

18.08.2020

Digital Image Processing (CSE/ECE 478)

Lecture-2: Discussion

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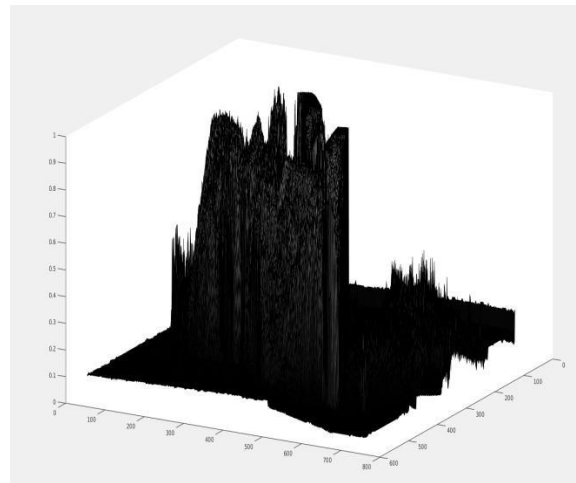
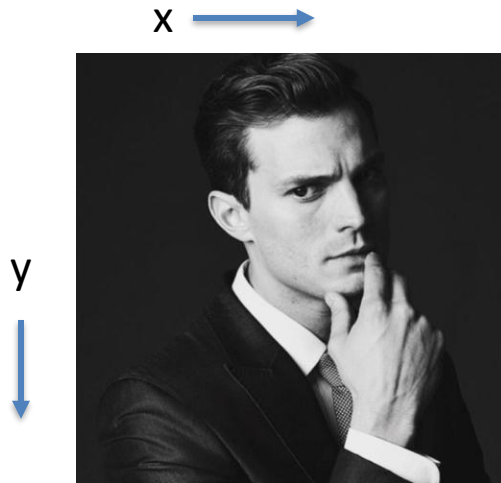


Image as a function / 3D surface

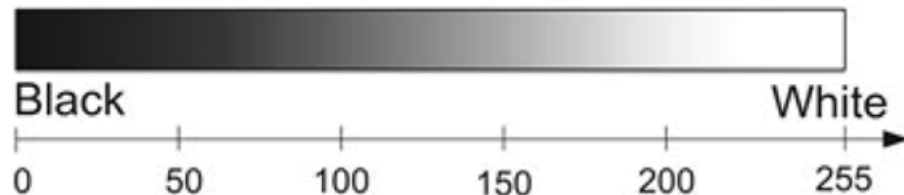
► $f(x,y) = z$

► Domain : (x,y)

► Range = Intensity



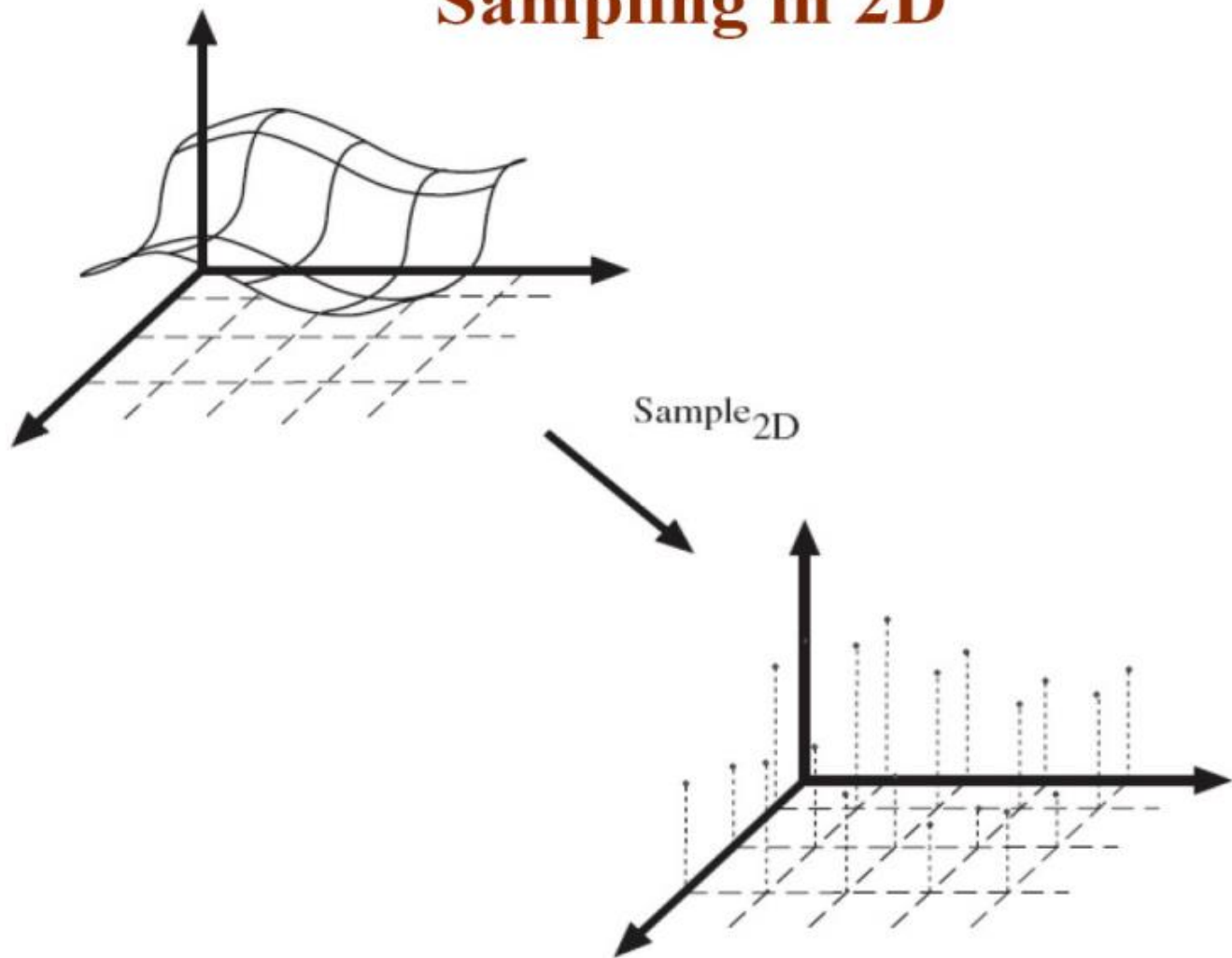
Shades of grey



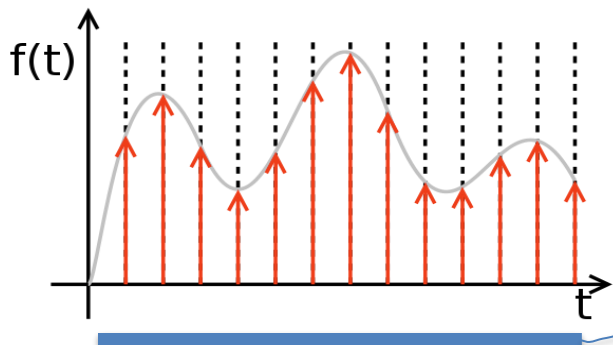
Demo:

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

Sampling in 2D



Summary



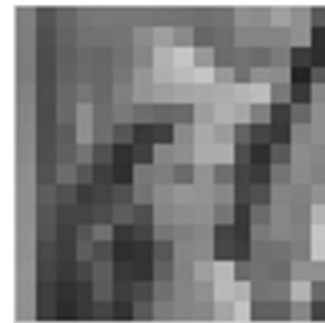
Sampling



256 × 256

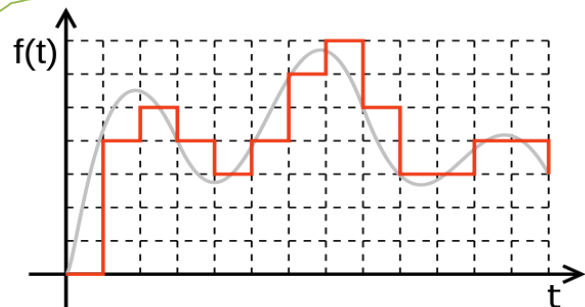


32 × 32



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



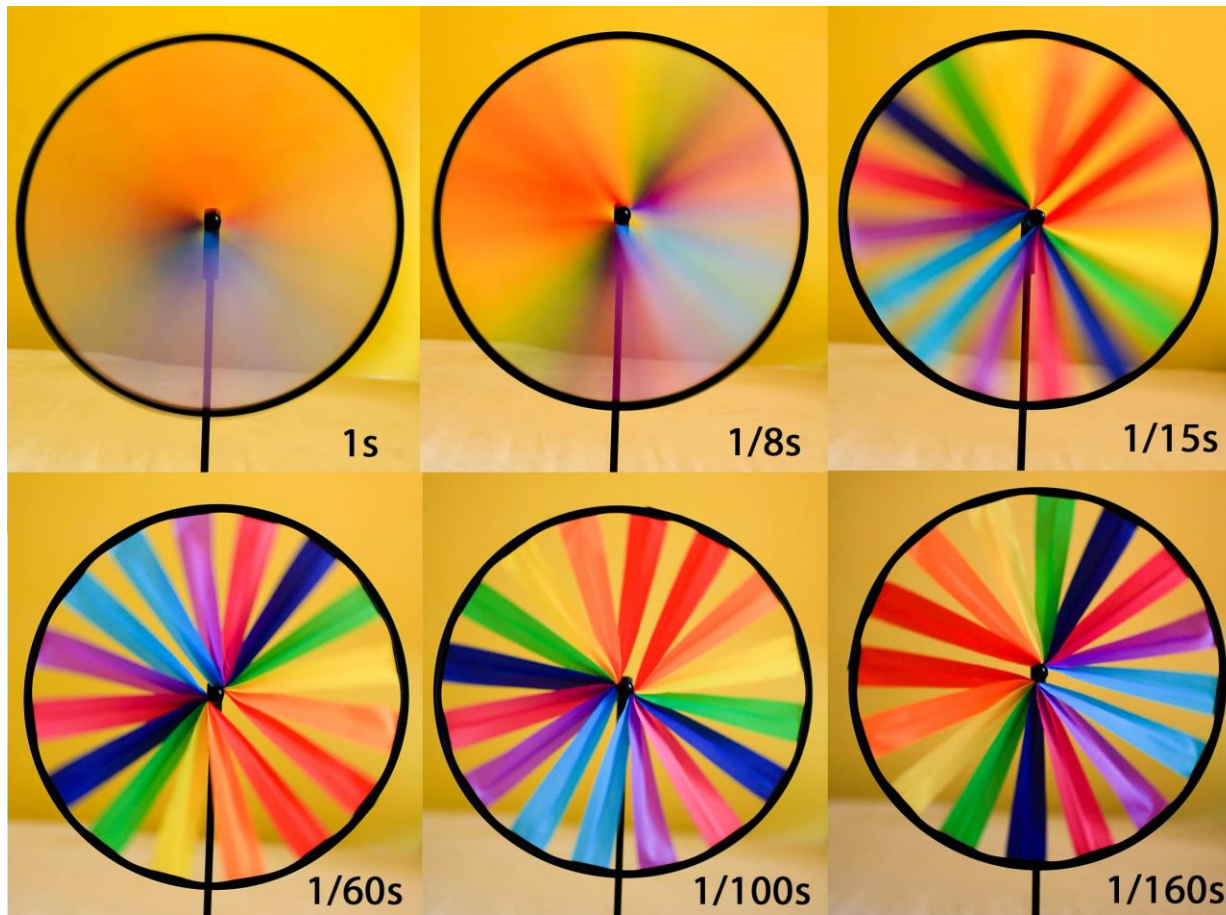
ISO 12800



ISO 25600

high
sensitivity

Temporal Sampling



Temporal Sampling



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Digital Image Processing (CSE/ECE 478)

Lecture-3: Intensity Transforms, Histogram Processing

Ravi Kiran

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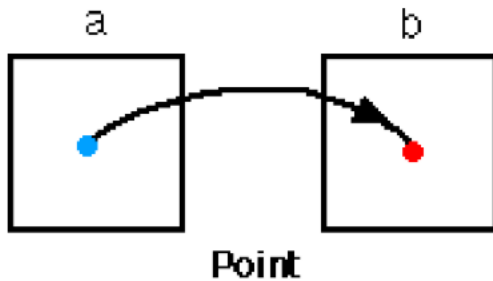


Image Processing – Two Paradigms

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

Spatial Domain Processing

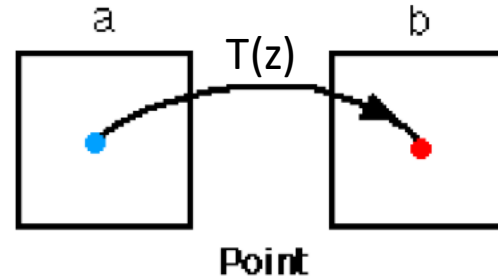
- ▶ Manipulating Pixels Directly in Spatial Domain
- ▶ 3 approaches
- ▶ 1. Point to Point



Intensity Transforms – Point to Point

► $a(x,y) = z$

► $b(x,y) = z' = T(z) = T(a(x,y))$



Intensity levels $r:[0, L-1]$

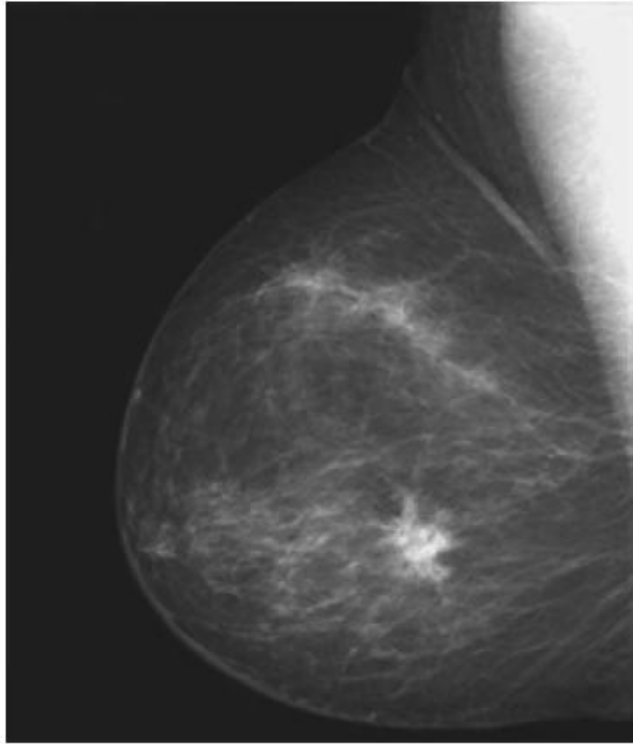
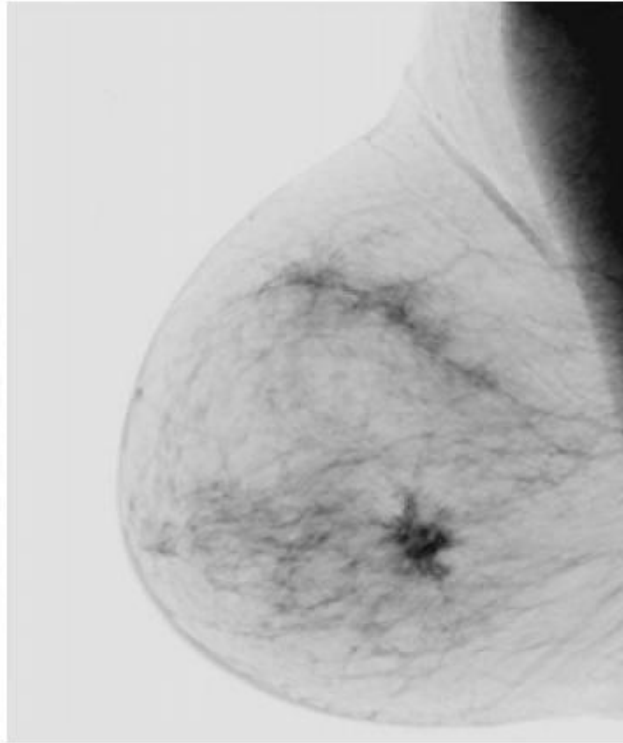
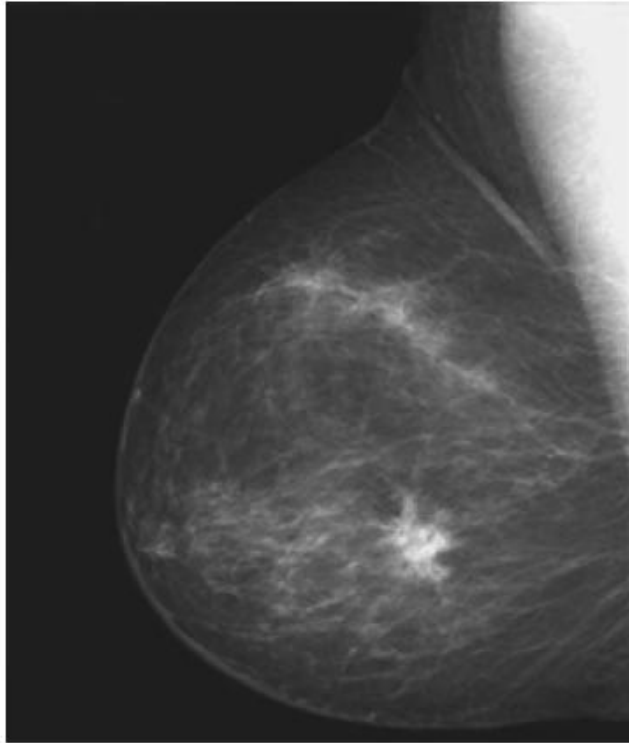


Image Negatives

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.)

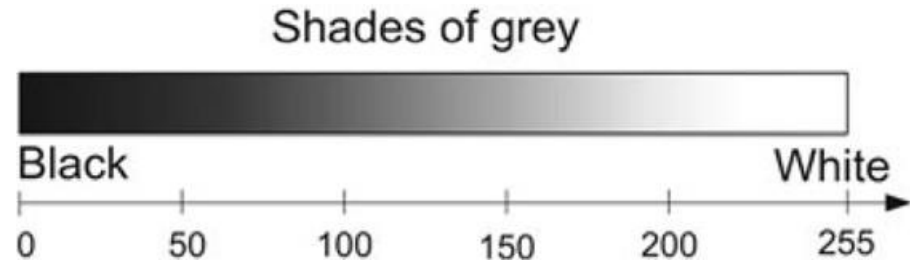
Intensity Transforms

► $T(z) = z + K$

► $T(z) = z - K$

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>

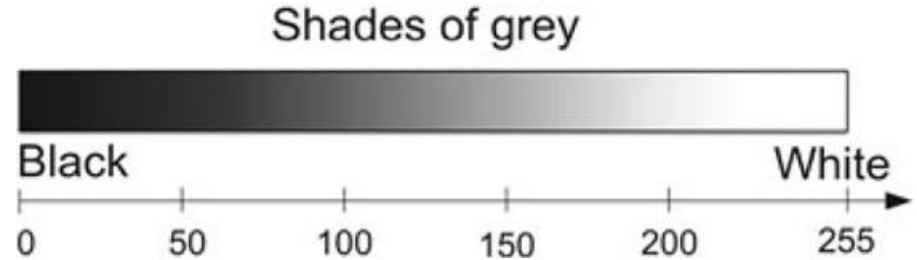
Linear Intensity Transforms

► $T(z) = z + K$

► $T(z) = z - K$

► $T(z) = Kz$

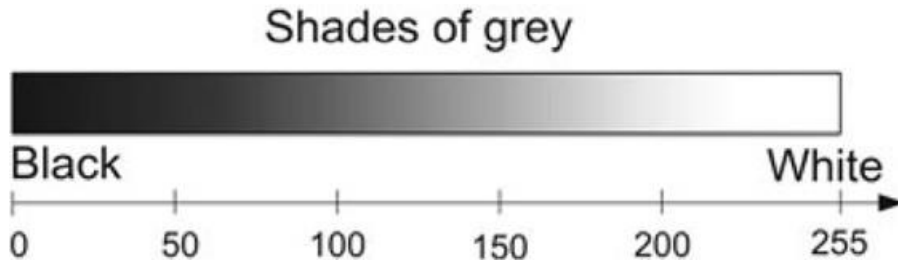
► $T(z) = K_1z + K_2$



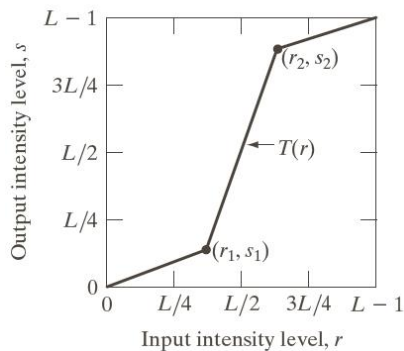
Data visualization: Map to display range

Normalize to range :

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

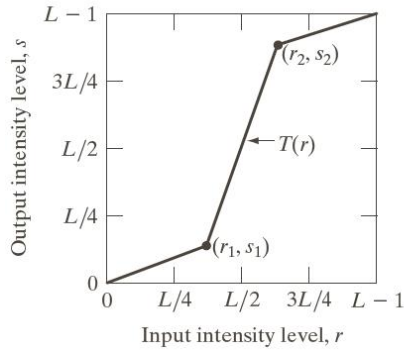


Piecewise-Linear Transformations



- Can be arbitrarily complex
- Finer control over transformation

Piecewise-Linear Transformations



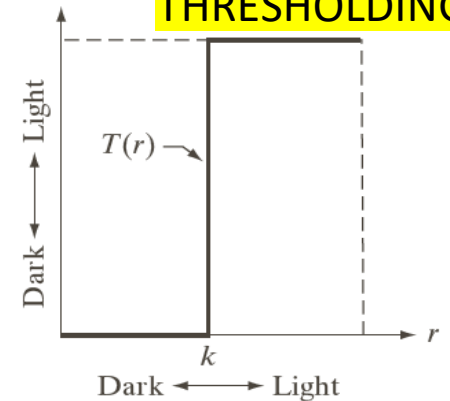
$$s = T(r)$$

THRESHOLDING



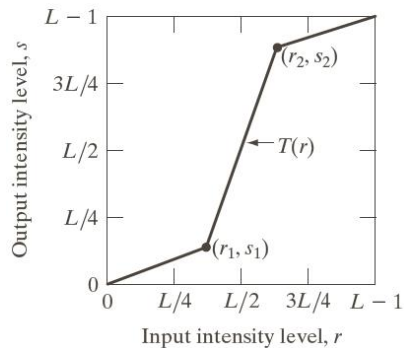
$$(r_1, s_1) = ?$$

$$(r_2, s_2) = ?$$



Piecewise-Linear Transformations

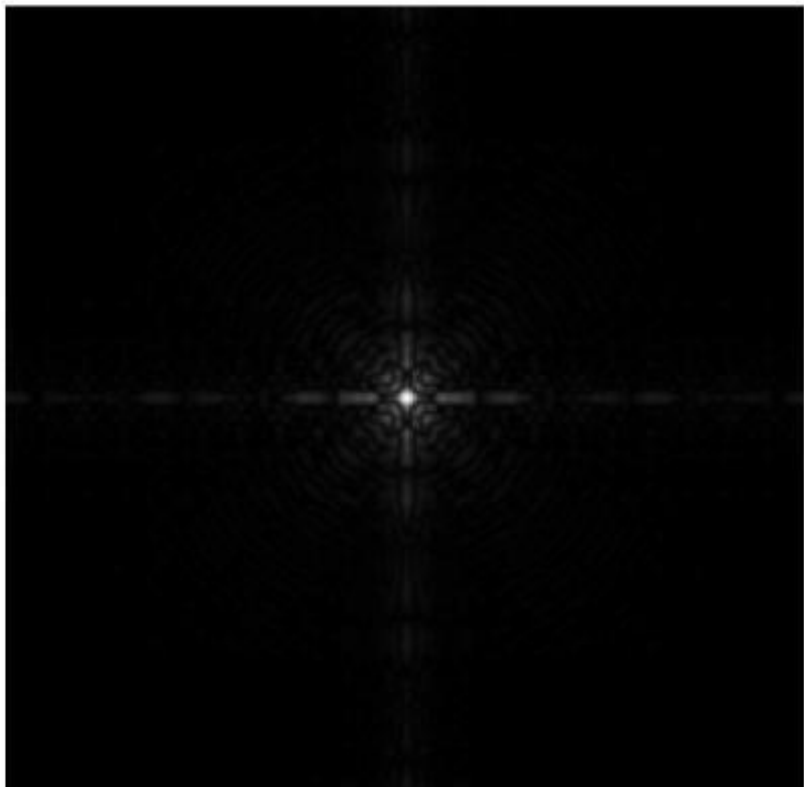
- Contrast stretching



Expand intensity range to **full intensity range**

What are the constraints on (r_1, s_1) and (r_2, s_2) ?

Non-linear Intensity Transformations



Demo:

<https://colab.research.google.com/drive/11qIL0VKleZnONTpuxAryAf9WkUC7kEMI#scrollTo=PQ4N62YyFesG>

Range : $[0, 10^6]$

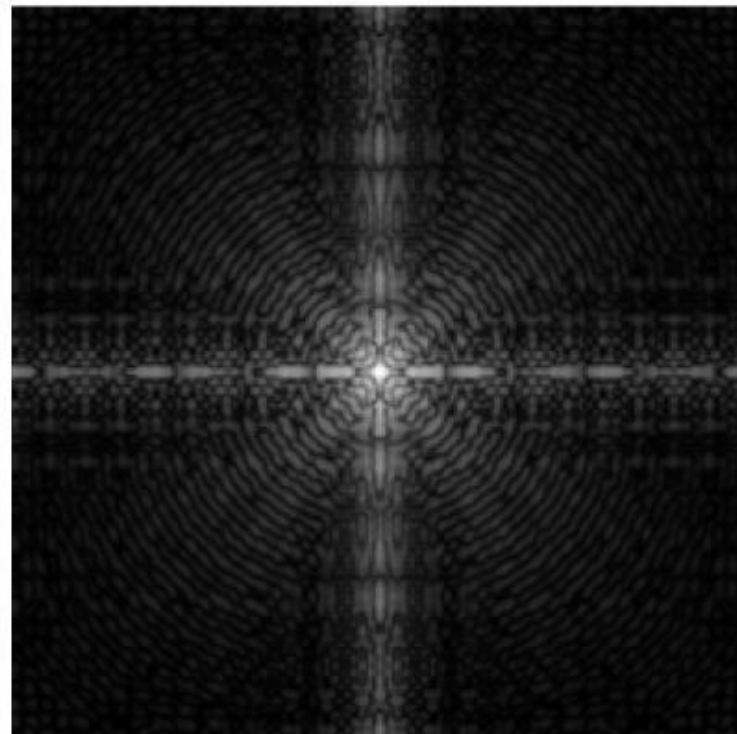
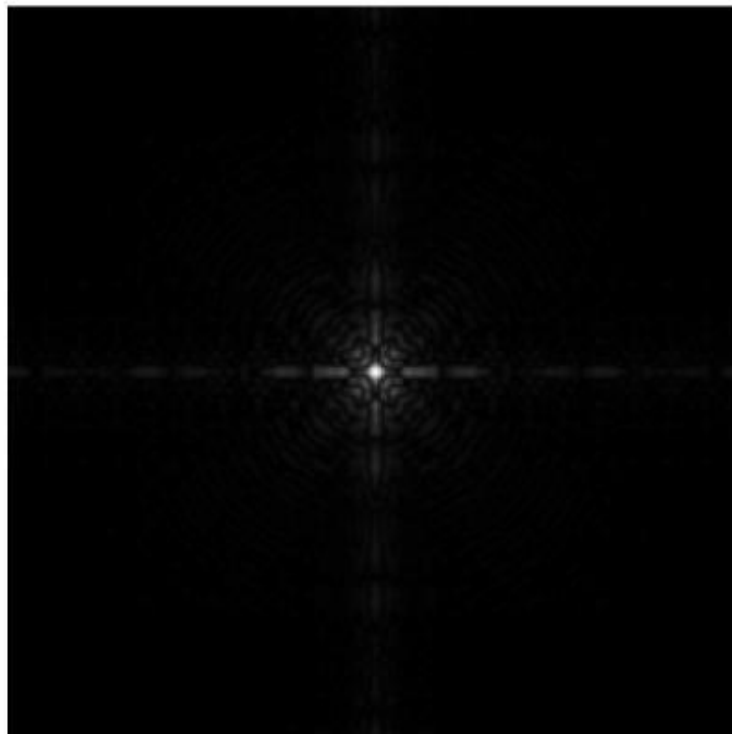
Log Transformations

a b

FIGURE 3.5

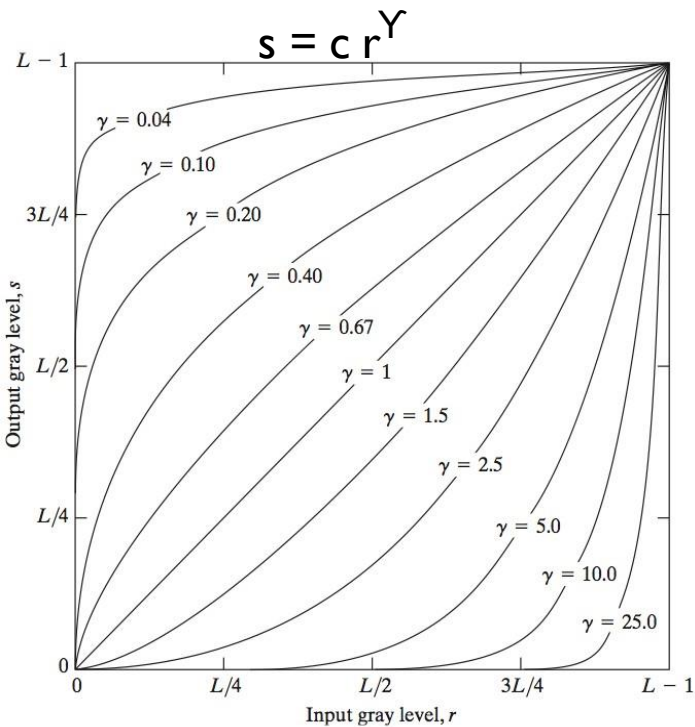
(a) Fourier spectrum.

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

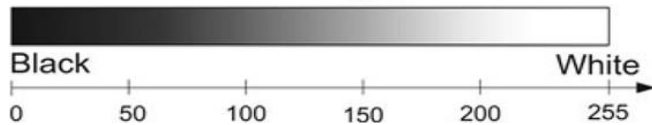


$$s = T(r) = c \log(1 + r)$$

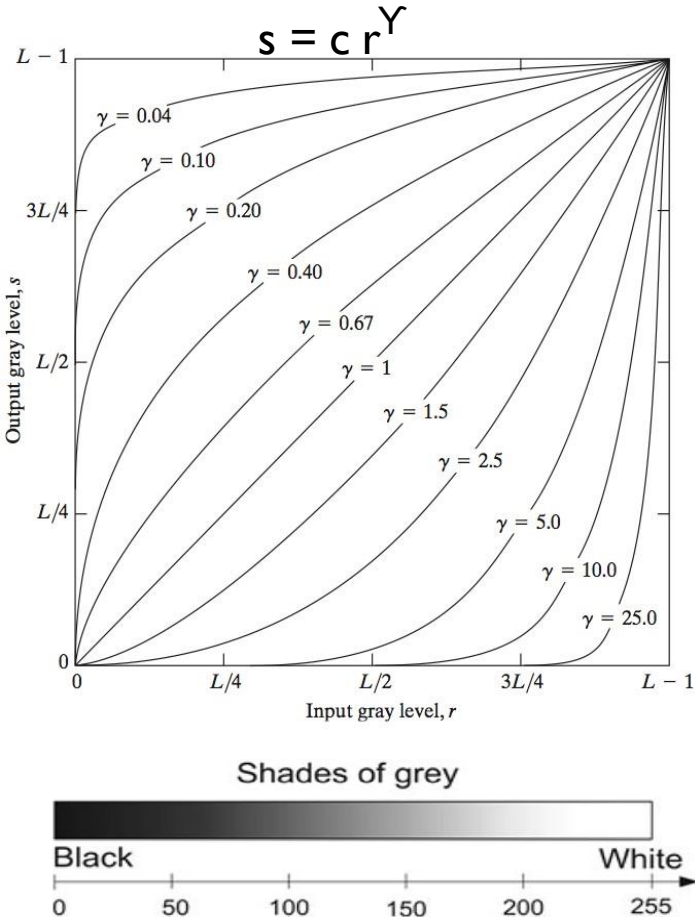
Power-Law Transformations



Shades of grey



Power-Law Transformations

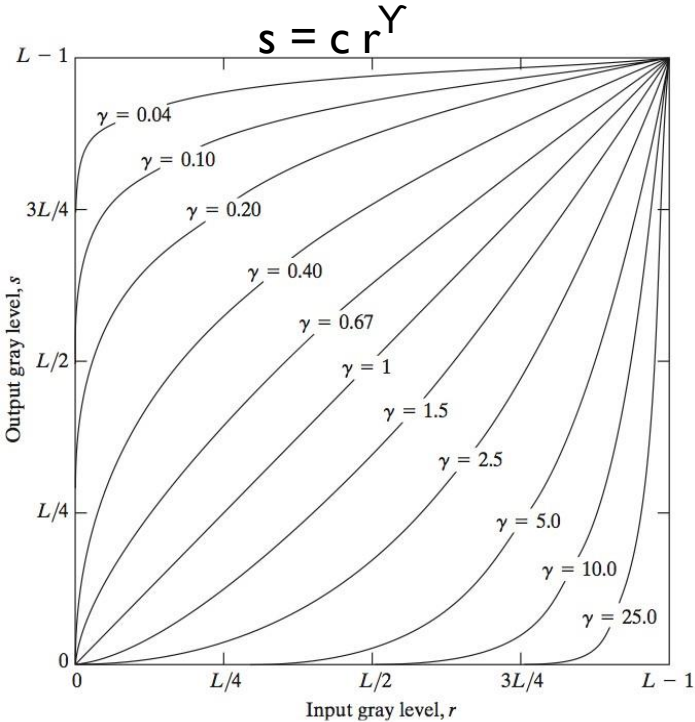


a b
c d

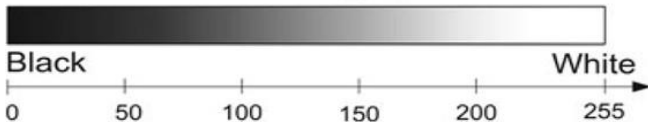
FIGURE 3.9
(a) Aerial image.
(b)–(d) Results of
applying the
transformation in
Eq. (3.2-3) with
 $c = 1$ and
 $\gamma = 3.0, 4.0$, and
 5.0 , respectively.
(Original image
for this example
courtesy of
NASA.)



Power-Law Transformations



Shades of grey



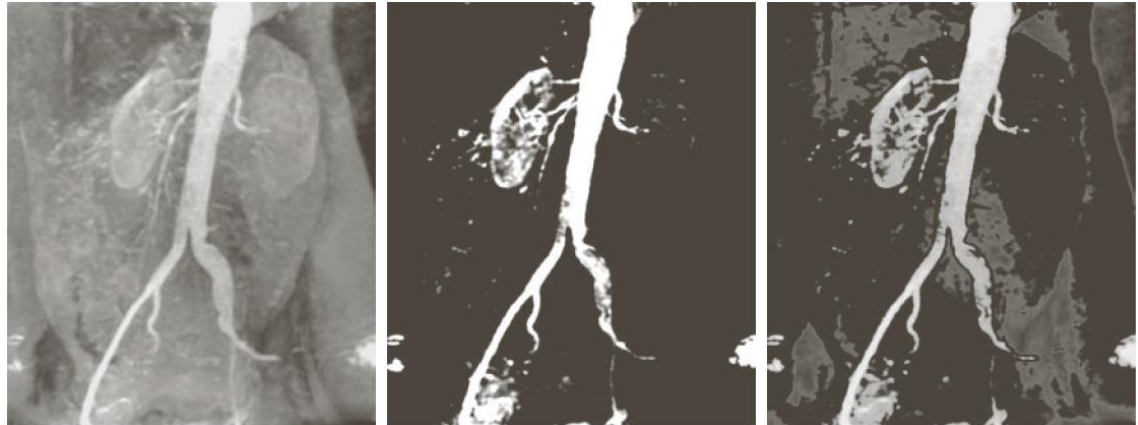
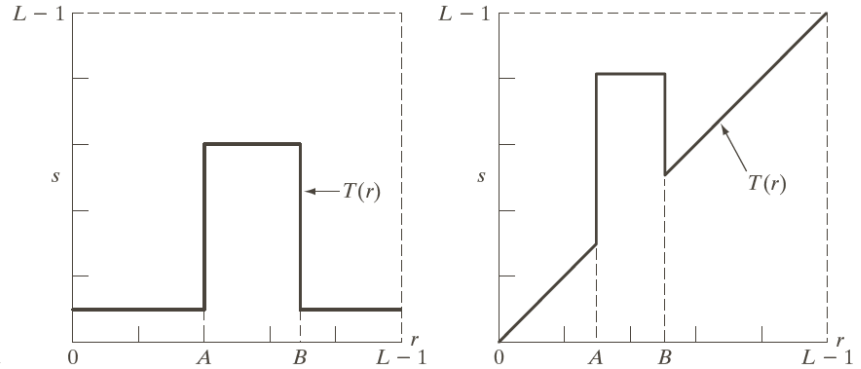
Demo:

<https://colab.research.google.com/drive/11qL0VKleZnONtPuxAryAf9WkUC7kEMI#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

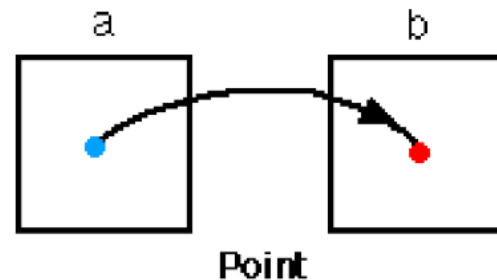
Summary

- ▶ 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



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