

# CSSE463: Image Recognition

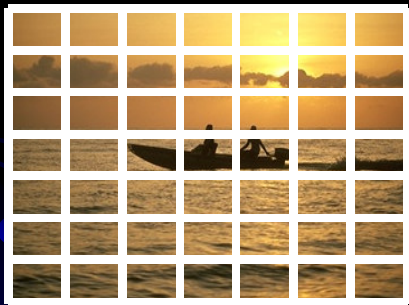
Day 2

- Roll call
- Announcements:
  - Reinstall Matlab if you are having problems: Lab 1 has directions.
  - Angel has drop box for Lab 1
  - Bonus points to first person to find errors in course materials!
  - Tomorrow: more Matlab how-to (bring laptop)
- Last class we discussed:
  - Today: Color and color features
  - Questions?

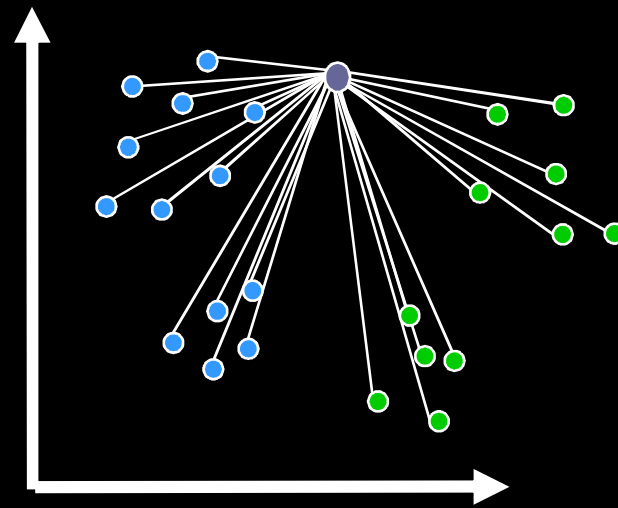
# Pixels to Predicates

1. Extract features from images

2. Use machine learning to cluster and classify



Color  
Texture  
Shape  
Edges  
Motion

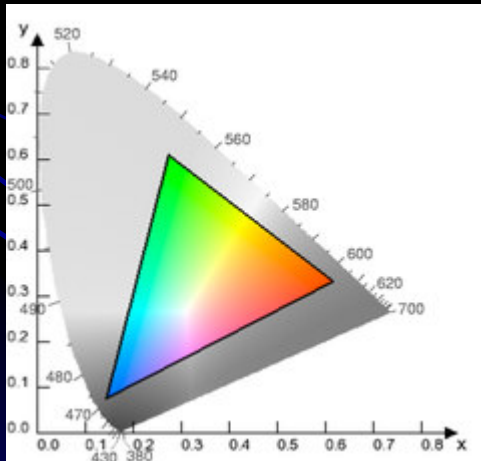


Principal components  
Neural networks  
Support vector machines  
Gaussian models

# Basics of Color Images



- A color image is made of red, green, and blue *bands*.
  - Additive color
    - Colors formed by adding primaries to black
  - Comments from graphics?
  - RGB mimics retinal cones in eye.
  - RGB used in sensors and displays
    - Why “16M colors”?
    - Why 32 bit?



Source: Wikipedia

# Basics of Color Images

- Each band is a 2D matrix
- Each R, G, or B value typically stored in a byte.
  - Range of values?
- The 4<sup>th</sup> byte is typically left empty
  - Allows for quicker indexing, because of alignment
  - Reserved for transparency (in graphics)
- How much storage is required for a 4 megapixel color image (uncompressed)?

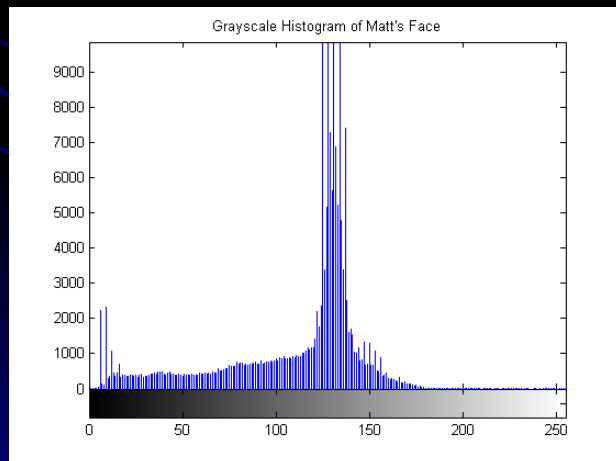
# Color Features (statistics from images)

- 1. Color histograms
- 2. Color moments
- 3. Color coherence vectors

Related to the feature types

- Some color spaces “work better”
- Spatial components can help

# Color histograms



- Gives distribution of colors
- Sample to left is for intensities only
- Pros
  - Quantizes data, but still keeps lots of info
- Cons
  - How to compare two images?
  - Spatial info gone
  - Histogram intersection (Swain and Ballard)

# Color moments



$m_1 = 116.3$   
 $m_2 = 1152.9$   
 $m_3 = -70078$   
 $m_4 = 7.4 \text{ million}$

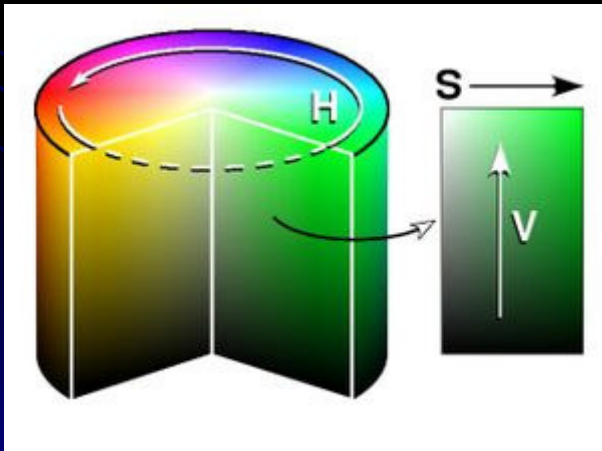
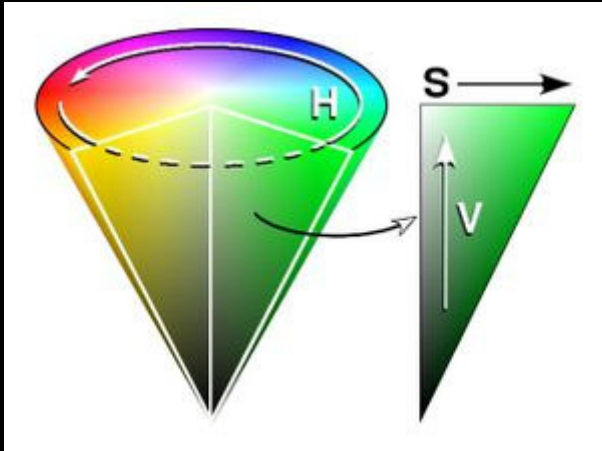


$m_1 = 132.4$   
 $m_2 = 2008.2$   
 $m_3 = 4226$   
 $m_4 = 12.6 \text{ million}$

- Central moments are *statistics*
  - 1<sup>st</sup> order = mean
  - 2<sup>nd</sup> order = variance
  - 3<sup>rd</sup> order = skew
  - 4<sup>th</sup> order = kurtosis
  - Some have used even higher order moments, but less intuitive
- For color images, take moments of each band

$$m_d = \frac{1}{n} \sum_{i=1}^n (x_i - \mu)^d$$

# HSV color space



Source: Wikipedia

- Hue-saturation-value (HSV) cone
  - also called HSI (intensity)
  - Intuitive
    - H: more than “what color”: it’s the position on the spectrum!
    - S: how vibrant?
    - V: how light or dark
- “Distance” between colors
  - Must handle wraparound of hue angle correctly ( $0 = 2\pi$ )
- Matlab has method to convert from rgb to hsv, can find formula [online](#).



# Other color spaces

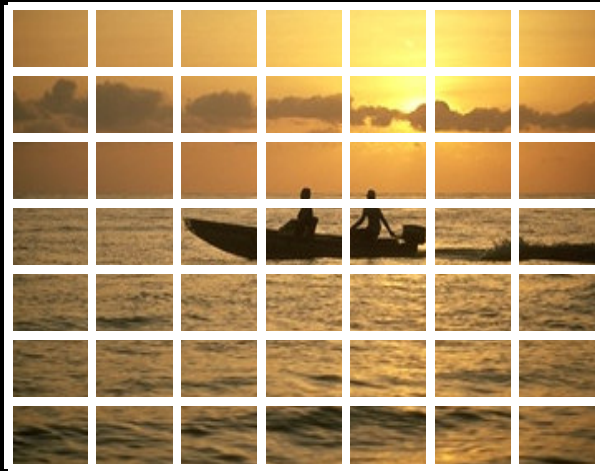
- LST

- L = luminance:  $L = R + G + B$
- S and T are *chroma* bands.
  - S: red vs. blue:  $S = R - B$
  - T: green vs. magenta:  $T = R - 2G + B$
  - (Typically, we then normalize these to the same scale)
- These 3 are the *principal components* of the RGB space (PCA and eigenvectors later in course)
- Slightly less intuitive than HSV
- No problem with wraparound

- Others

- YIQ (TV signals), QUV, Lab, LUV

# Spatial component of color



- Break image into parts and describe each one
  - Can describe each part with moments or histograms
- Regular grid
  - Pros?
  - Cons?
- Image regions
  - Pros?
  - Cons?

# Additional reading

- Color gamuts
  - <http://en.wikipedia.org/wiki/Gamut>
- Color coherence vectors
  - Extension of color histograms within local neighborhoods
  - Used in:
    - A. Vailaya, H-J Zhang, and A. Jain. On image classification: City images vs. landscapes. Pattern Recognition 31:1921-1936, Dec 1998.
  - Defined in:
    - G Pass, R Zabih, and J Miller. Comparing images using color coherence vectors. 4<sup>th</sup> ACM Conf. Multimedia, pp 65-73, Boston, 1996.

# ICME Sunset Paper

- Answer quiz questions
- We'll answer some in-class as time allows.