Digital Image Processing (CSE/ECE 478)

Lecture 3 : Intensity Transforms and Histogram Processing

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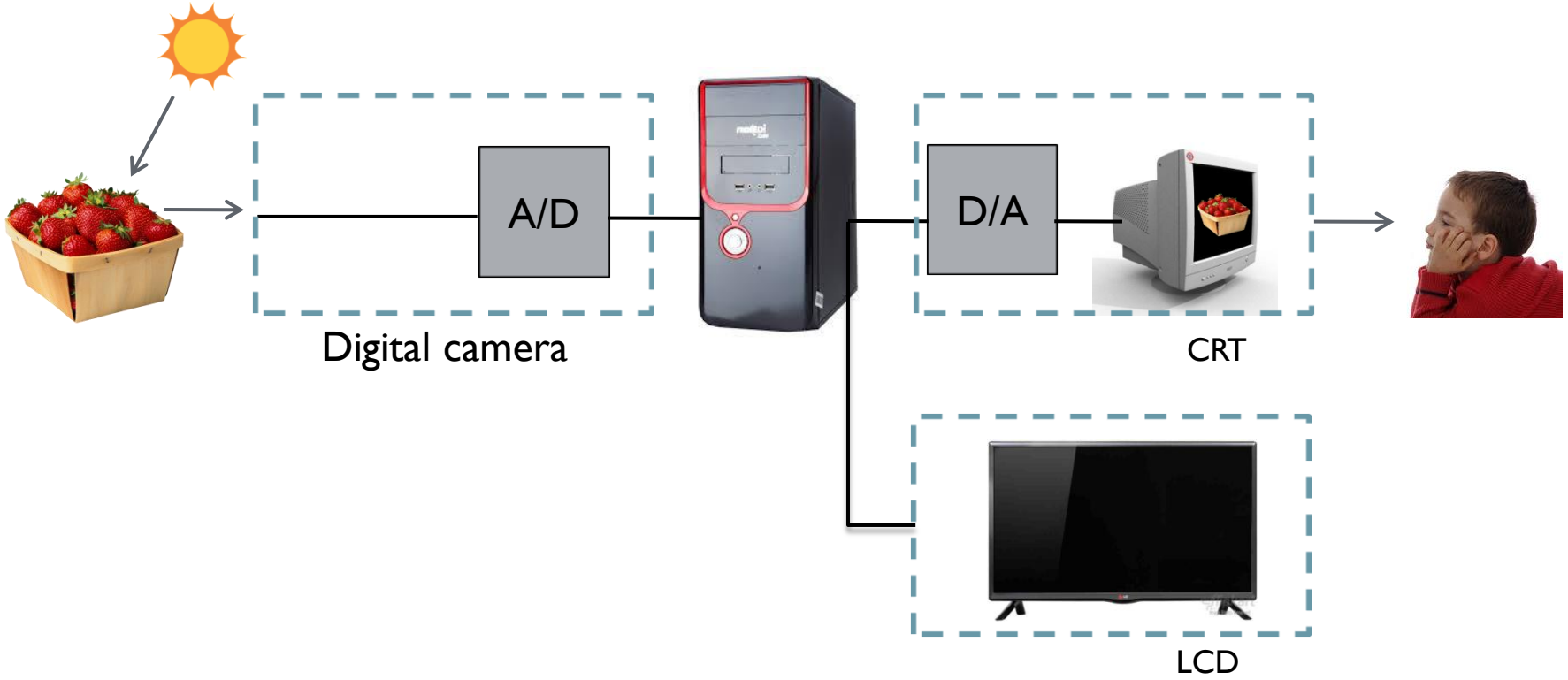
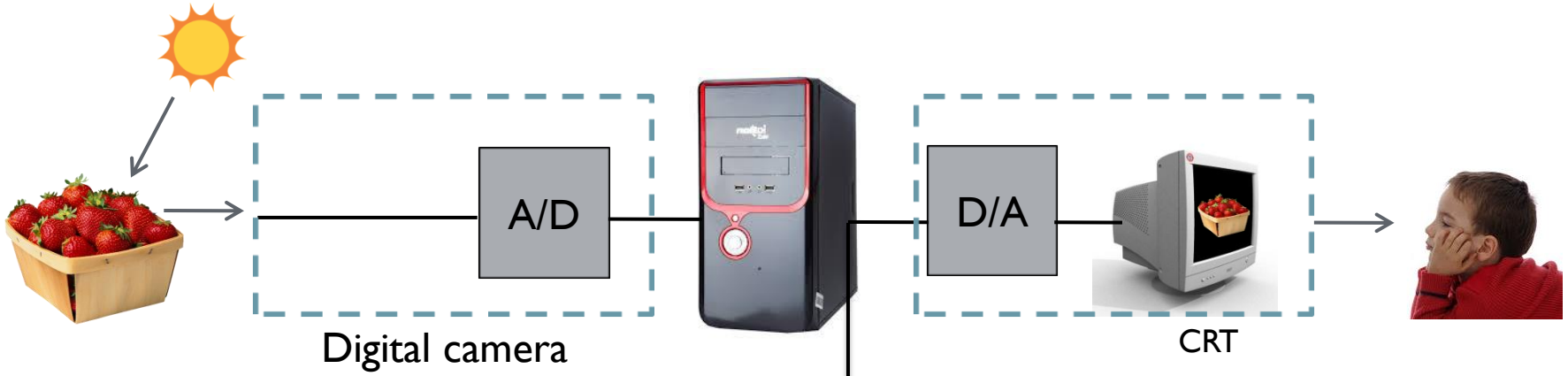
Announcements

- Assignment – I Will be released today
- Tutorials will start from this Saturday
  - 3.30PM – 4.30PM
  - H-203
- Add/Drop is done

Previous Lecture

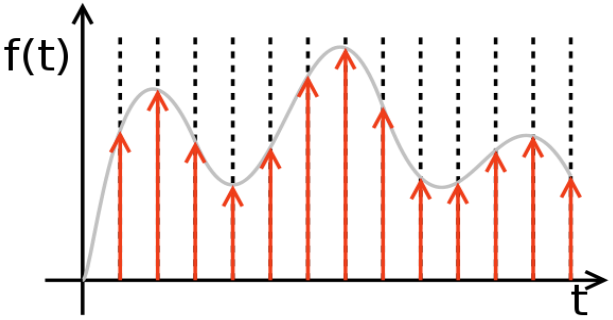


Previous Lecture



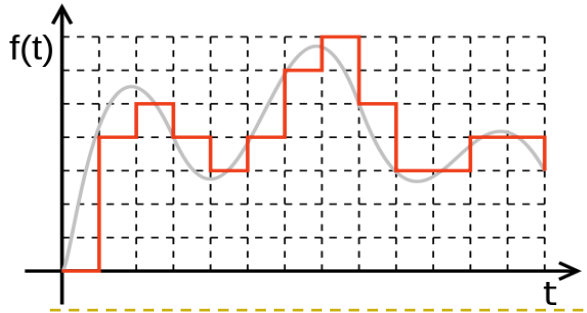
- Digital Image Acquisition
- Sampling & Quantization

Recap …



Sampling

256 × 256 | 32 × 32 | 16 × 16

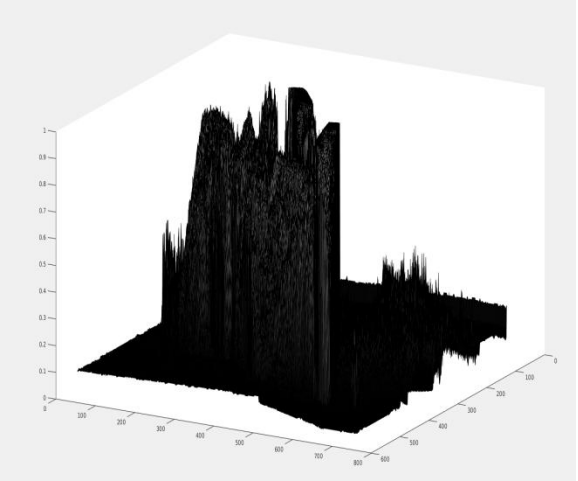


Quantization

8 bits per pixel | 4 bits per pixel | 2 bits per pixel | 1 bit per pixel

Image as a function / 3D surface

- $f(x,y) = z$
- Domain : (x, y)
- Range = Intensity



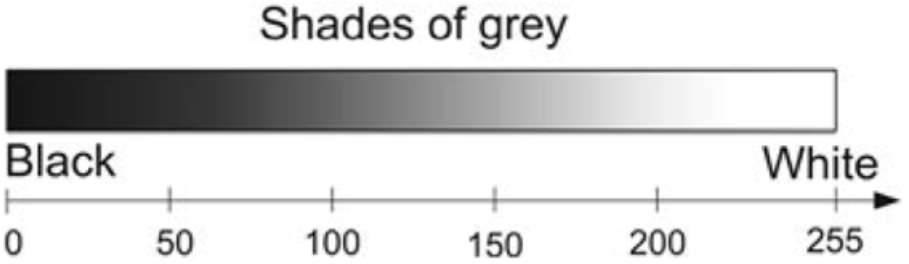


Image as a function / 3D surface

- $f(x,y) = z$
- Spatial Domain
- Intensities (Pixel Values)

Image as a function / 3D surface

- *f*(x,y) = z
- Spatial Domain
- Intensities (Pixel Values)

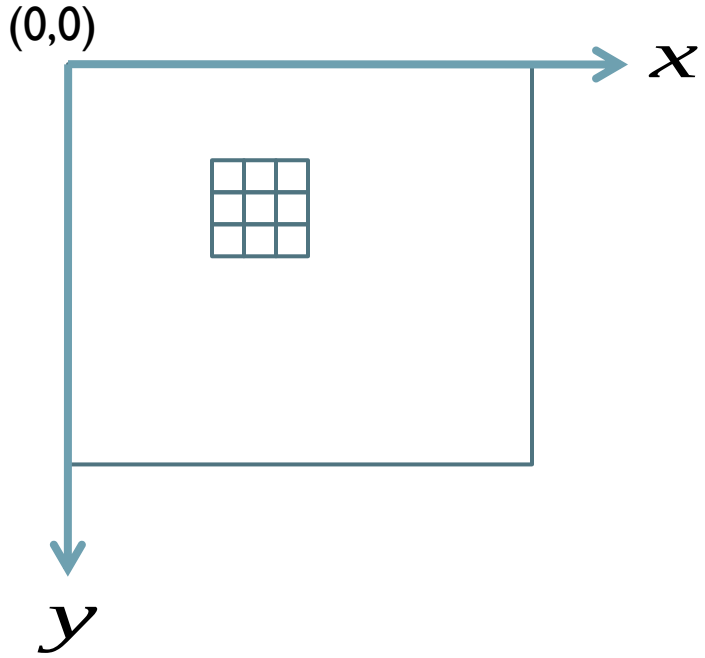


Image as a function / 3D surface

- $f(x,y) = z$
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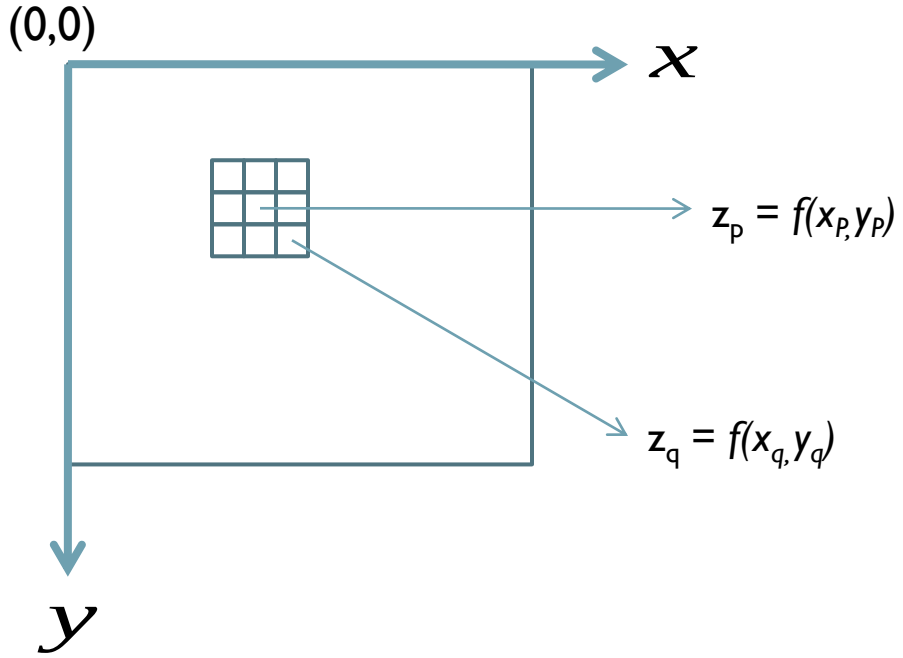
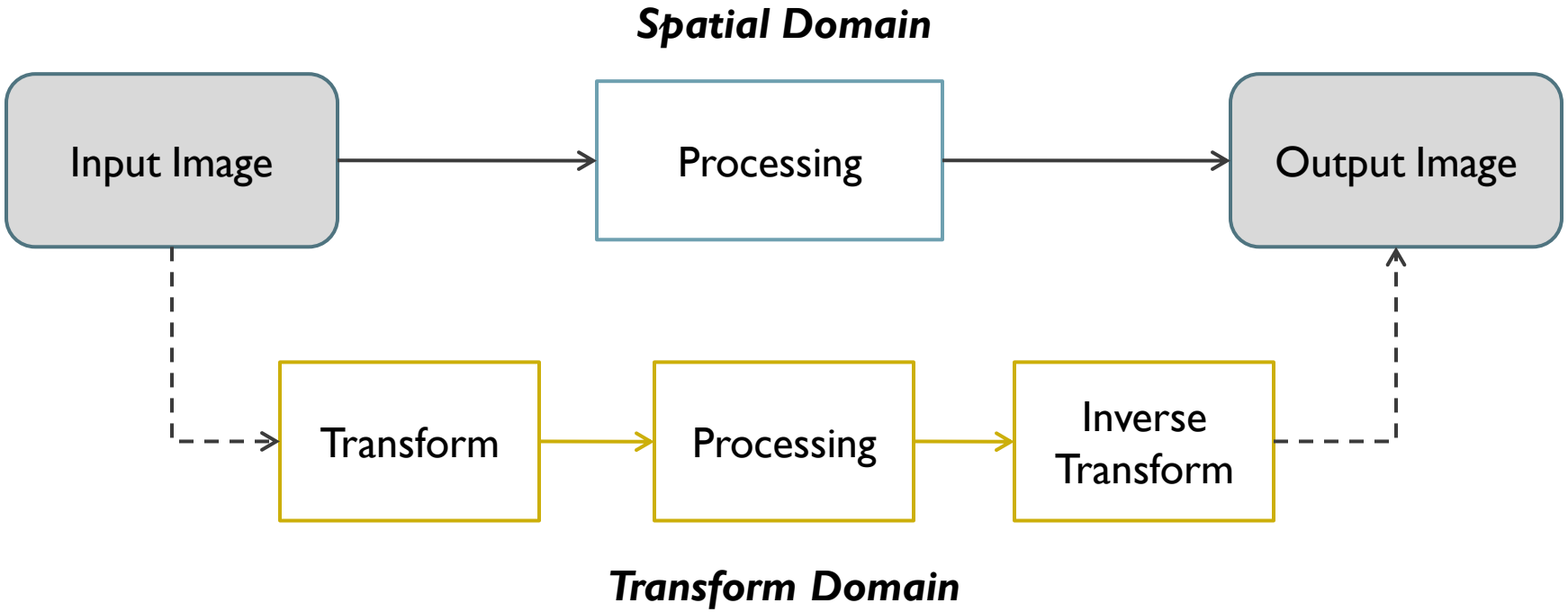


Image Processing

- Directly manipulating pixels in spatial domain
- Manipulating in transform domain

Spatial vs. Transform Domain Processing



Spatial vs. Transform Domain Processing

Bandhani / Bandhej

Tie Dye

Spatial vs. Transform Domain Processing

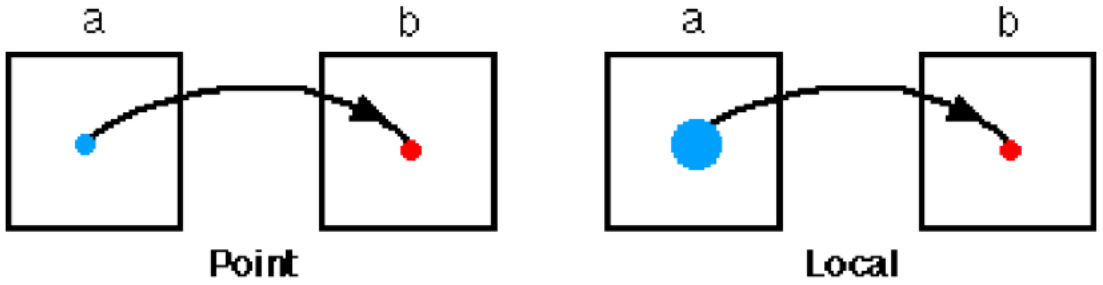
Transform (Tie)

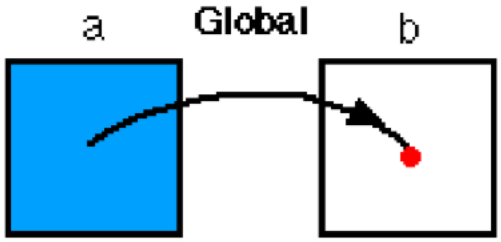
Process (Dye)

Inverse Transform (Untie)

Spatial Domain Processing

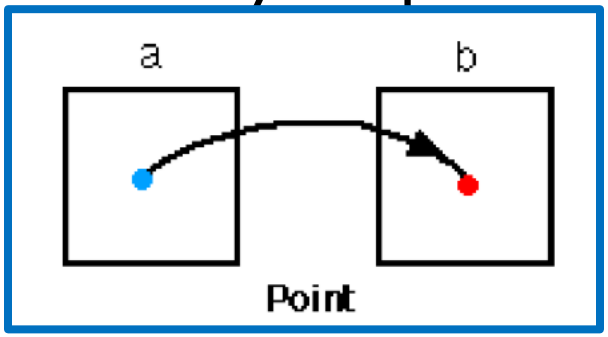
- Manipulating Pixels Directly in Spatial Domain
- Point to Point
- Neighborhood to Point
- Global Attribute to Point

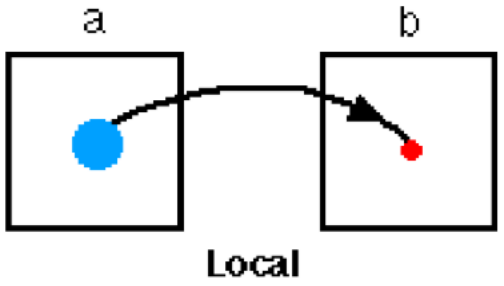


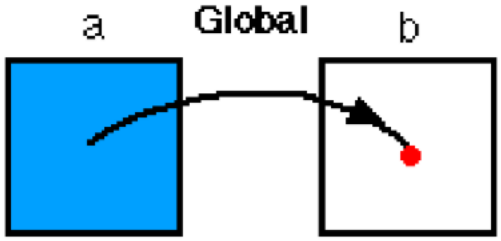


Spatial Domain Processing

- Manipulating Pixels Directly in Spatial Domain
- **Point to Point**
- Neighborhood to Point
- Global Attribute to Point





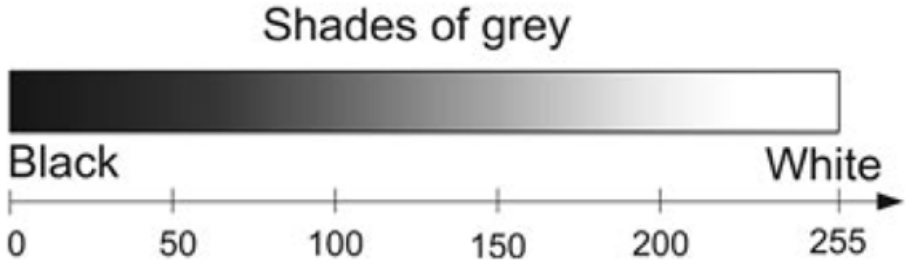


Intensity Transforms

- $f(x,y) = z$
- $z' = g(z) = g(f(x,y))$
- Function g is a mapping between intensity value **z** at pixel (x,y) to a new value **z'**

Intensity Transforms

- $g = z + K$
- $g = z - K$
- $g = Kz$
- $g = K_1 z + K_2$



Intensity Transforms

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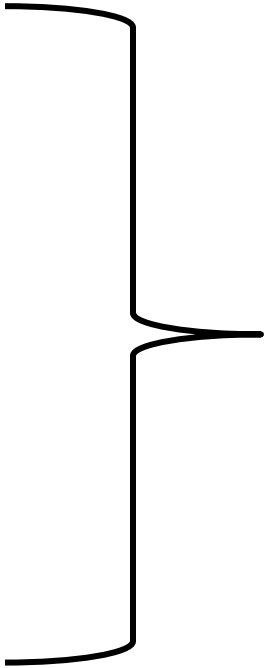
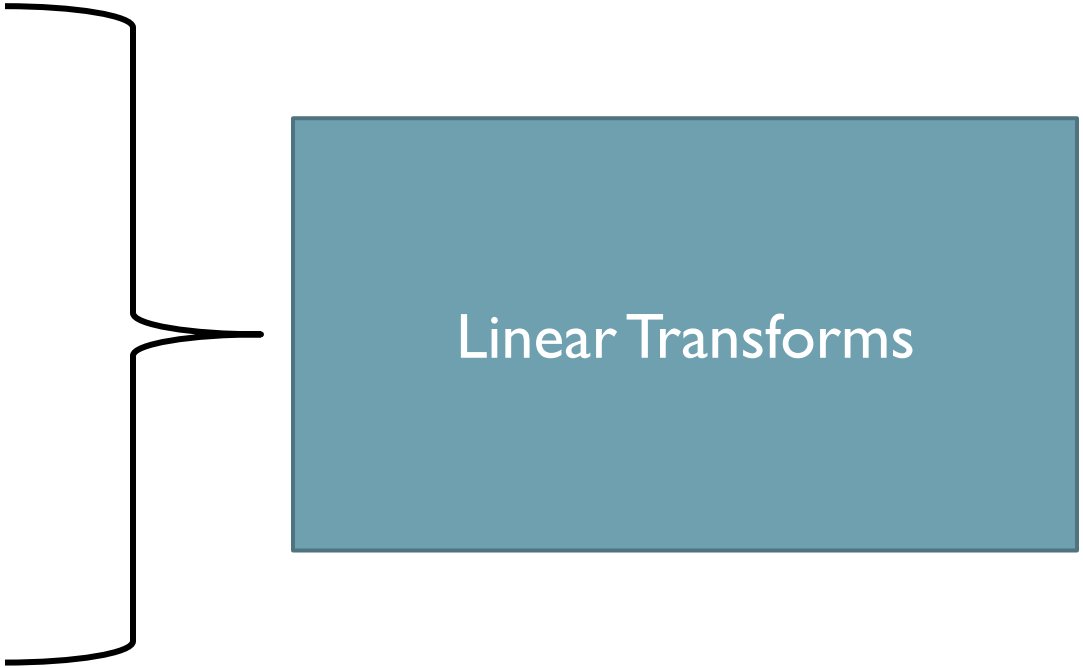


What is common?

Intensity Transforms

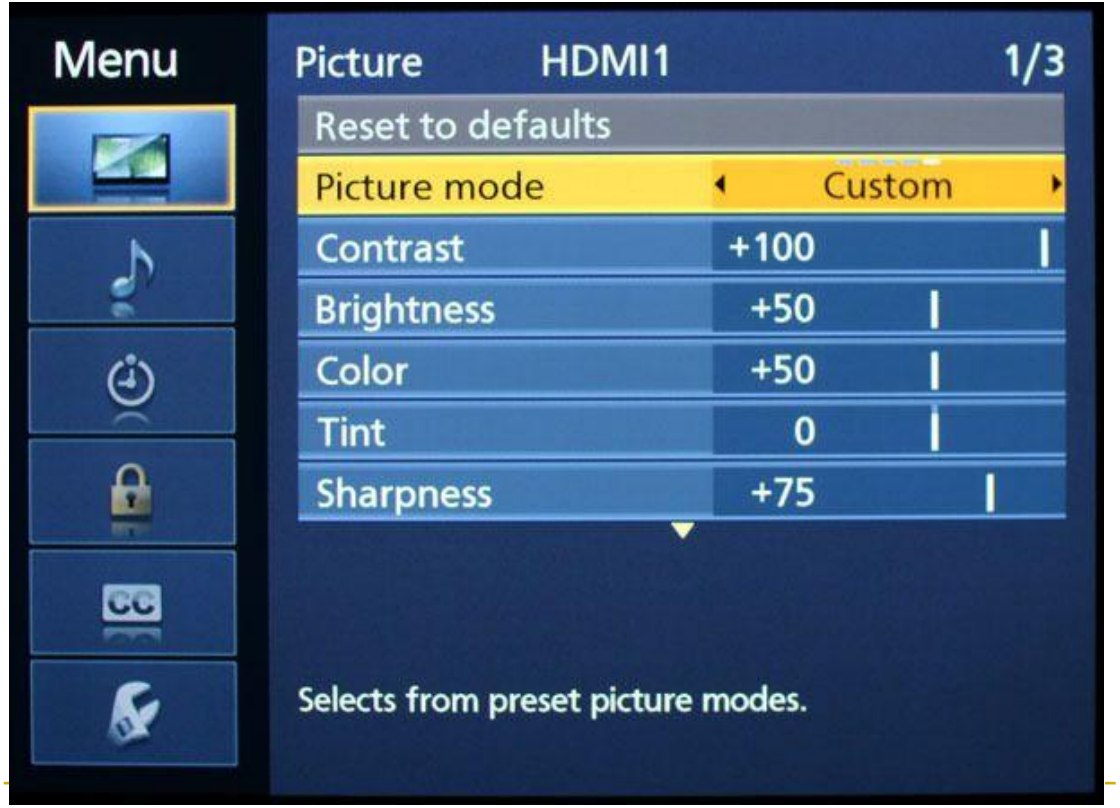
- $g = z + K$
- $g = z - K$
- $g = Kz$
- $g = K_1 z + K_2$



Intensity Transforms

- What form can function g take?
- It has to be meaningful too!
- What does the intensity transform achive?
  - Application specific

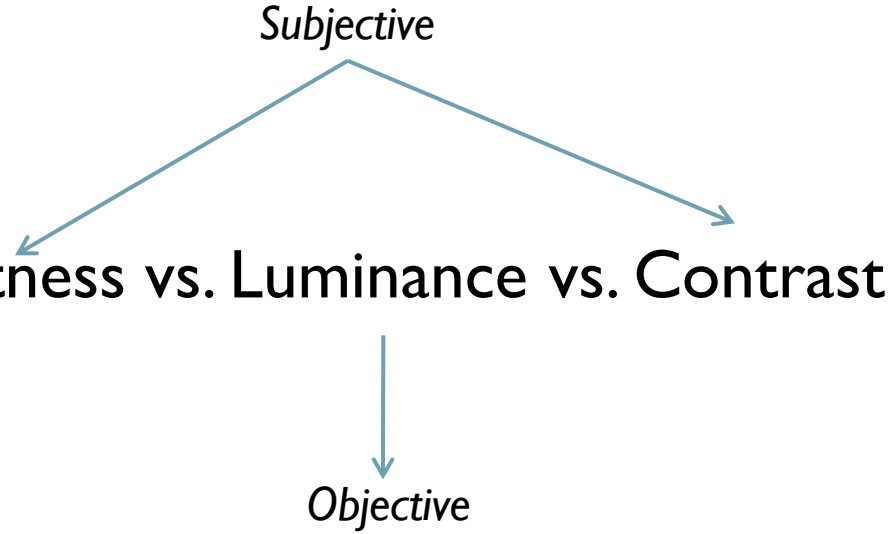
Time for Show & Tell!



Time for Show & Tell!

To Be Continued

Brightness & Contrast



Brightness & Contrast

Brightness vs. Luminance vs. Contrast

Simultaneous Contrast & Perceived Brightness

Simultaneous Contrast & Perceived Brightness

Simultaneous Contrast & Perceived Brightness

Other Perceptual Phenomena

- Just Noticeable Difference (Weber Constant)
- Match Bands
- Chromatic Adaption
- And more …

Intensity Transforms

- What form can function g take?

Standard Intensity transformations

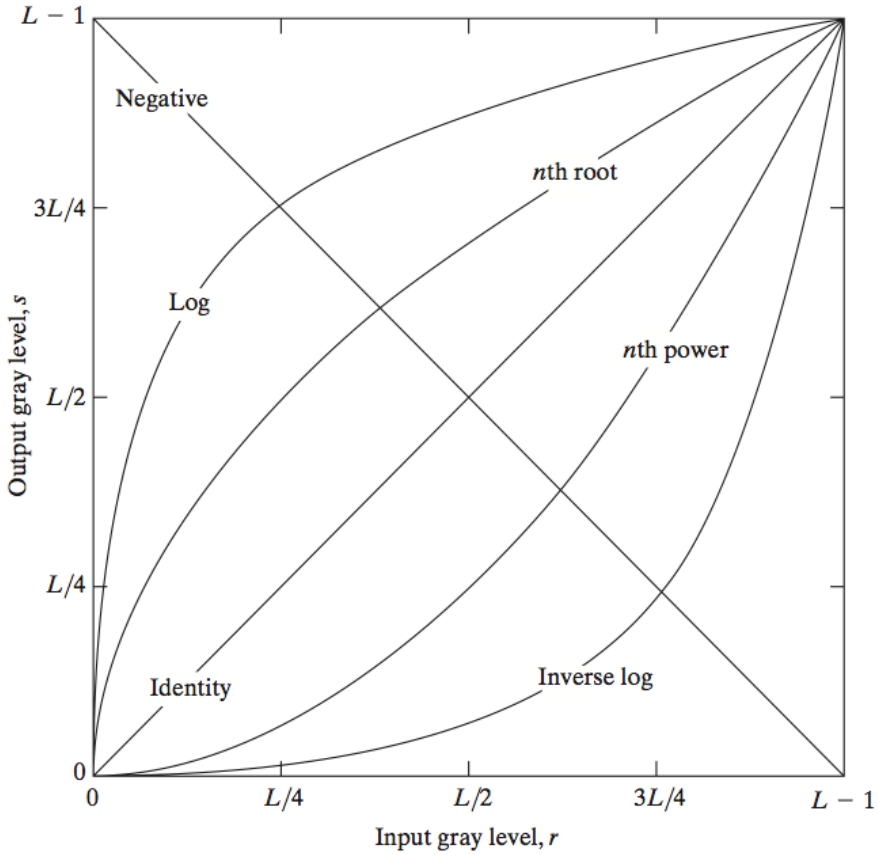
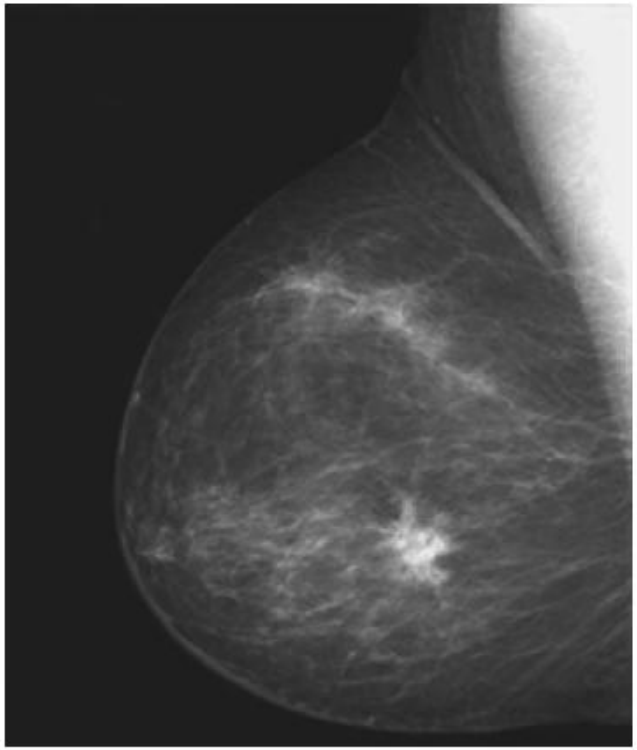
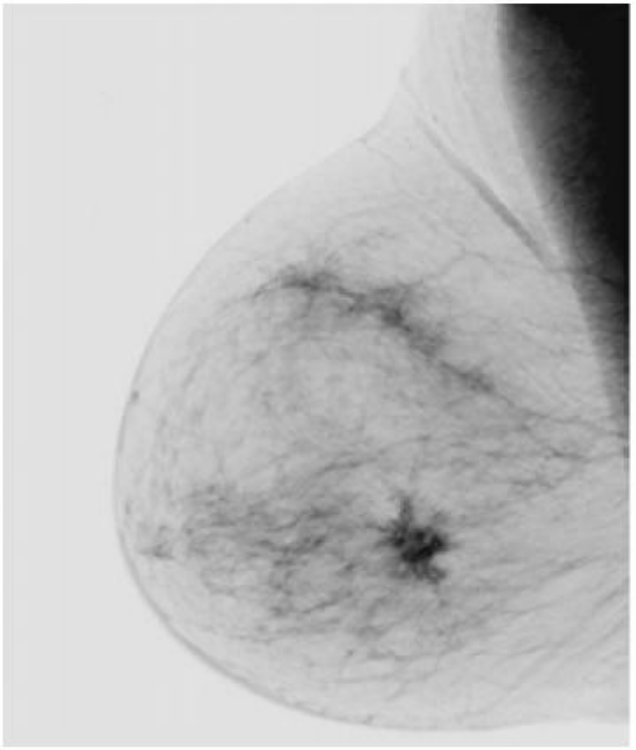


Image Negatives





a b

FIGURE 3.4
(a) Original digital mammogram. (b) Negative image obtained using the negative transformation in Eq. (3.2-1). (Courtesy of G.E. Medical Systems.)

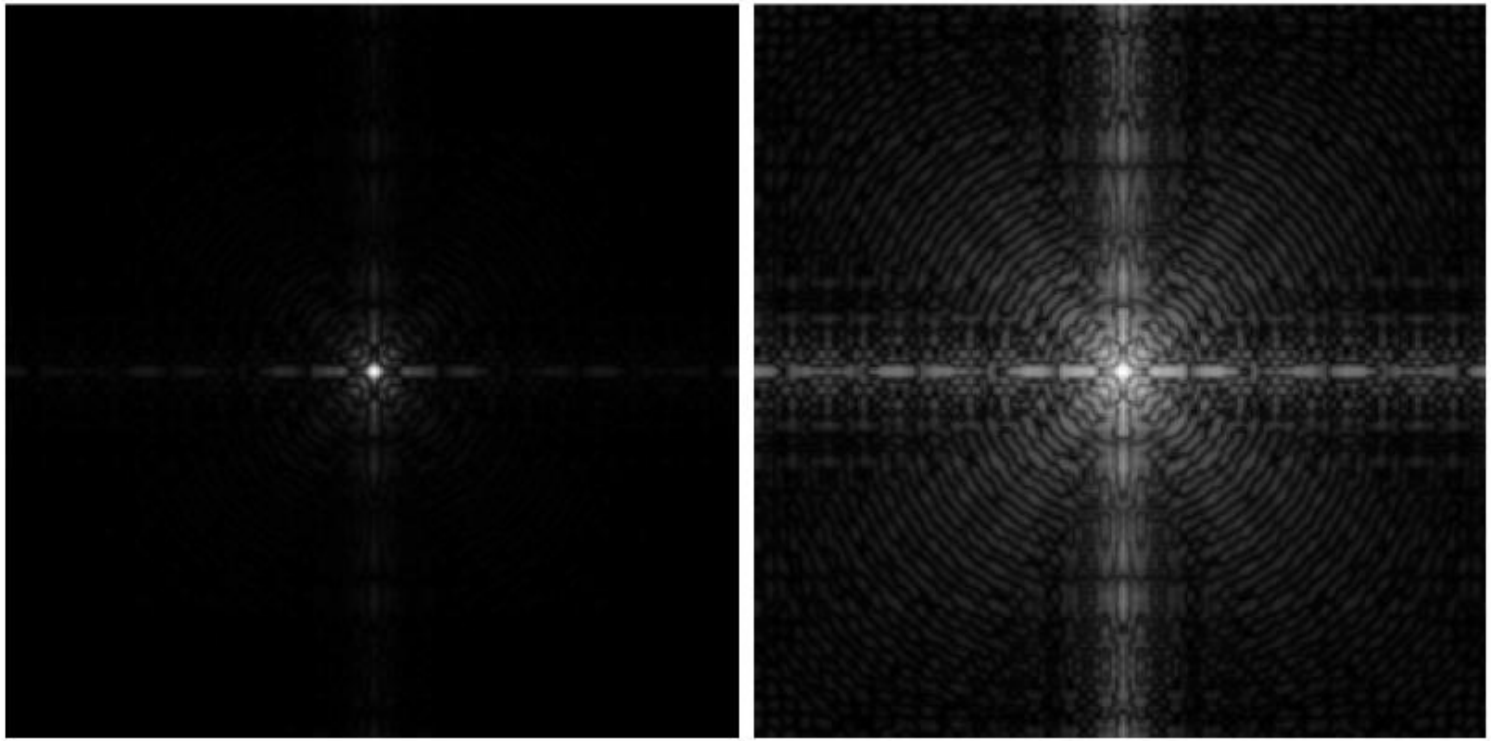
Intensity levels: [0, L-1]

Transformation: $s = L - 1 - r$

Log Transformations

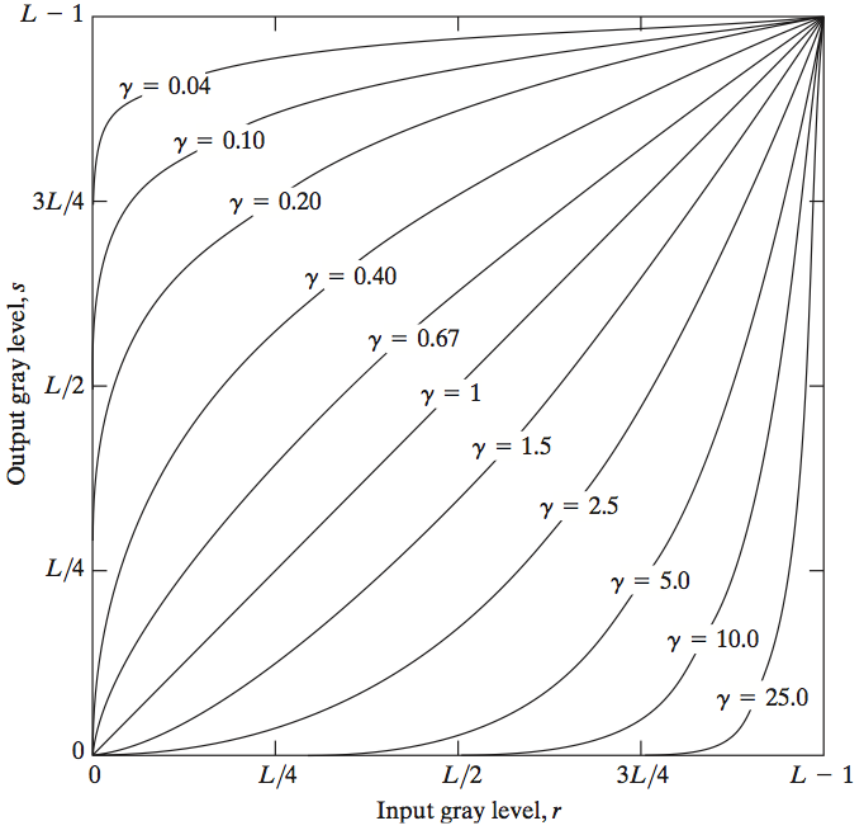
a b

FIGURE 3.5
(a) Fourier spectrum.
(b) Result of applying the log transformation given in Eq. (3.2-2) with $c = 1$.



$s = c \log(1+r)$

Power-Law (Gamma) Transformations



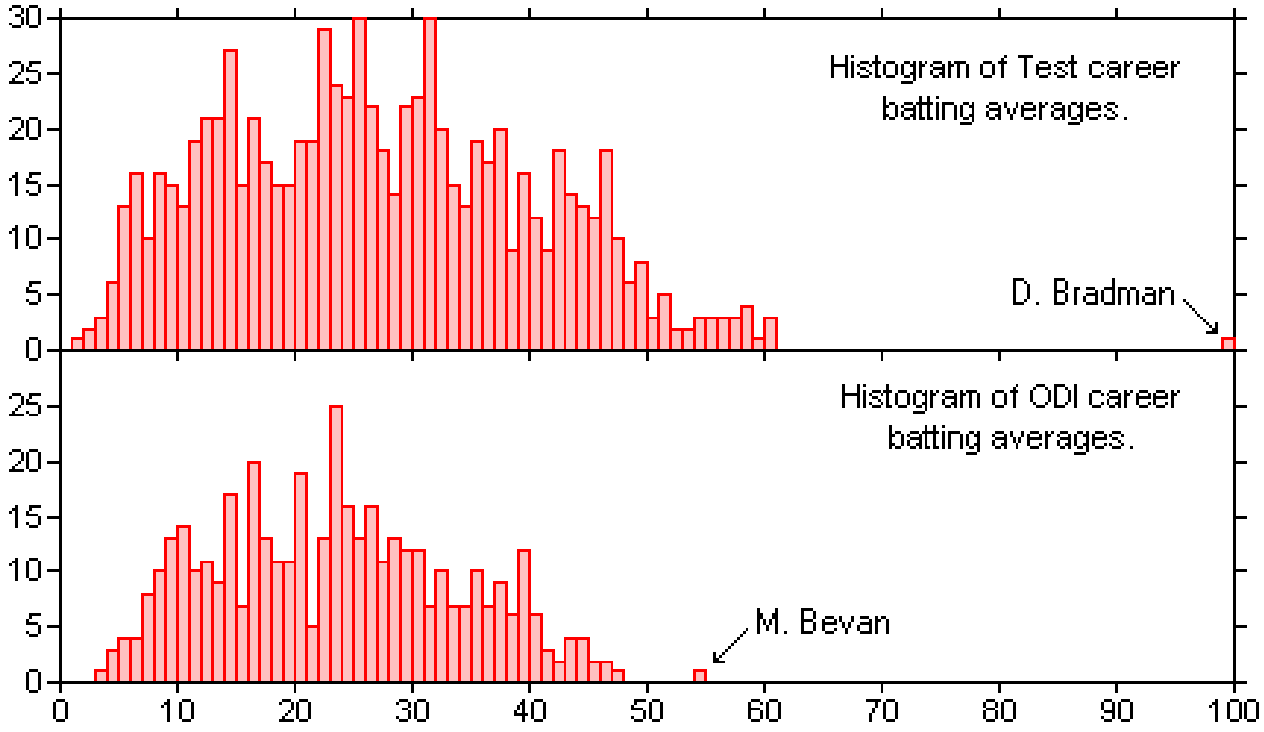
$s = c\, r^{\gamma}$

Power-Law Transformations

a b
c d

FIGURE 3.9
(a) Aerial image. (b)–(d) Results of applying the transformation in Eq. (3.2-3) with $c = 1$ and $\gamma = 3.0, 4.0$, and 5.0, respectively. (Original image for this example courtesy of NASA.)

Histogram



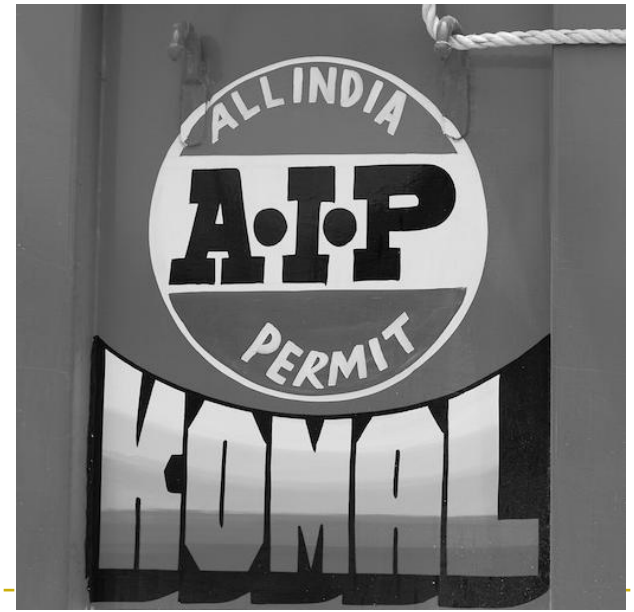
Courtesy: wikipedia

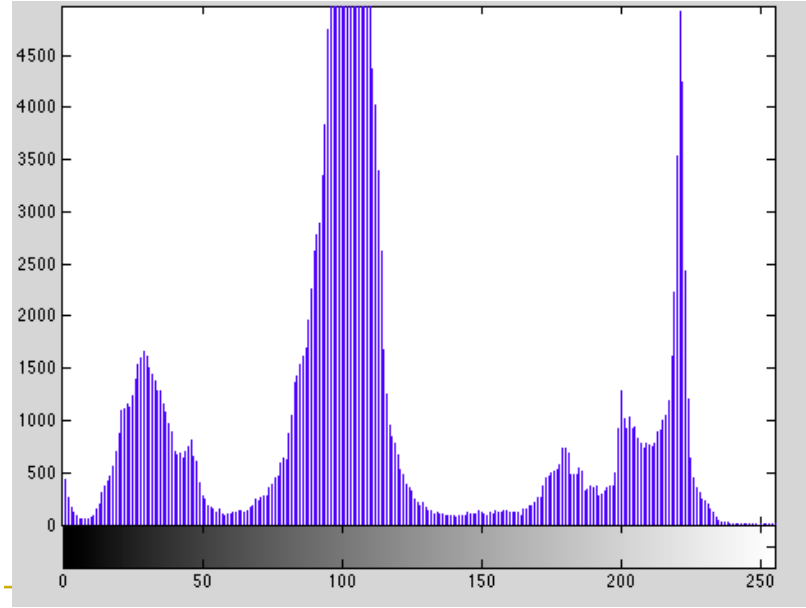
Histogram

$$h_r(i) = n_i$$

i → intensity value, range [0 L-1]

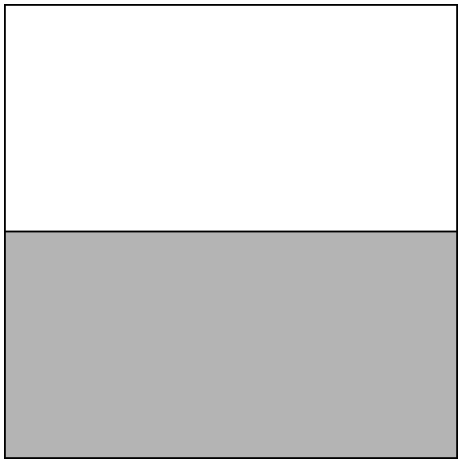
n_i → number of pixels with intensity i

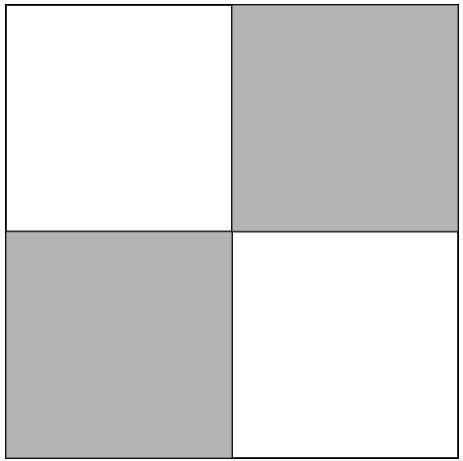


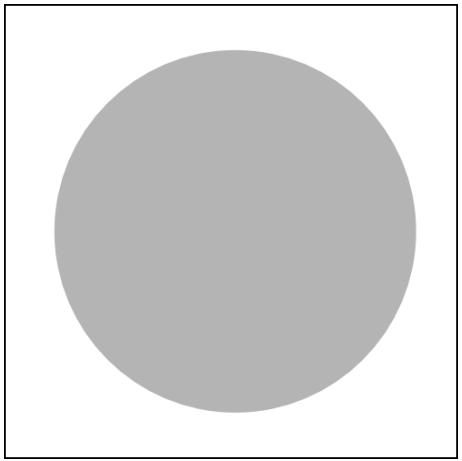


Histograms

- Different images can have same histogram







- No information about spatial distribution of intensity values

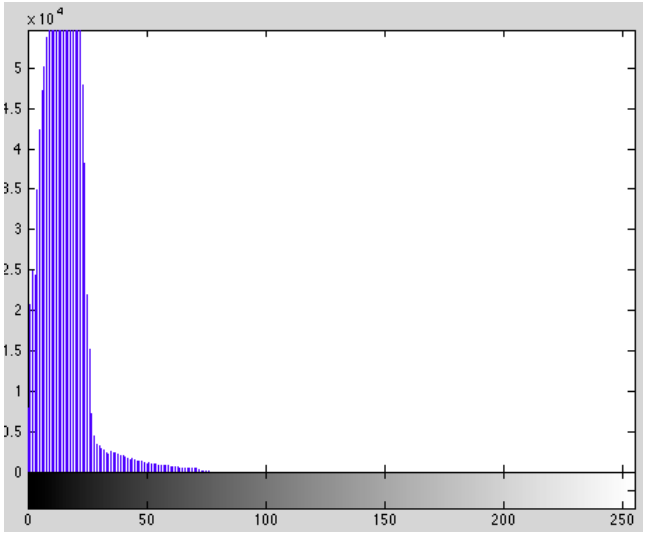
Histograms

- What can we infer from histograms?

Histogram viewing standard in most DSLR cameras

Histograms

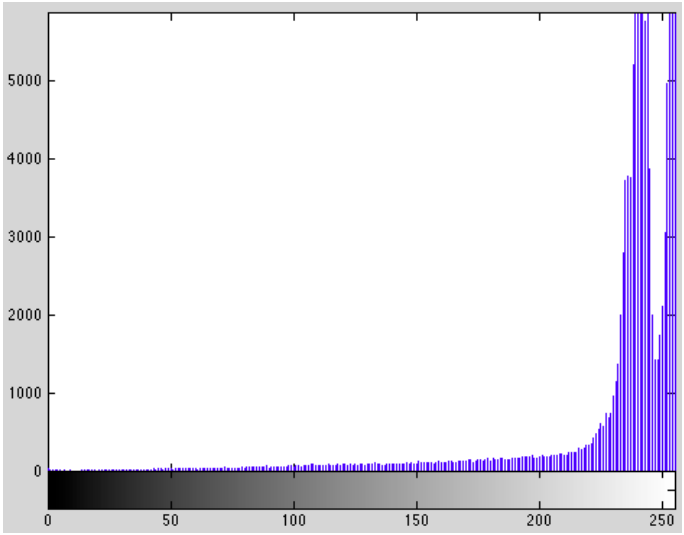
- Histograms and brightness



Under exposure

Histograms

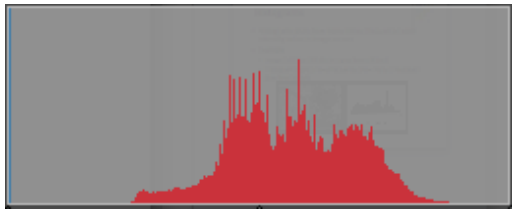
- Histograms and brightness

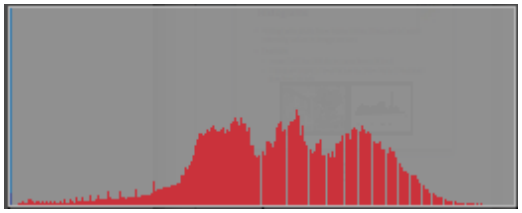


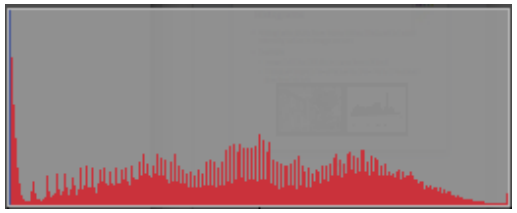
Over exposure

Histograms

- Histogram and contrast

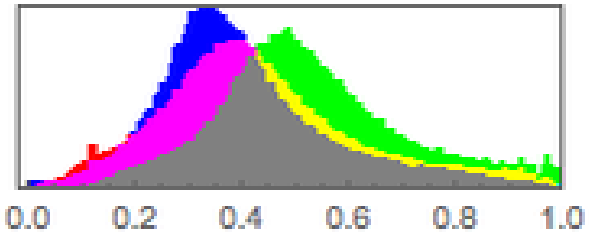



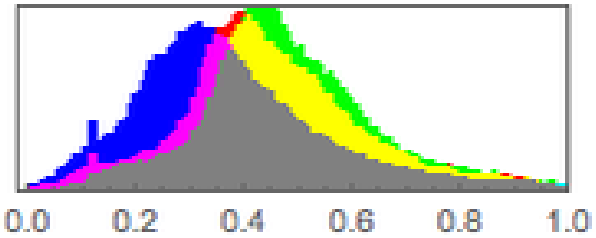


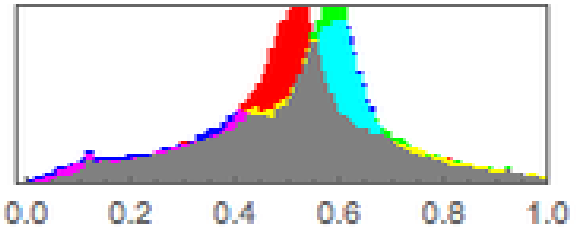


Histogram

Histogram as color distribution



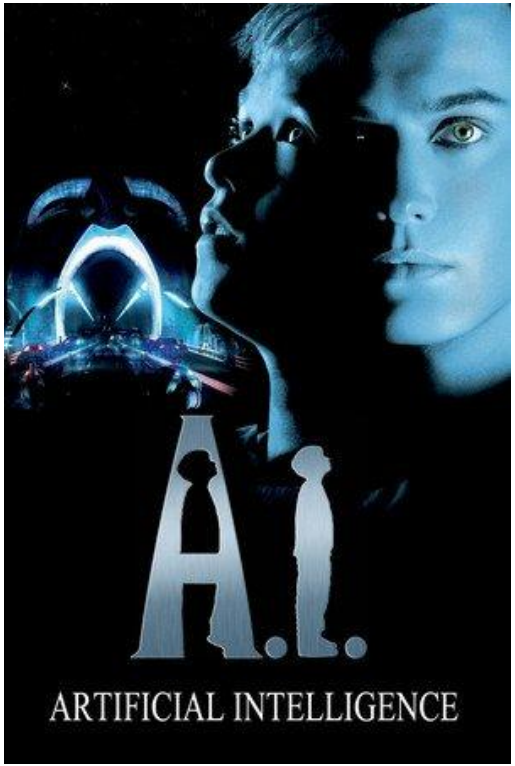




Time for a (de)tour!

Processing Images for Whom?

vs.



Processing Images for Whom?

vs.