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
Colorspsaces

- RGB good for light

- 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
  - \((\text{int}) 0x0000FF00 = (\text{int}) 0xFF00\)
  - \((\text{int}) ((\text{byte}) 0xFF) = (\text{int}) 0xFFFFFFFF\)

- Watch out for shifts
  - \(0xFD000000 >> 8 = 0xFFFFD0000\)
Example

How about

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

- Use

```java
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
  - computationally 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