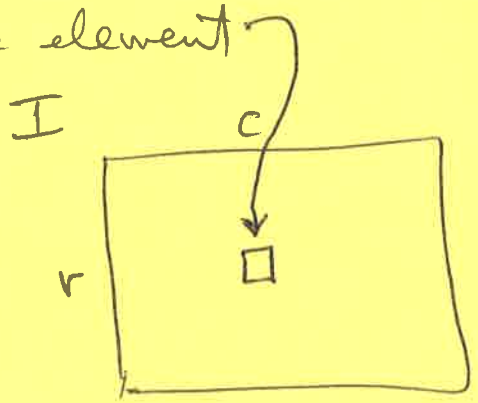
3\1

<u>pixel</u> : picture element



row, col : (r, c)

x, y [upper left] : (x, y)

we have discussed values & meanings

Operations on images A, B

$\neg A$	binary inverse negative image
$A + B$	sum
$A - B$	difference
$A .* B$	product (pixel-wise)
$A ./ B$	quotient (")
$A + V$ ↑ value (positive)	brightens
$A - V$ ↑ value (positive)	darkens

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Matlab

imadd
imsubtract
imabsdiff
} truncate to range

immultiply — increase contrast
im_divide — compare image differences

imcomplement

Thresholding

im2bw

look at cell image
look at trees

Point operations

= improve contrast for human viewing

logarithmic

$$I' = \underset{\substack{\uparrow \\ \text{scales output}}}{c}\, \ln(\underbrace{1}_{\text{avoids } \ln(0)} + \overbrace{(e^{\sigma} - 1)}^{\text{scales input}} I)$$

$$c = \frac{255}{\log(1 + \max(I))}$$

$(e^{\sigma} - 1)$ missing in book

* increase dynamic range in dark regions
decrease — — — — — — brighter "

cameraman = → ~~12~~ =

exponential transform

$$I' = c\left[(1+\alpha)^{I} - 1\right]$$

$$c = \frac{255}{((1+\alpha)^{\max(I)} - 1)}$$

may enhance brighter regions

plot log + exp values

gamma transform

$$I' = c\, I^{\gamma}$$

enhances contrast of brighter parts of image

corrects for non-linear (analog) brightness sent to monitor.

see imadjust

Histograms

: relative frequency of a gray level

normalized: sums to 1

imhist

thresholding: coins > 80

combo(mat2gray(coins), coins<80);

graythresh (126) too high

Adaptive Thresholding

local threshold
CS4640_adapt

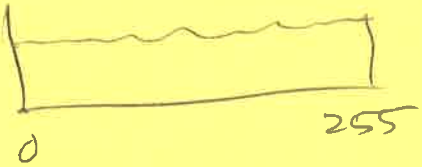
Histogram Equalization

view histogram as probability of a gray level

Then :

converting image so that all gray levels are equally likely will increase local contrast

Gives



Look at tom

imhist
histeq

Histogram matching

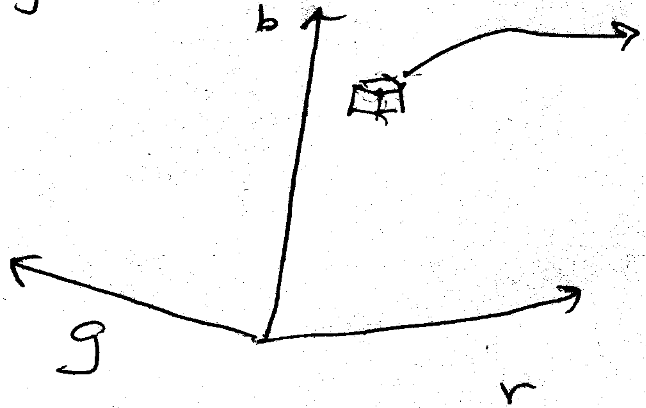
convert image to match histogram which characterizes a "type" of image or scene

Look at autumn & tom
histeq (tom, imhist (autumn))

Color histogram

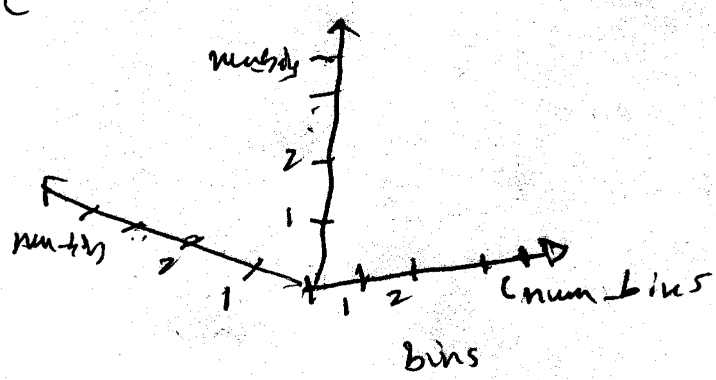
- Most straight forward is 256 × 256 × 256 array

H_{rgb}



$H_{rgb}(r,g,b) = $ # pixels with r,g,b

- Normalize it to make it a probability distribution
- Linearize it so it's $P(x)$
- Subsample because $(2^8)^3 = 2^{24}$ is big !
- hc = CS6640_hist_color (im, num_bins)



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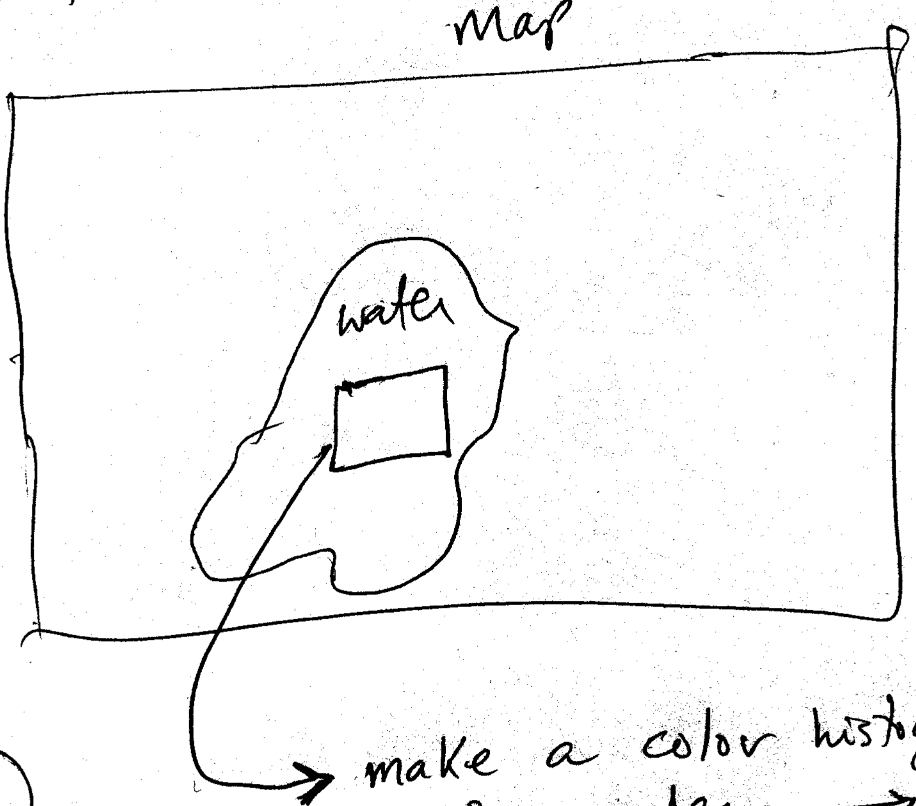
How to use it?



① make a color histogram for water → P

② Go through entire image, and make a color histogram for a comparable window around each pixel → Q

③ Compute the distance between the two distributions P, Q

→ Kullback-Leibler divergence

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$$KL(P \| Q) = \sum_{x \in X} P(x) \log\left(\frac{P(x)}{Q(x)}\right)$$

* if $P \equiv Q$ then $\log\left(\frac{P(x)}{Q(x)}\right) = 0$
& divergence is 0

* if P or Q $\equiv 0$, set log to 0
[hint: make sure neither P nor Q has 0 value]