value is converted to digital, high values may be “clipped” to the max digital value
- quantization effects
 - converting a continuous range to a discrete range loses precision
- chromatic distortion
 - lens has the index of refraction (bending) different for different wavelengths (colors)

Problems in digital images



- images from “Computer Vision” by Shapiro and Stockman
- Blooming(left) & Barrel distortion (right)

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some definitions

- analog image
 - “infinite” precision in space and intensity value
- digital image
 - discrete 2D array of limited precision intensity values
- grey-scale image
 - one intensity per pixel (e.g. if one byte intensity range is 0-255)
- multispectral image
 - a vector of values at each pixel (for color, usually 3 values representing values for red, green and blue)
- binary image
 - each pixel has value 0 or 1

some definitions

- labelled image
 - all pixel values are from some finite alphabet
 - usually generated from a digital image based on some way to decide which label a pixel gets
 - example on board
- picture function
 - $f(x,y)$ where x and y are spatial variables and $f(x,y)$ is the intensity at x,y

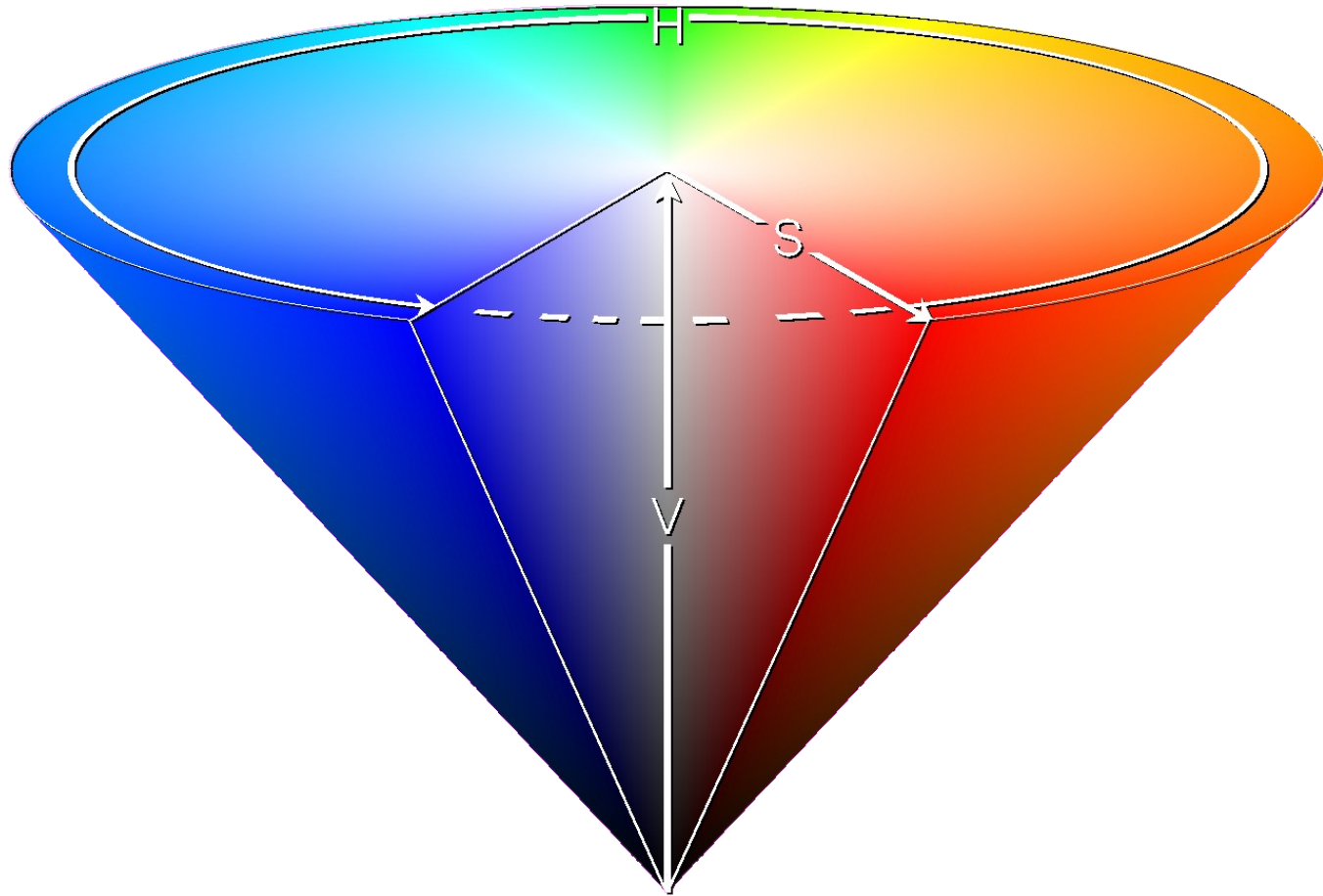
HSV

- We covered RGB already.
- HSV is another color space that separates out the color into one channel (Hue) and Saturation and Value into two other channels
- H = Hue --- usually what we name the color
- S = Saturation --- a measure of how pure the spectral color is
- V = Value --- high values are brighter, but this value for different hues/saturations do not all have the same perceived brightness
- The range of H is 0-359 (think 360 degrees of a circle)
- S and V have the range (0-255) or a real number in range (0-1)
- In openCV, HSV color space, H has range 0-179 --- just double it to get the more typical 360 degree range

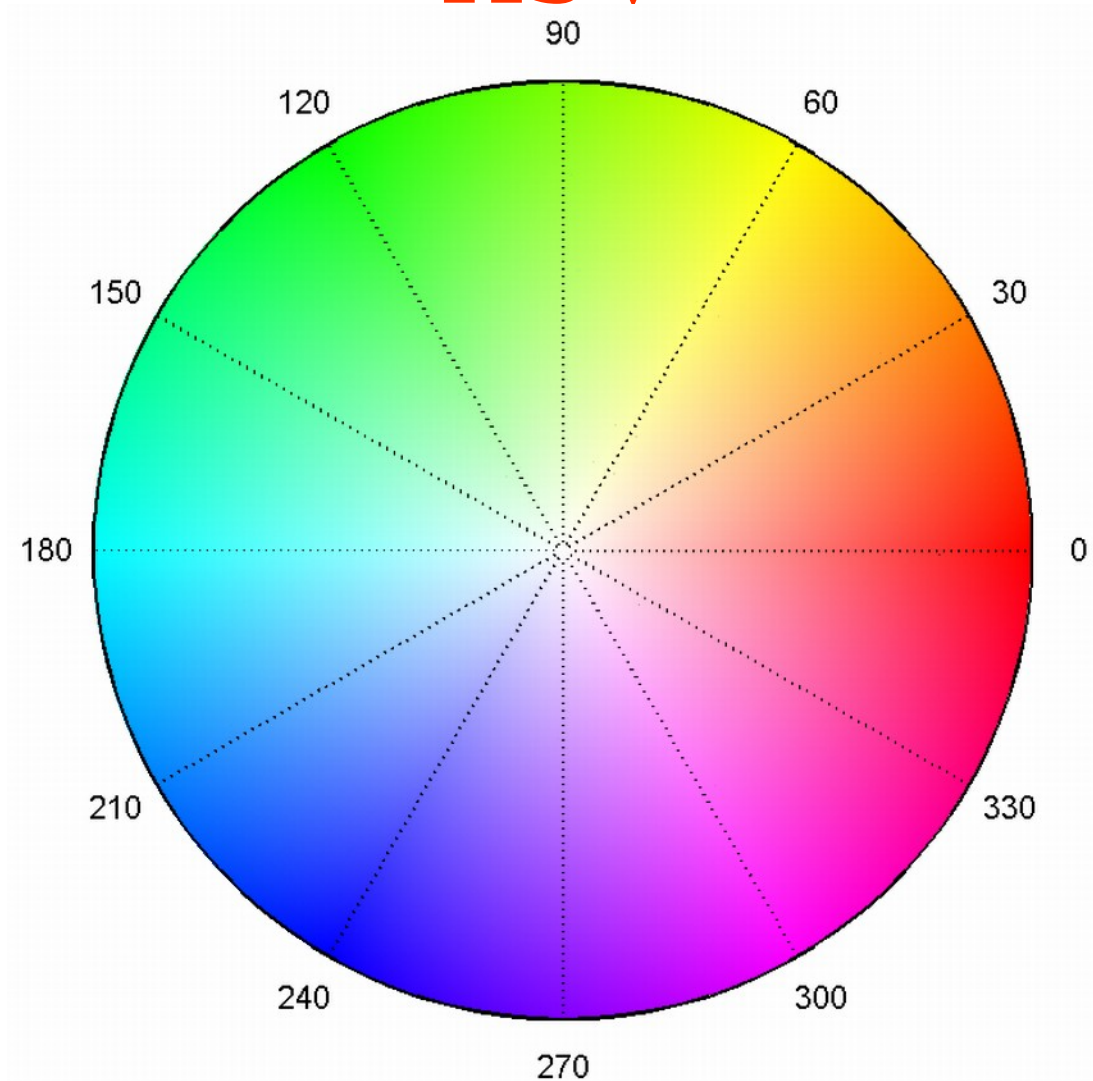
HSV

- S = Saturation --- a measure of how pure the spectral color is
 - Example: think of the red hue. A pure red is highly saturated whereas pink is a less saturated red. Pink is red with a large amount of white added to it.
 - V = Value --- high values are brighter, but this value for different hues/saturations do not all have the same perceived brightness
- low values are dark

HSV



HSV



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HSV

592 Achromatic and Colored Light

```
void RGB_To_HSV (double r, double g, double b, double *h, double *s, double *v)
/* Given: r, g, b, each in [0,1]. */
/* Desired: h in [0,360), s and v in [0,1] except if s = 0, then h = UNDEFINED, */
/* which is some constant defined with a value outside the interval [0,360]. */
{
    double max = Maximum (r, g, b);
    double min = Minimum (r, g, b);
    *v = max;                                /* This is the value v. */
    /* Next calculate saturation, s. Saturation is 0 if red, green and blue are all 0 */
    *s = (max != 0.0) ? ((max - min) / max) : 0.0;
    if (*s == 0.0)
        *h = UNDEFINED;
    else {
        double delta = max - min;            /* Chromatic case: Saturation is not 0, */
        /* so determine hue. */
        if (r == max)
            *h = (g - b) / delta;             /* Resulting color is between yellow and magenta */
        else if (g == max)
            *h = 2.0 + (b - r) / delta;       /* Resulting color is between cyan and yellow */
        else if (b == max)
            *h = 4.0 + (r - g) / delta;       /* Resulting color is between magenta and cyan */
        *h *= 60.0;                          /* Convert hue to degrees */
        if (*h < 0.0)
            *h += 360.0;                     /* Make sure hue is nonnegative */
    } /* Chromatic case */
} /* RGB_To_HSV */
```

Fig. 13.33 Algorithm for converting from RGB to HSV color space.

HSV

- To show you how HSV can be used to select hues, the hue color wheel looks to have greens with H in range of about 80 to 160.
- Because openCV has H value half that I selected all the pixels with H 40 to 80, excluding those with low saturation (those with too much white added to it) and low value (those that are too dark, where hue loses meaning).
- In the next image, the variety of RGB values that have a green hue is large --- easier to pick the range of H for the green hues than have rules for relationship of R to G to B for all the green hues

Original image



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Only those pixels with Green hue



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