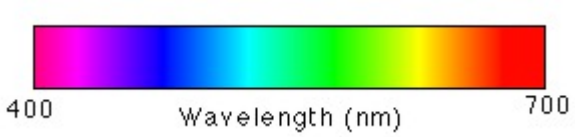
January 5, 2005

Agenda

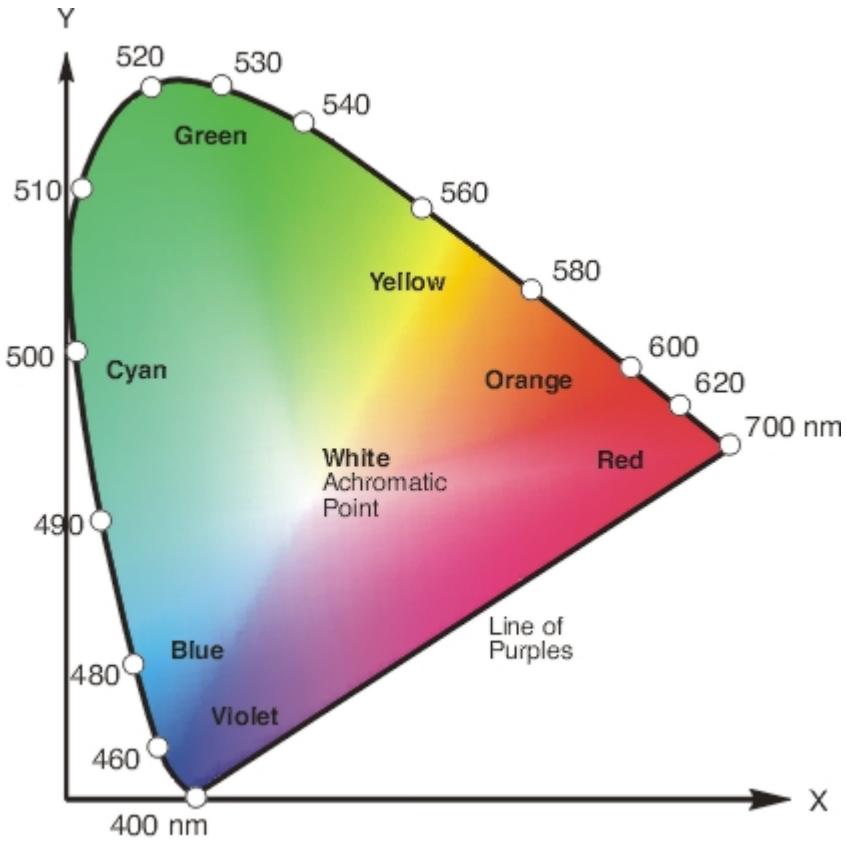
- Color and colorspaces
- Numbers and Java
- Feature detection

What are Colors?

- Frequencies are one dimensional…



- But human perception of color is not!

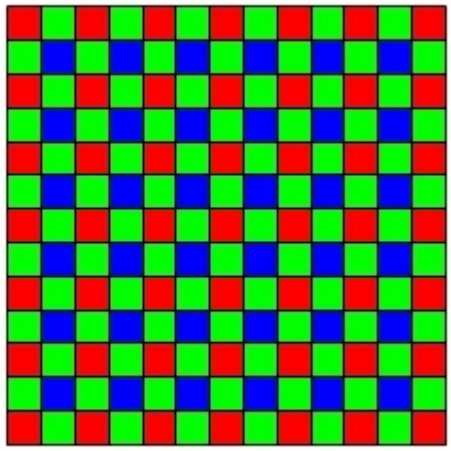


http://www2.ncsu.edu/scivis/lessons/colormodels/color_models2.html

Humans and Vision

- We use cones to detect red, green, and blue
- So computer monitors use the same, with one byte per channel (RGB).
  - image 640x480 = 900 KB !
  - computers can cheat…
- …like our cameras:

  interpolate pixel values



Bayer filter

Colorspaces

- RGB good for light

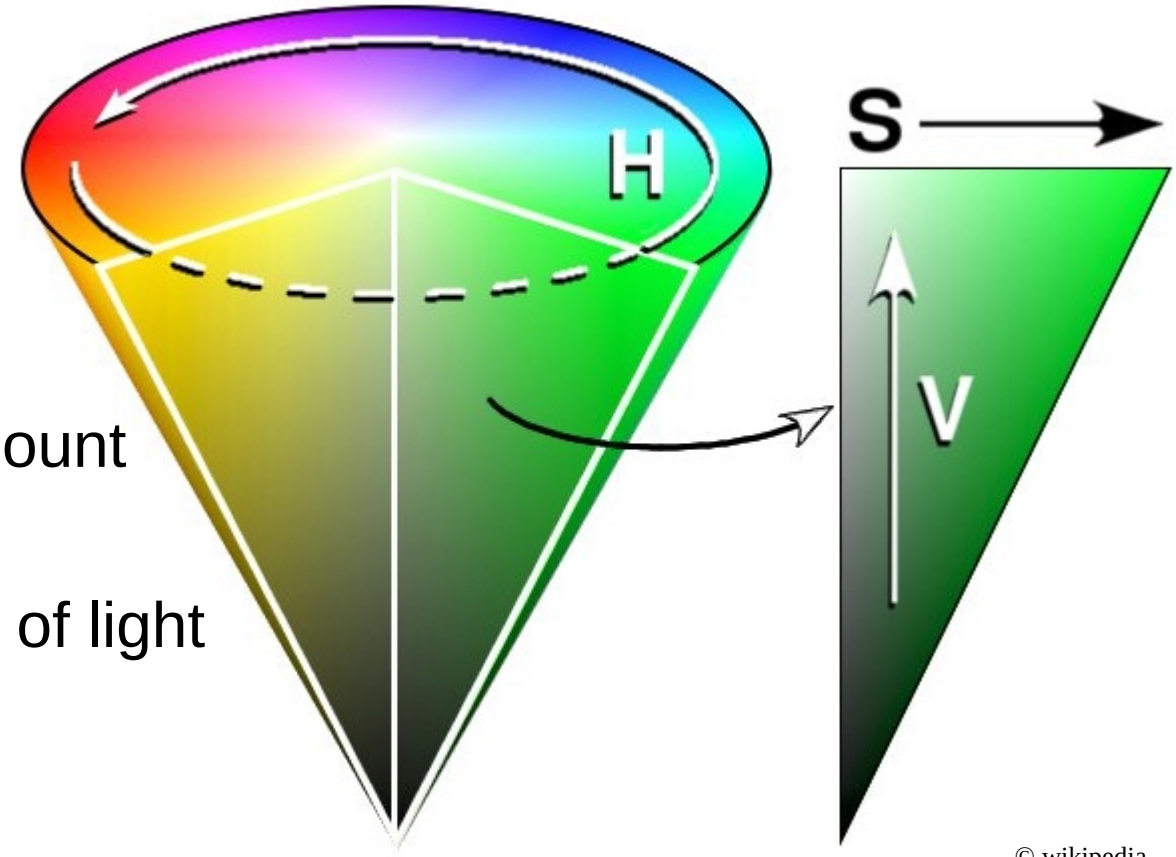
wikipedia

- CYMK good for pigment

  … but both mix color, tint, and brightness

Maslab Colorspace: HSV

- Hue (color):
- Saturation (amount of color)
- Value (amount of light and dark)



Using the colorspace

- We provide the code to convert to HSV
- For hue: 360 degrees mapped to 0 to 255
- Red is both 0 and 255!
- White is low saturation, but can have any hue.
- Black is high value, but can have any hue.

Tips on Differentiating Colors

- Globally define thresholds
- Self-calibrate for different lights
- Use the gimp/bot client on real images

How HSV values are stored

- Uses Hexadecimal (base 16)
  - 1,2,3,4,5,6,7,8,9,A,B,C,D,E,F,10,11,12…
  - 0x12 = 18
- A color is four bytes = 8 hexadecimal numbers
  - Alpha
  - Hue
  - Saturation
  - Value

Manipulating HSV values

- Use masks to pick out parts:
  - 0x12345678 & 0x00FF0000 = 0x00340000
- Shift to move parts around:
  - 0x12345678 >> 8 = 0x00123456
- Example: hue = (X >> 16) & 0xFF

A note on java…

- All java types are signed
  - A byte ranges from –128 to 127
  - Coded in two's complement: to change sign, flip every bit and add one
- Don't forget higher order bits
  - (int) 0x0000FF00 = (int) 0xFF00
  - (int) ((byte) 0xFF) = (int) 0xFFFFFFFF
- Watch out for shifts
  - 0xFD000000 >> 8 = 0xFFFD0000

Example

- How about

```
int v = image.getPixel(25,25); // v = 0x8AC12390
byte hue = (v >> 16) & 0xFF   //hue = 0xC1
 if (hue > 200)
    foundRedBall();
```

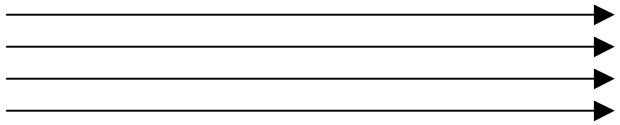
Solution

- Use

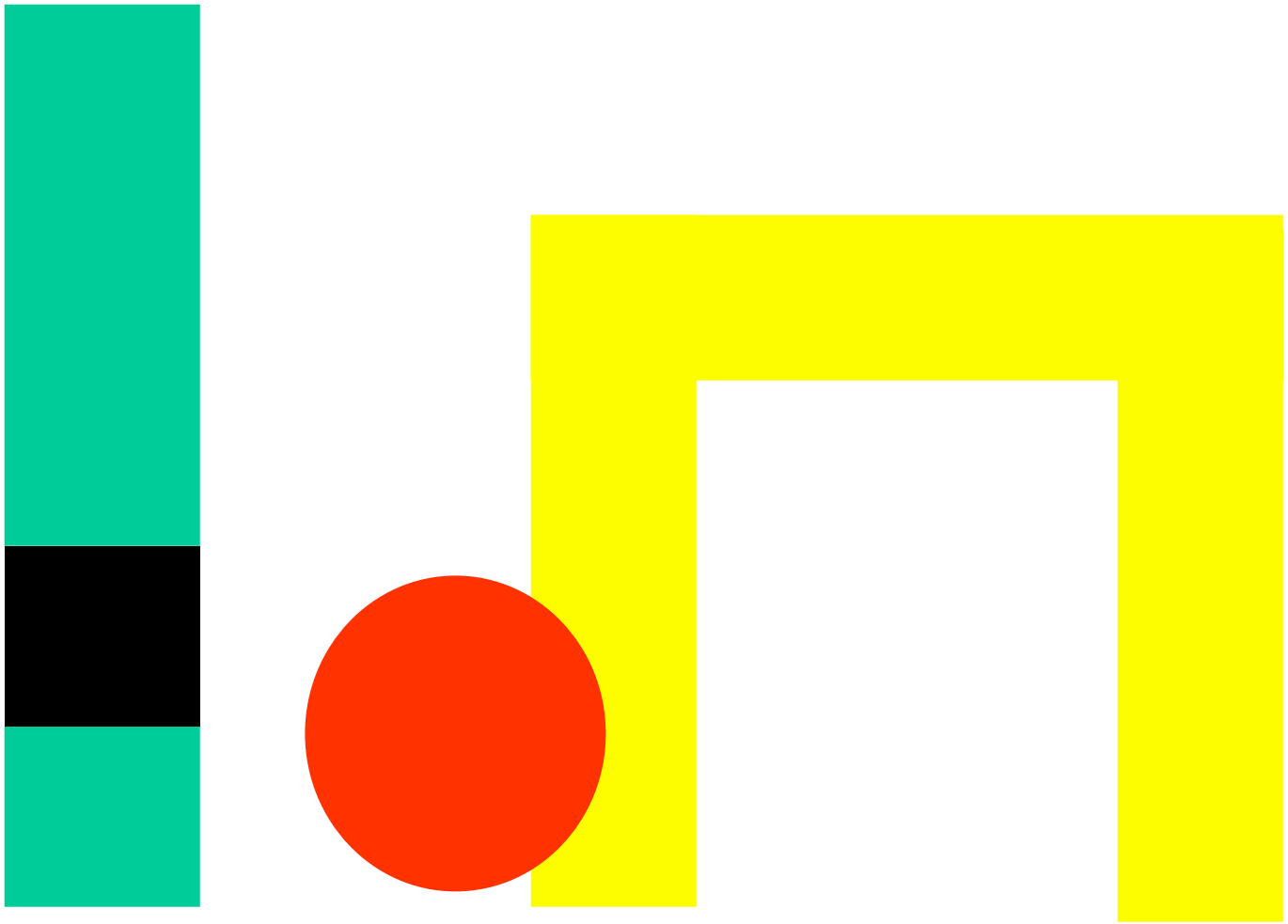
```
int v = image.getPixel(25,25); // v = 0x8AC12390
int hue = (v >> 16) & 0xFF   //hue = 0xC1
 if (hue > 200)
    foundRedBall();
```

Performance…

- Getting an image performs a copy
  - Int[] = bufferedImage.getRGB(…)
- Getting a pixel performs a multiplication
  - int v = bufferedImage.RGB(x,y)
  - offset = y*width + x
- Memory in rows, not columns…so go across rows and then down columns



Feature Detection…
and other Concepts



Maslab Features

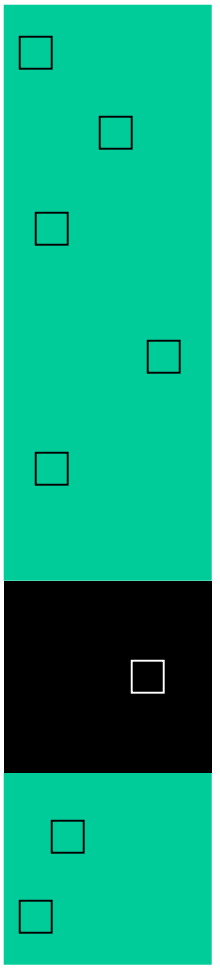
- Red balls
- Yellow Goals
- Blue line
- Blue ticks
- Bar codes

Blue line ideas

- Search for ‘n’ wall-blue pixels in a column
- Make sure there’s wall-white below?
- Candidate voting
  - in each column, list places where you think line might be
  - find shortest left to right path through candidates

Bar code ideas

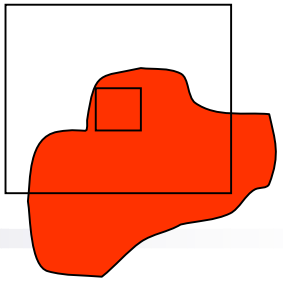
- Look for green and black
- Is there not-white under the blue line?
- Check along a column to determine colors
- RANdom SAmple Consensus (RANSAC)
  - Pick random pixels within bar code
  - Are they black or green?



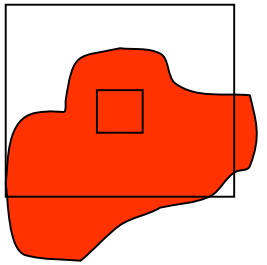
Finding a single color object

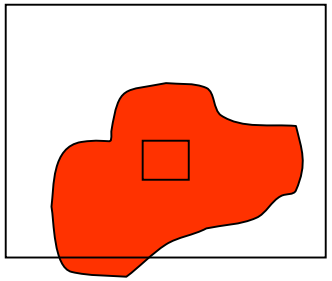
- Matched filter: convolve the image with a matched filter
  - compuatationally expensive
  - don’t know the scale

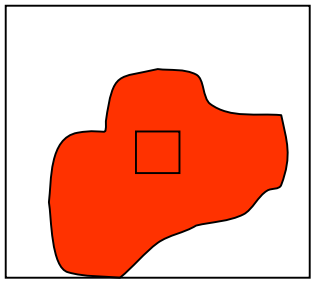
Other things to try



- Look for a red patch
- Set center to current coordinates
- Loop:
  - Find the new center based on pixels within d of the old center
  - Enlarge d and recompute
  - Stop when increasing d doesn't add enough red pixels

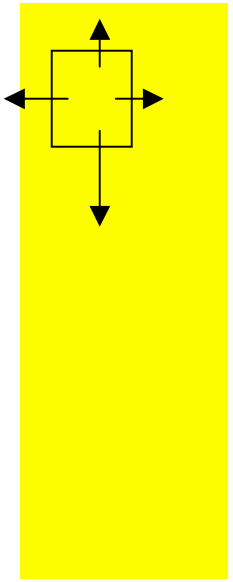






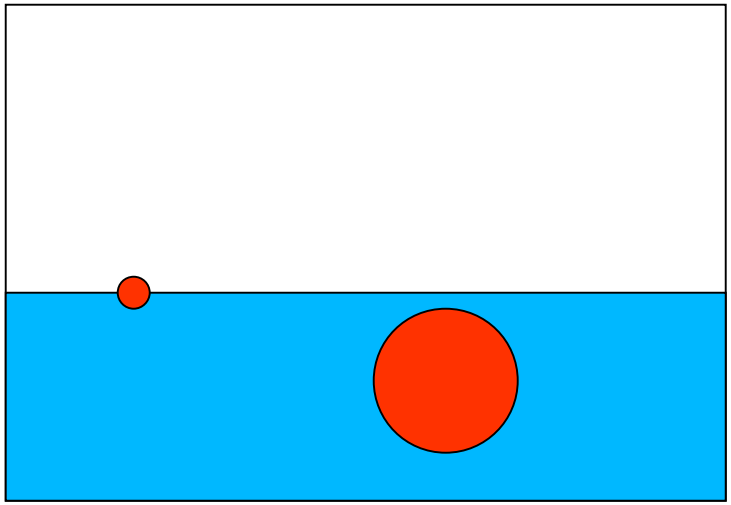
Or try fitting a rectangle

- Scan image for a yellow patch
- In each direction, loop:
  - Make rectangle bigger
  - If it doesn't add enough new yellow pixels, then stop



Estimating distance

- Closer objects are bigger
- Closer objects are lower



Feature-based processing

- Image processing for navigation
- In each frame, list ‘corners’ – such as the blue tick marks
- Match corners from one image to the next
- Estimate the rigid 3D transformations to that best map the corners

Reminders

- Basics to get you started
  - (cool advanced stuff on Monday)
- Try out your own algorithms! Have fun!
- Must prune out silly solutions:
  - Noise
  - Occlusion
  - Acute viewing angles
  - Overly large thresholds

Updates on Rules

- Robot must fit in tub
- There will be yellow field goal posts over the goals (above the yellow line)
- Using outside parts: cost = how much it would cost another team to have similar functionality

- Also, don’t forget to refresh wiki periodically during the day and check for updates

Your job for today

- Finish yesterday's activity
- Read a barcode
- Work on Friday's check point