24.08.2021

Digital Image Processing (CSE/ECE 478)

Lecture-2: Recap

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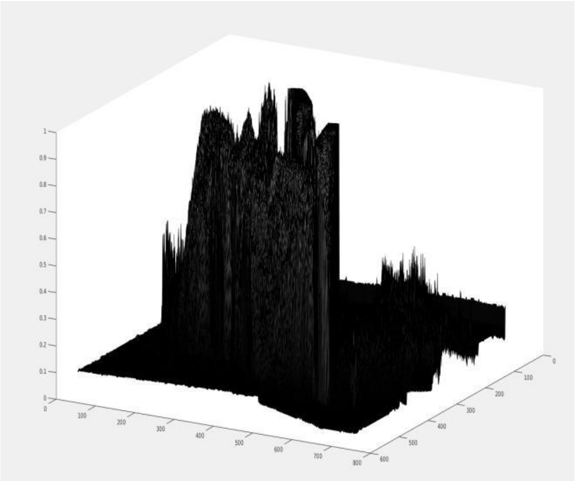
Image as a function / 3D surface

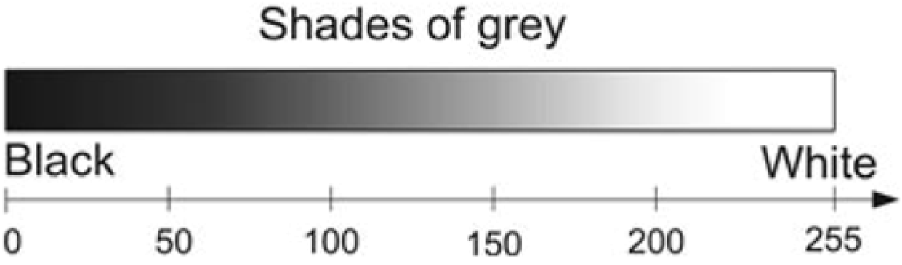
- $f(x,y) = z$
- Domain : (x,y)
- Range = Intensity

x

y

Clickto add text

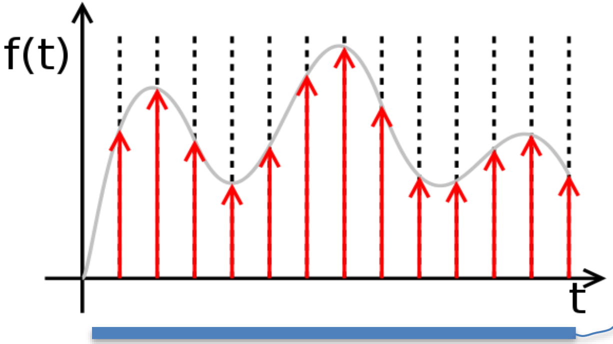




Demo:

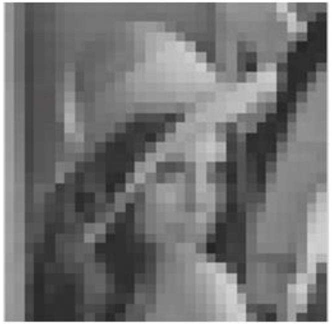
https://colab.research.google.com/drive/11qIL0VKleZnONtPuxAryAf9WkUC7kEMI#scrollTo=ViONAp9VVzpB

Summary



Sampling

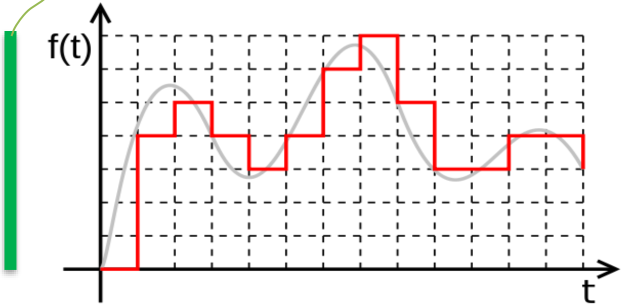
256 × 256



32 × 32

16 × 16

Quantization



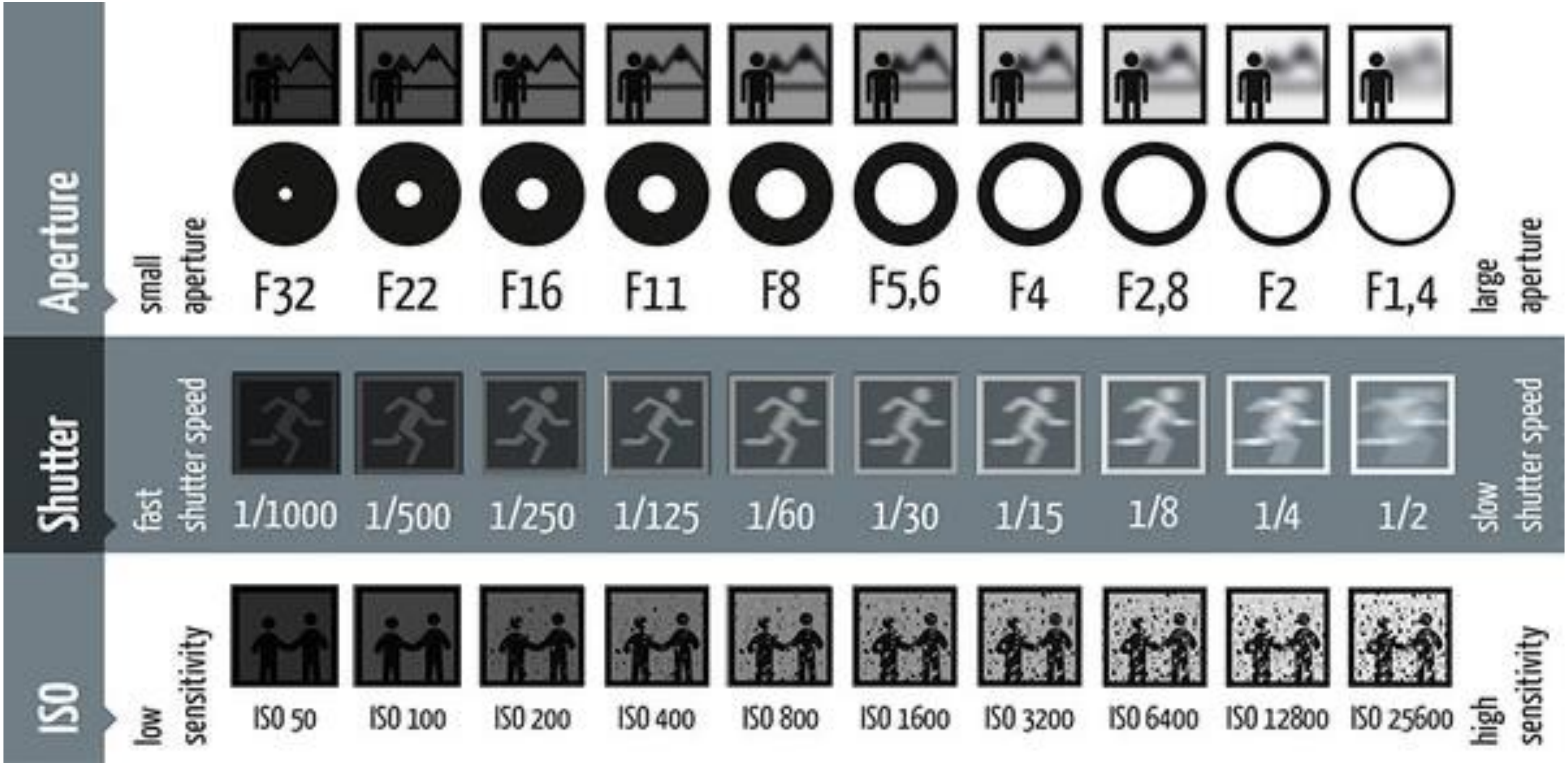
8 bits per pixel

4 bits per pixel

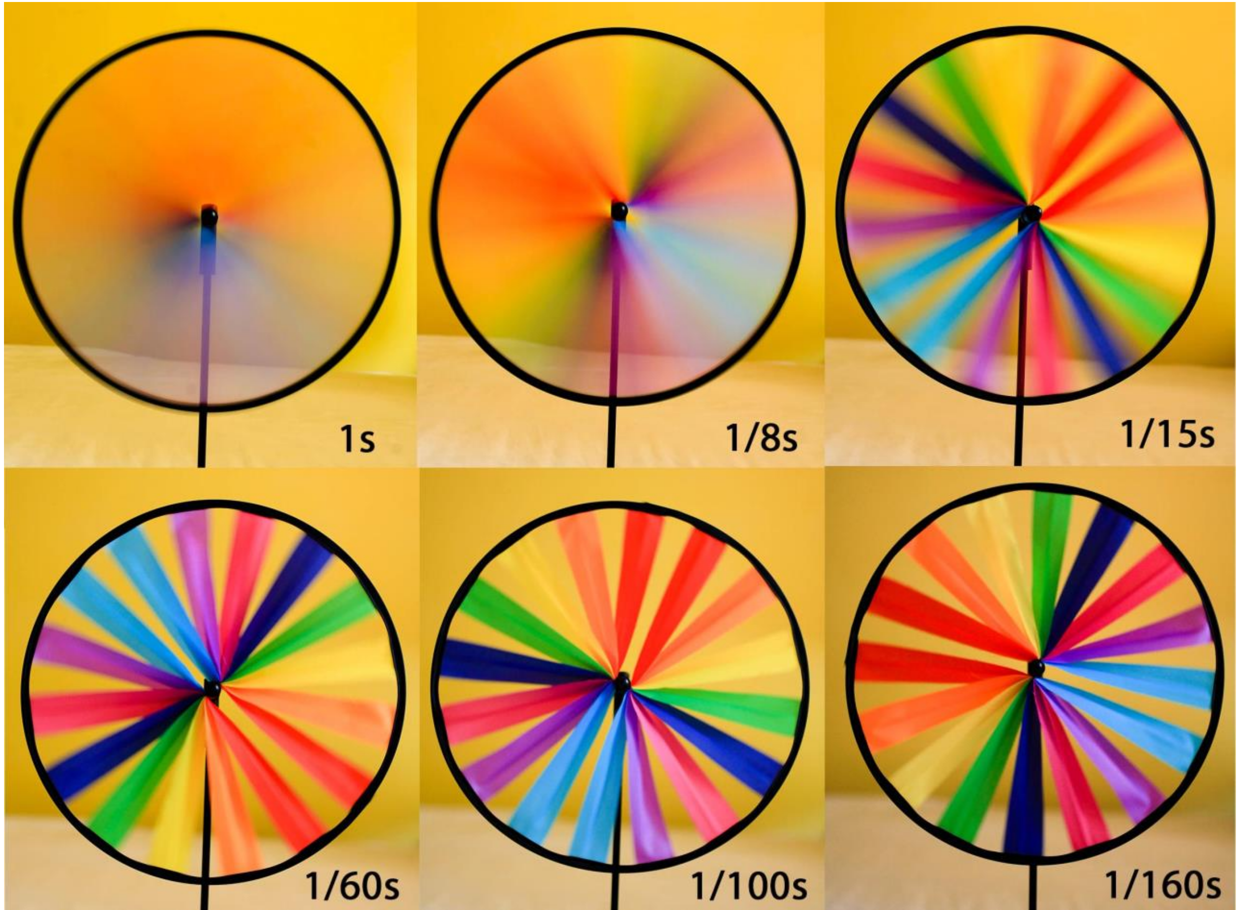
2 bits per pixel

1 bit per pixel

Temporal Sampling


Aperture
small aperture
F32
F22
F16
F11
F8
F5,6
F4
F2,8
F2
F1,4
large aperture
Shutter
fast shutter speed
1/1000
1/500
1/250
1/125
1/60
1/30
1/15
1/8
1/4
1/2
slow shutter speed
ISO
low sensitivity
ISO 50
ISO 100
ISO 200
ISO 400
ISO 800
ISO 1600
ISO 3200
ISO 6400
ISO 12800
ISO 25600
high sensitivity

Temporal Sampling



Temporal Sampling

24.08.2021

Digital Image Processing (CSE/ECE 478)

Lecture-3: Intensity Transforms, Histogram Processing

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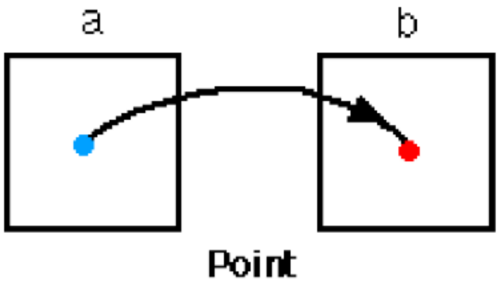
Image Processing – Two Paradigms

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

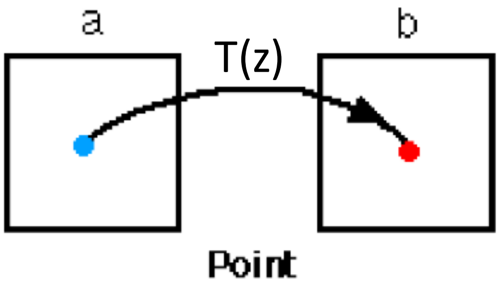
Spatial Domain Processing

- Manipulating Pixels Directly in Spatial Domain
- 3 approaches
- 1. Point to Point



Intensity Transforms – Point to Point

- $z = a(x,y)$
- $z' = b(x,y) = T(z) = T(a(x,y))$



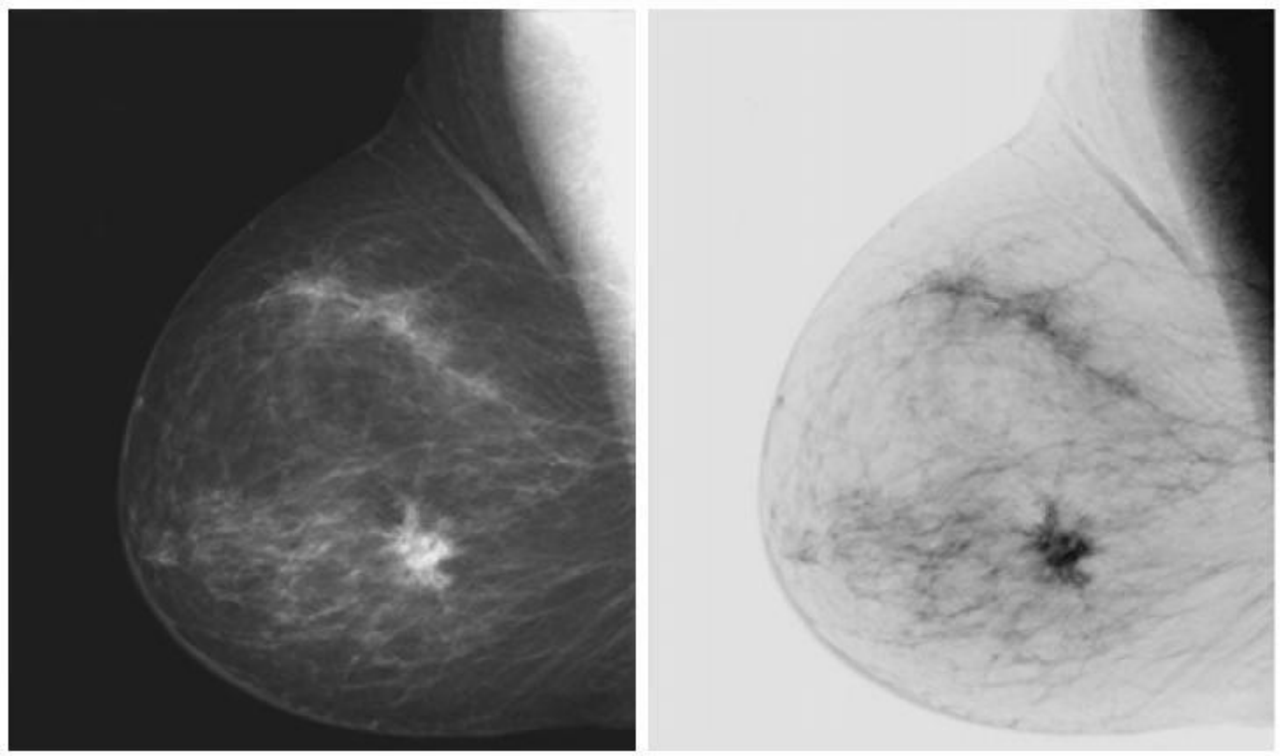
Intensity levels r:[0, L-1]

Click to add text

Click to add text

Image Negatives

Intensity levels r:[0, L-1]   s = T(r) =



a b

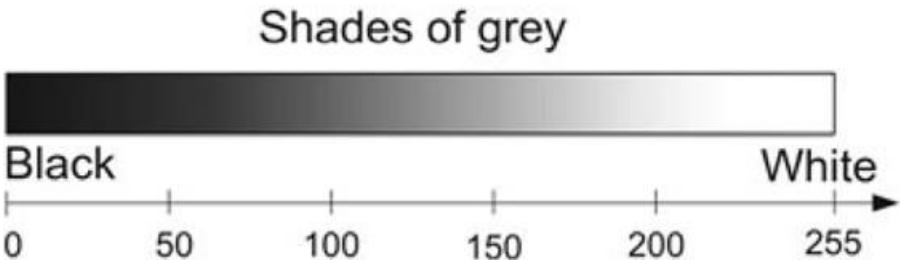
FIGURE 3.4 (a) Original digital mammogram. (b) Negative image obtained using the negative transformation in Eq. (3.2-1). (Courtesy of G.E. Medical Systems.)

Intensity Transforms

- $T(z) = z + K$

- $T(z) = z - K$

Demo: https://colab.research.google.com/drive/11qIL0VKleZnONtPuxAryAf9WkUC7kEMI#scrollTo=WkBKnKz7aS6O&line=1&uniqifier=1

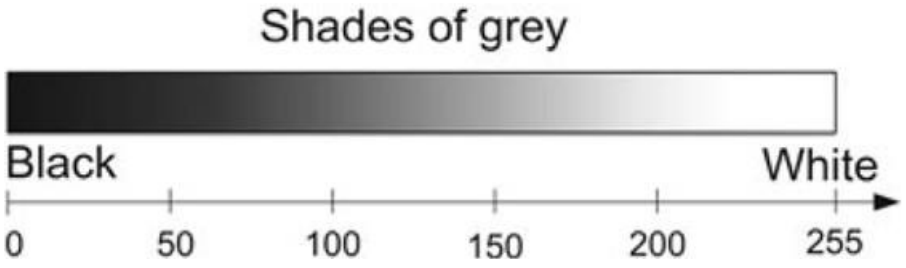


Storage v/s Display

- 8-bit image : [0,255]
- 4-bit image : [0,15]
- Demo: https://colab.research.google.com/drive/11qIL0VKleZnONtPuxAryAf9WkUC7kEMI#scrollTo=WkBKnKz7aS6O&line=1&uniqifier=1

Linear Intensity Transforms

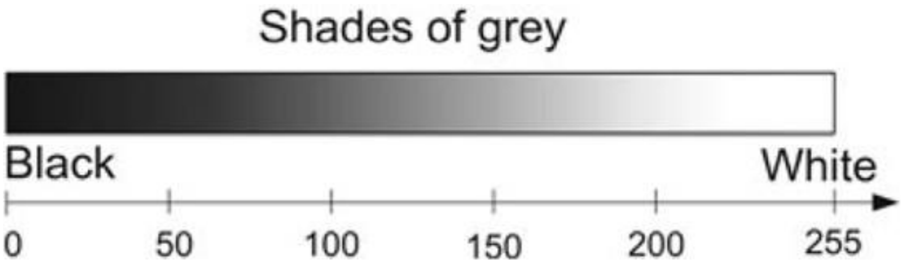
- $T(z) = z + K$
- $T(z) = z - K$
- $T(z) = Kz$
- $T(z) = K_1 z + K_2$



Data visualization: Map to display range

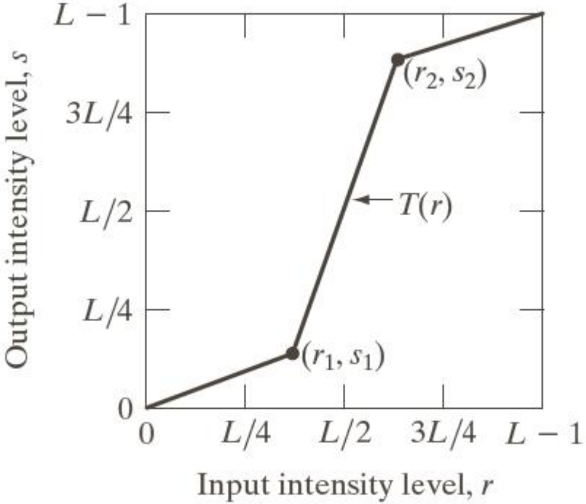
Normalize to range :

$$J = \texttt{round}\left(255 * \frac{I - min(I)}{max(I) - min(I)}\right)$$

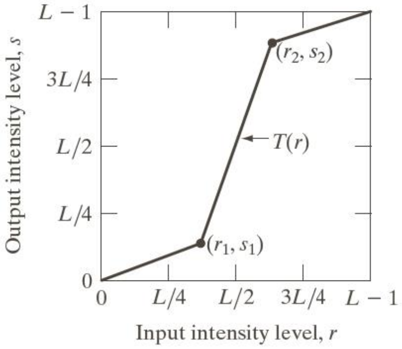


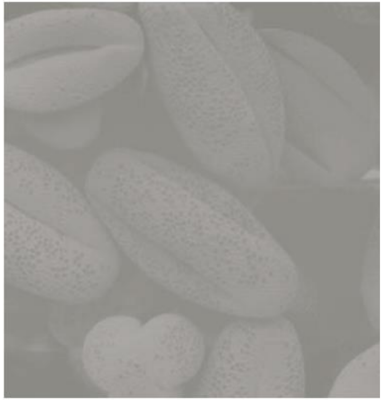
Piecewise-Linear Transformations

- Can be arbitrarily complex
- Finer control over transformation

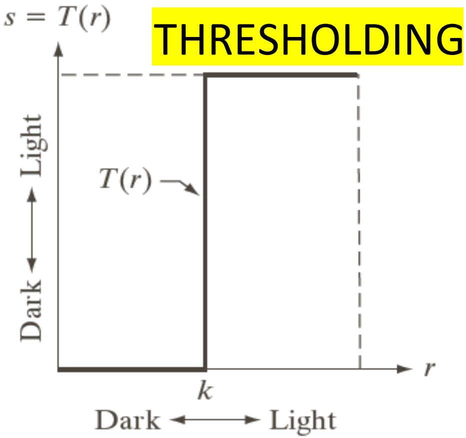


Piecewise-Linear Transformations





THRESHOLDING

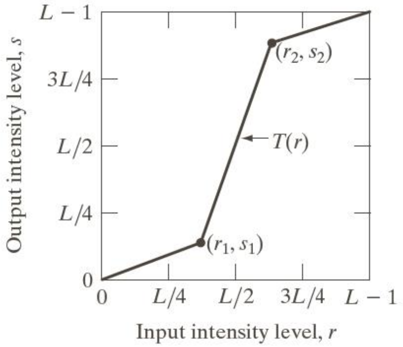


?

$(r1,s1) = ?$

$(r2,s2) = ?$

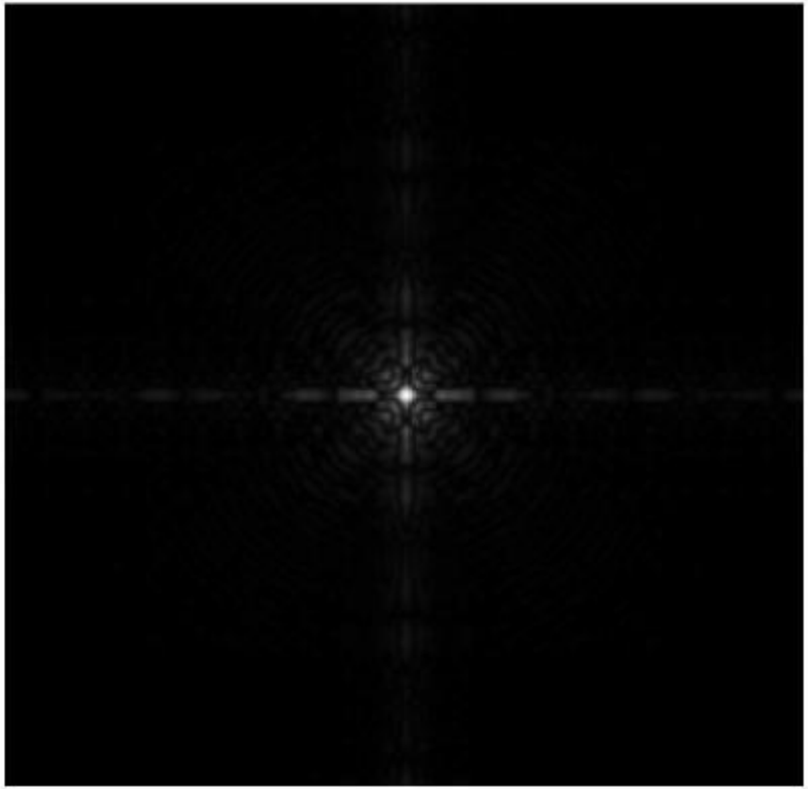
Piecewise-Linear Transformations - Contrast stretching



Expand intensity range to full intensity range

What are the constraints on (r1,s1) and (r2,s2) ?

Non-linear Intensity Transformations



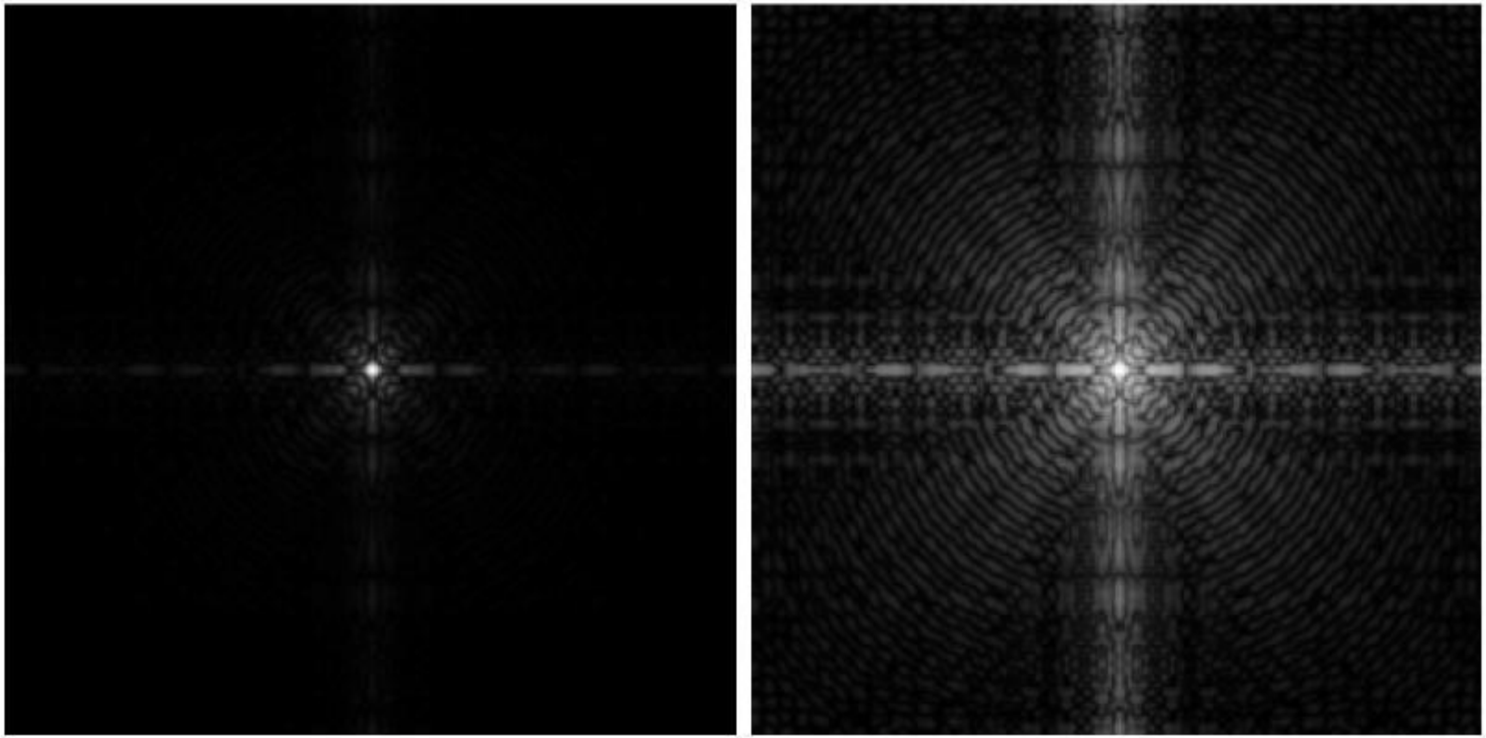
Demo:
https://colab.research.google.com/drive/11qIL0VKleZnONtPuxAryAf9WkUC7kEMI#scrollTo=PQ4N62YyFesG

Range : $[0, 10^6]$

Log Transformations

a b

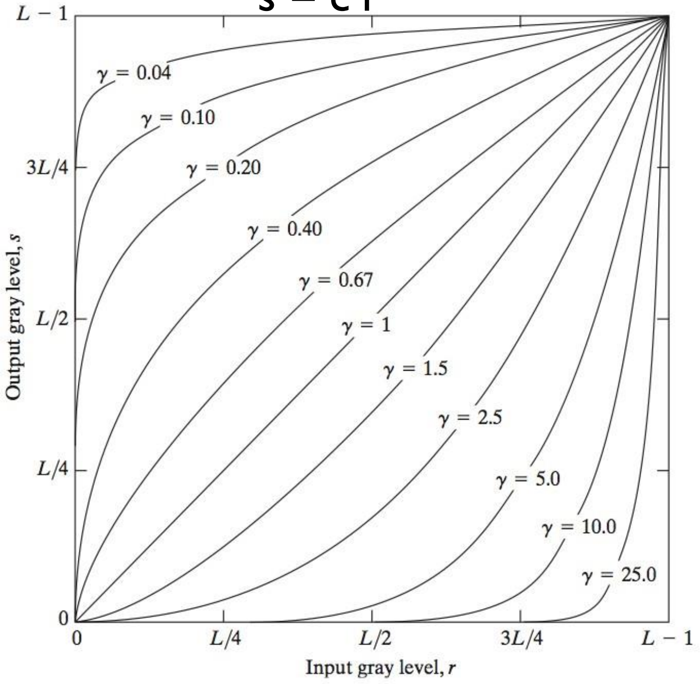
FIGURE 3.5 (a) Fourier spectrum. (b) Result of applying the log transformation given in Eq. (3.2-2) with $c = 1$.

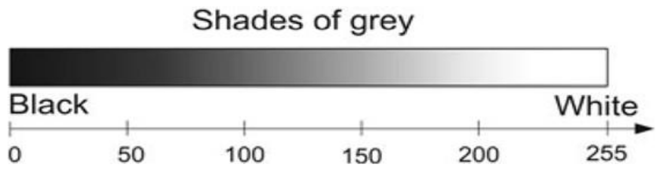


$$s = T(r) = c\ log(1 + r)$$

Power-Law Transformations

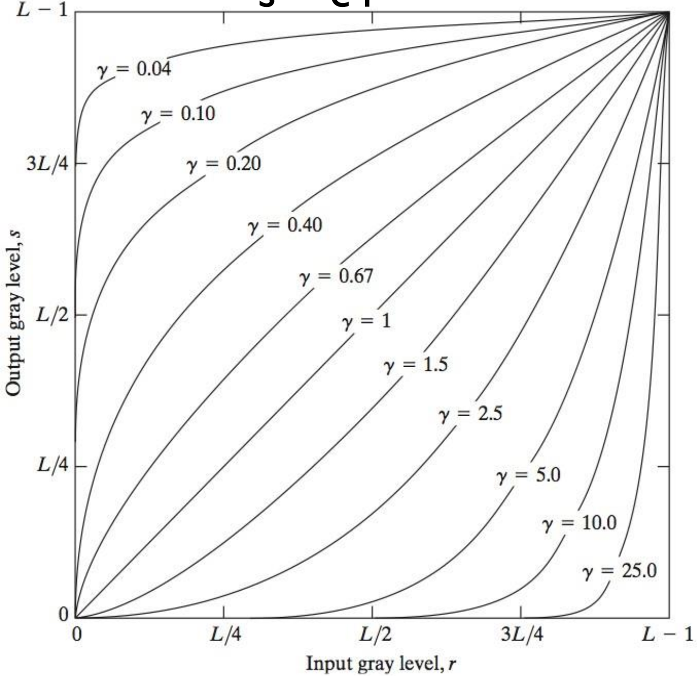
$s = c\,r^{\gamma}$

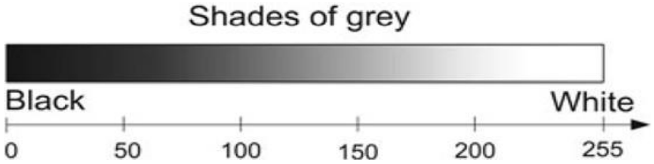




Power-Law Transformations

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



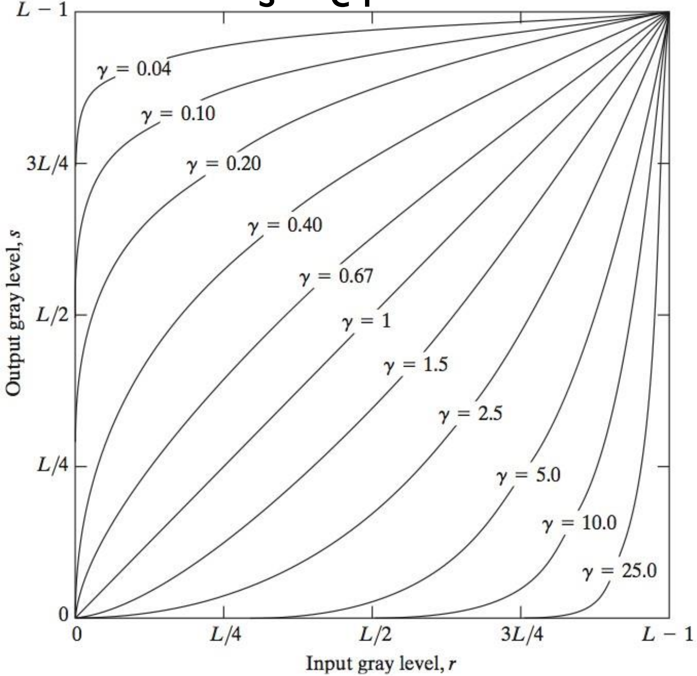


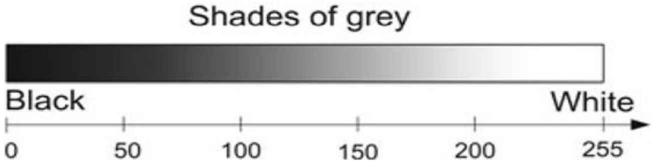
a b
c d

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.)

Power-Law Transformations

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



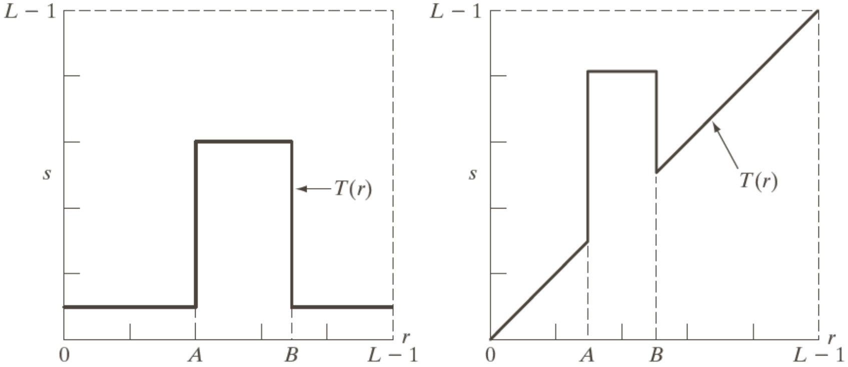


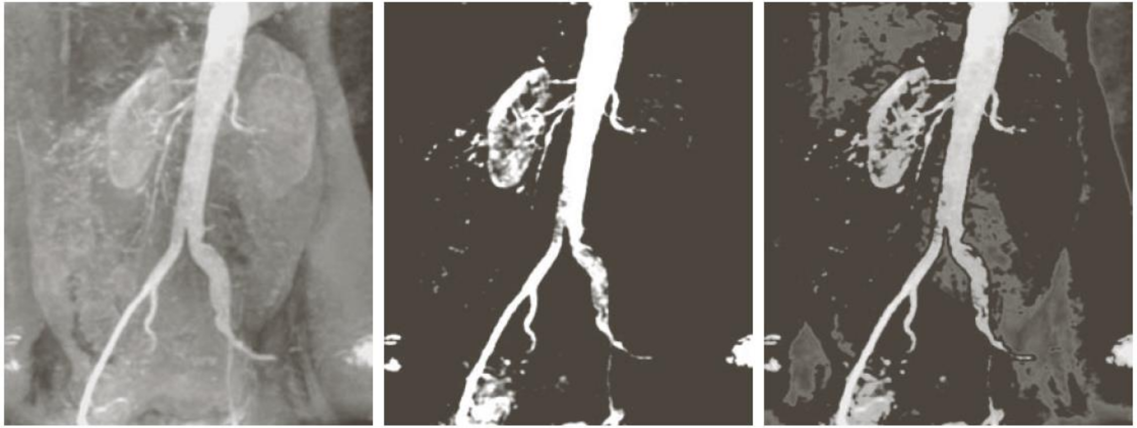
Demo:
https://colab.research.google.com/drive/11qIL0VKleZnONtPuxAryAf9WkUC7kEMI#scrollTo=aU5WQaqOpSCr&line=12&uniqifier=1

Intensity Slicing

a b

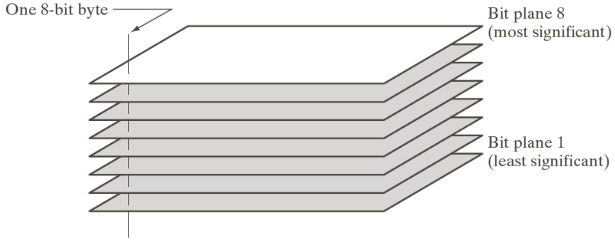
FIGURE 3.11 (a) This transformation highlights intensity range [A, B] and reduces all other intensities to a lower level. (b) This transformation highlights range [A, B] and preserves all other intensity levels.





a b c

Bit plane slicing



a	b	c
d	e	f
g	h	i

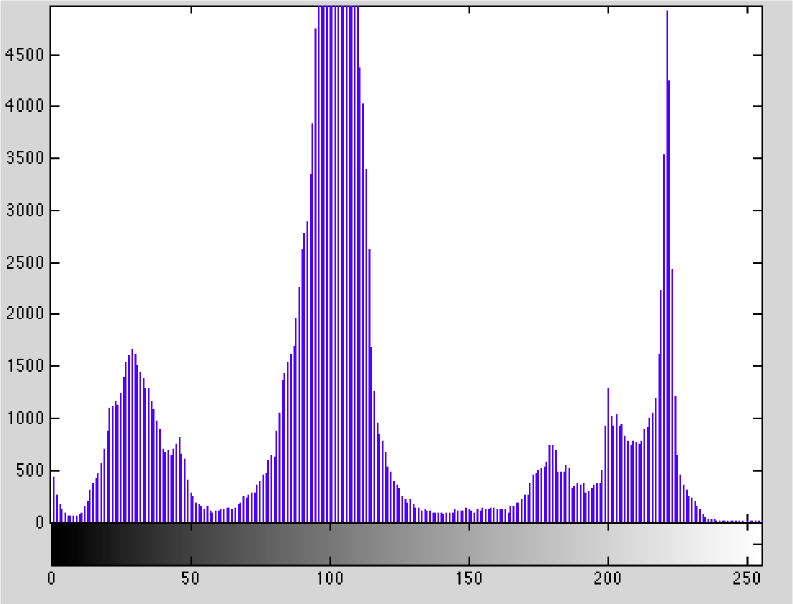
FIGURE 3.14 (a) An 8-bit gray-scale image of size 500 × 1192 pixels. (b) through (i) Bit planes 1 through 8, with bit plane 1 corresponding to the least significant bit. Each bit plane is a binary image.

Histogram

$$h_r(i) = n_i$$

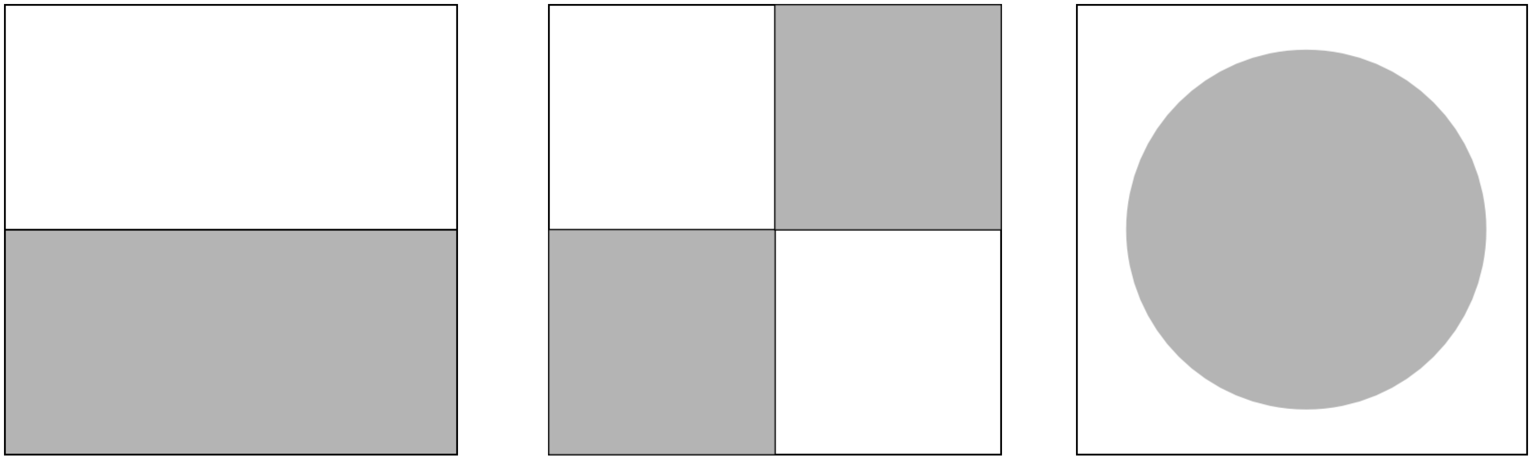
i → intensity value, range [0, L-1]

n_i → number of pixels with intensity i



Histograms

- Different images can have same histogram



- No information about spatial distribution of intensity values

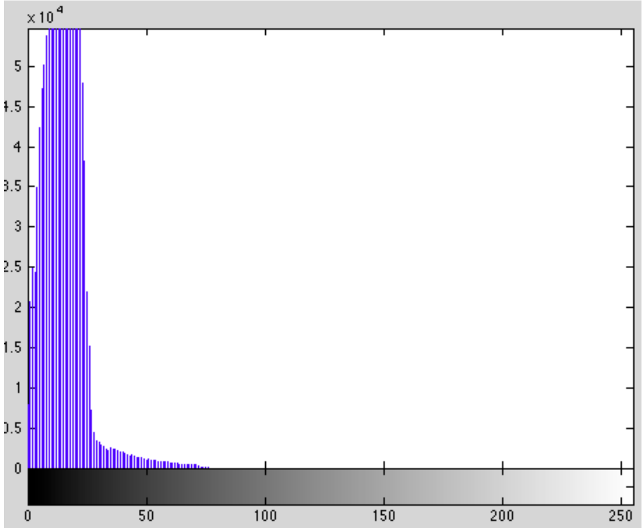
Histograms

- What can we infer from histograms?

Histogram viewing standard in most DSLR cameras

Histograms

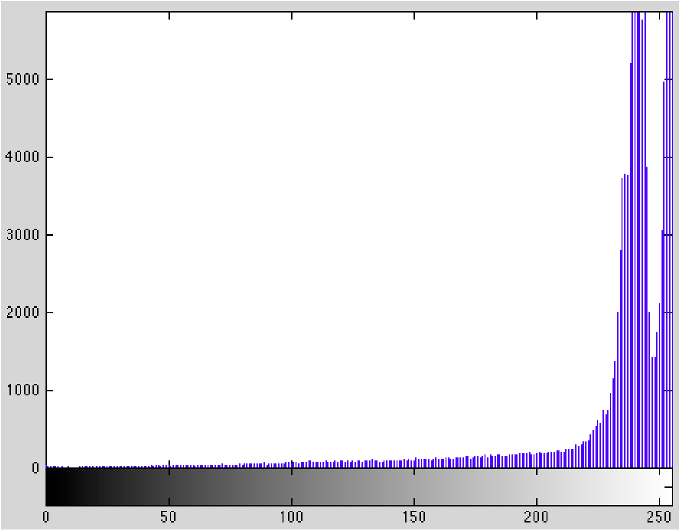
- Histograms and brightness



Under exposure

Histograms

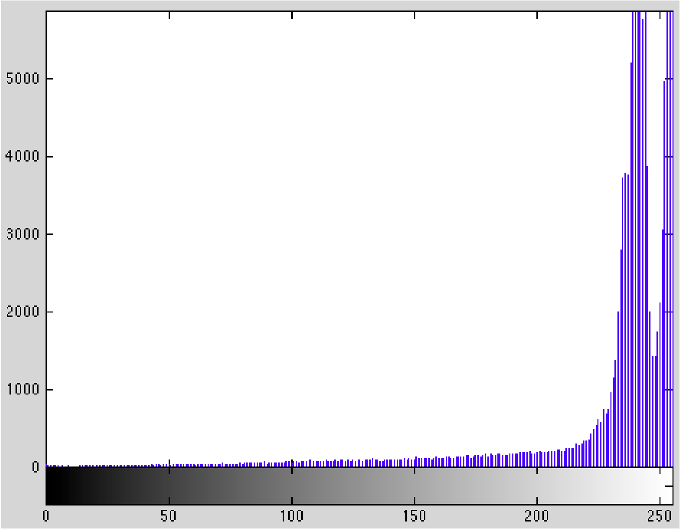
- Histograms and brightness



Over exposure

Histograms

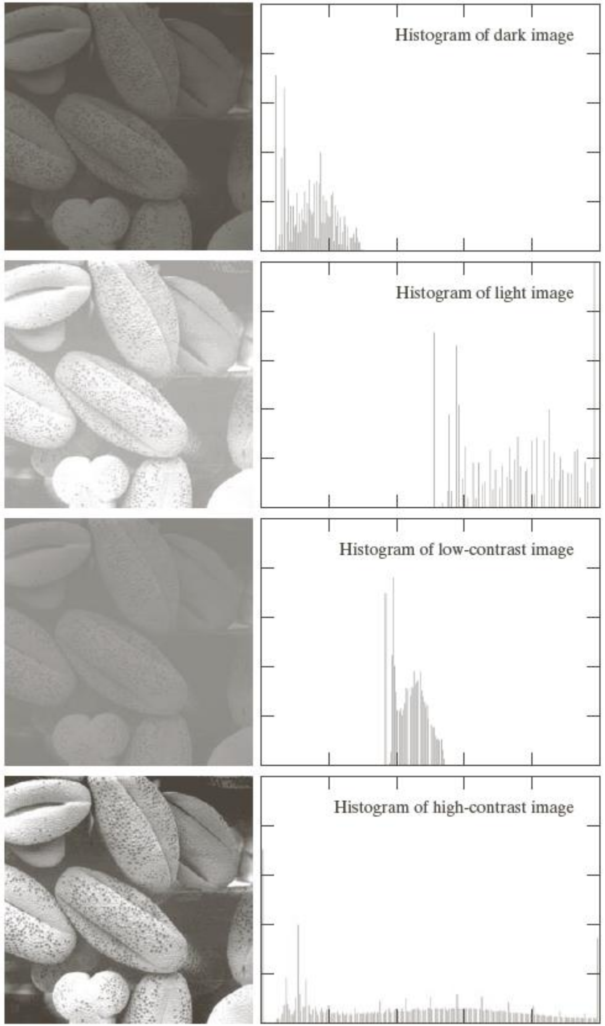
- Histograms and brightness



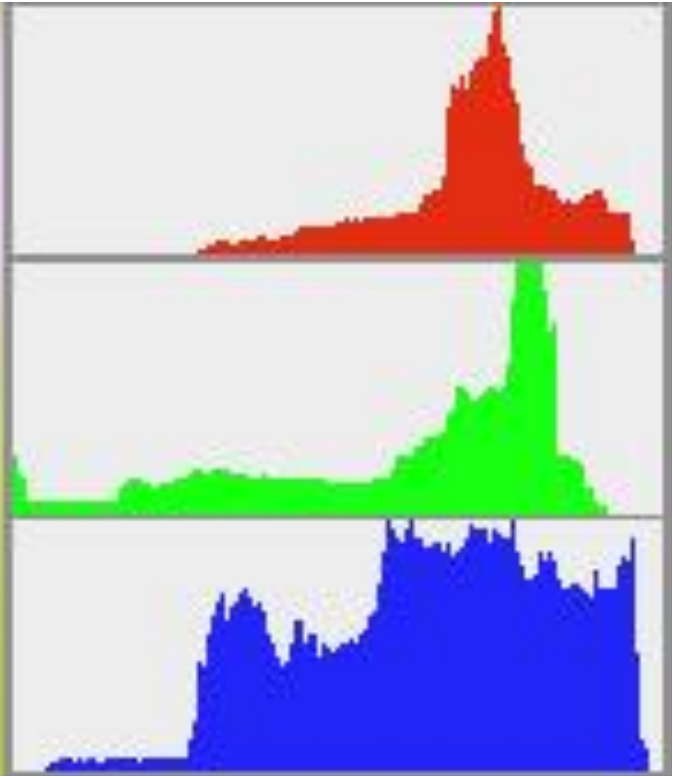
Over exposure

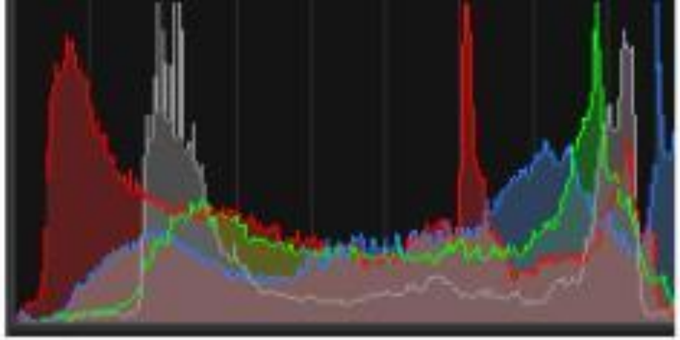
Histograms

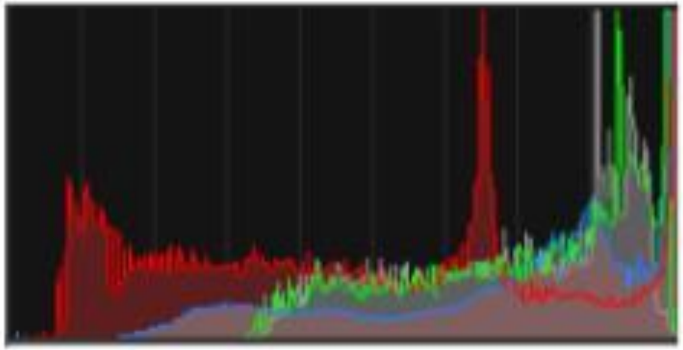
- Histogram and contrast

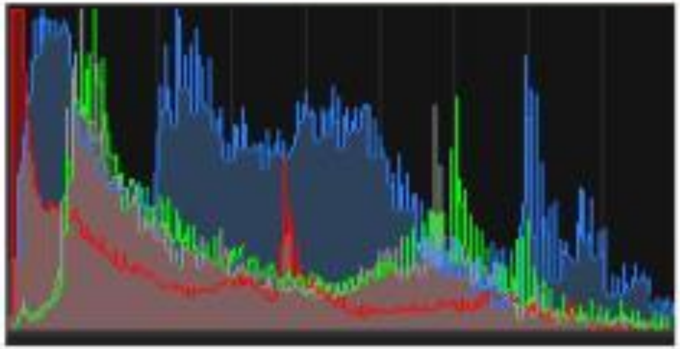


Histograms for RGB images

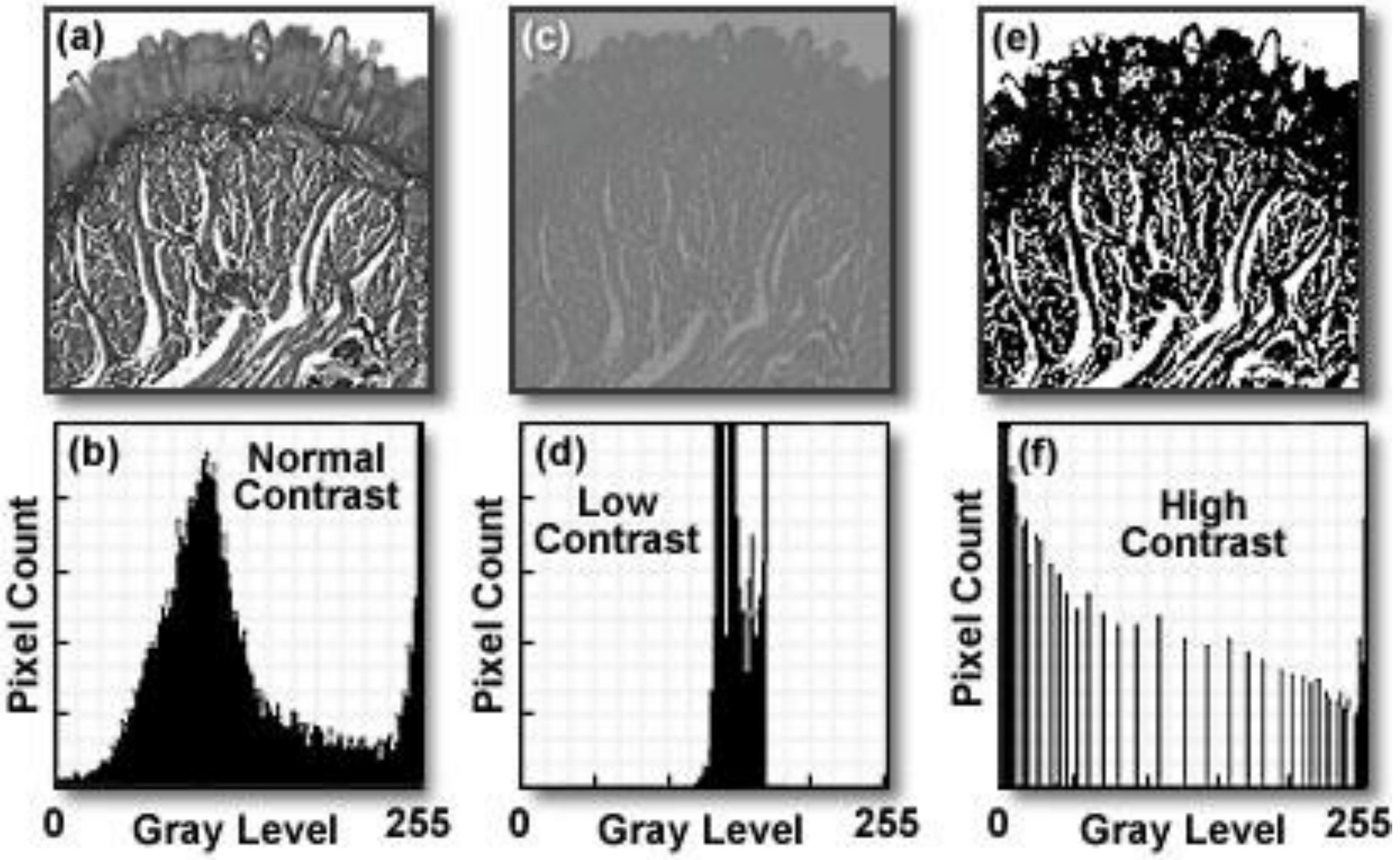




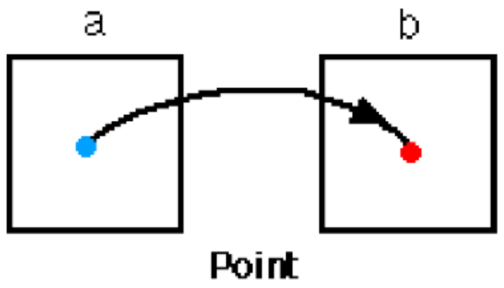


Grayscale Histograms and Contrast Levels in Digital Images



Summary

- Manipulating Pixels Directly in Spatial Domain
- 3 approaches
- 1. Point to Point



- Linear Intensity Transforms
  - E.g. Negative
- Non-linear Transforms
  - E.g. Logarithm
- Histogram