University of Al-Hamdaniya
Computer Science Department
Digital image processing

Image Enhancement

Lec-7

By

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Image enhancement

The principal objective of image enhancement is process an image to obtain new image which "**more suitable**" than the original image for a specific application by improving the image quality.

This technique including smoothing, sharping, highlighting features, normalizing illumination..etc.

There are two approaches for image enhancement:

- **Image Enhancement in the Spatial Domain**.
  based on direct manipulation of pixels in an image
- **Image Enhancement in the Frequency Domain.**
  based on modifying the Fourier transform of an image

Image enhancement in the spatial domain

Image Enhancement in the Spatial Domain ...

Spatial domain: is the aggregate of pixels composing an image and the procedures that operate directly on these pixels, denoted by the expression

هو ترتيب البكسل الذي يؤلف الصورة بحيث تكون عمليات التحسين جميعها على البكسل بشكل مباشر

$$g(x,y) = T[f(x,y)]$$

Where:

f(x,y) is the input image, **g(x,y)**is the processed image, **T** is an operator on f.

The form

$$s = T(r)$$

where, for simplicity in notation, **r** and **s** are variables denoting, respectively, the gray level of f(x,y) and g(x,y) at any point (x,y).

Image enhancement

1. Point processing (Spatial Domain Techniques)

gray-level modification (قيمة البكسل) تعديل مستوى الرمادي

2. Histogram processing

(Histogram Modification) تعديل المدرج التكراري

1. Point processing

This technique is used mapping transform that affect on the original gray level values and converts them to other values by the following equation:

$$g(x,y) = T[f(x, y)]$$

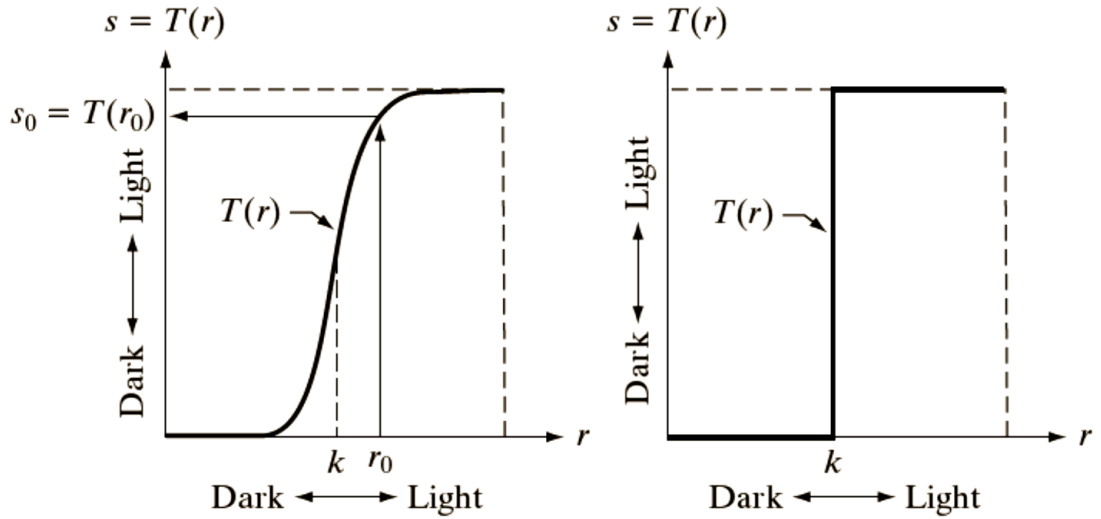
Enhancement using basic gray level transformations

Basic gray level transformation functions can be divided into:

- **Linear:** e.g. image negatives and piecewise linear transformation.
- **Non-linear:** e.g. logarithm and power-law transformations.

Image enhancement

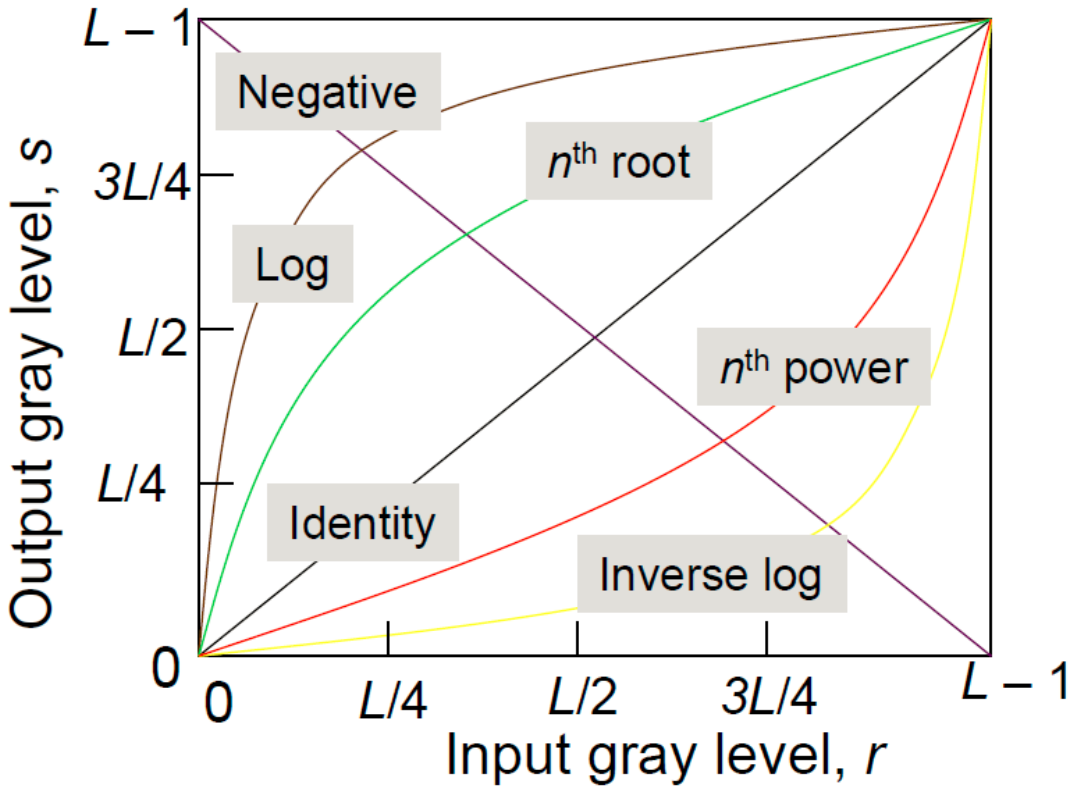
- The effect of this conversion is to produce an image with a higher contrast than the original image contrast by darkening the gray levels below the k level and increasing the brightness of the levels above k.
- In this technique, the lower levels of k are pushed by the shift function to a narrow range towards the dark end of the spectrum, and the opposite effect occurs for values of levels higher than k.
- As shown in Figure below. Because the processing process in this case depends on the gray level value at that point, this is called point processing.



Point Processing

An introduction gray level transformation, consider Figure below, which shows **three basic types** of functions used frequently for **image enhancement** :

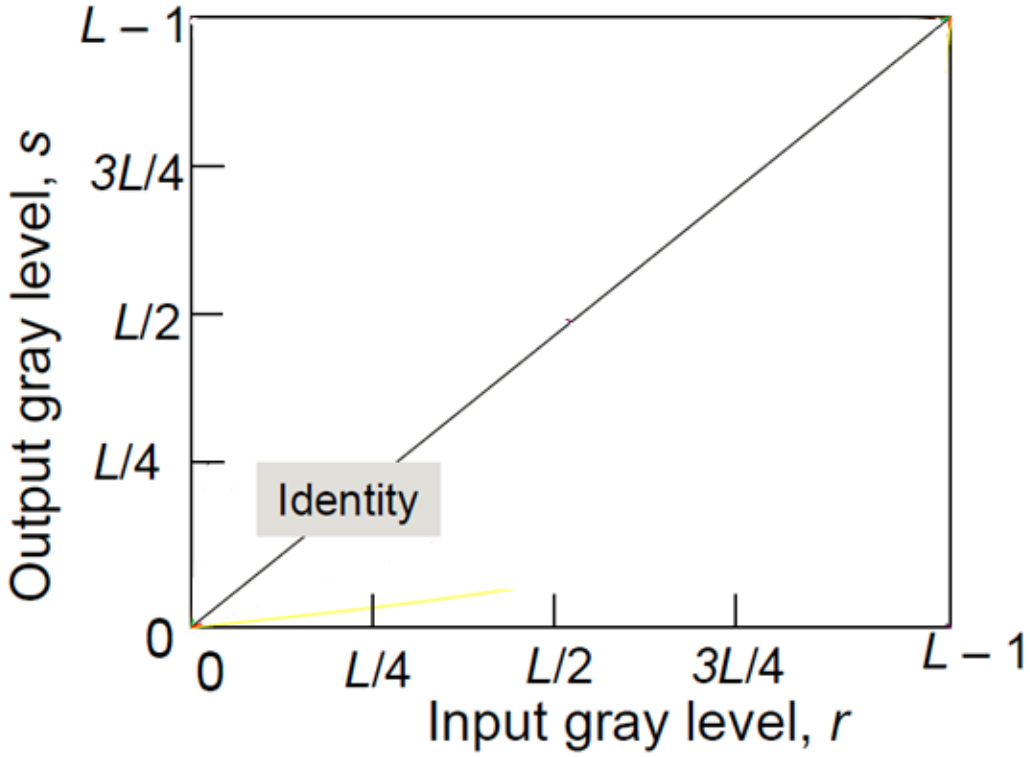
1. Linear (negative and identity)
2. Logarithmic (log and inverse log)
3. Power-law (nth power and nth root)



1. Linear (Identity Function)

- Output intensities are identical to input intensities
- This function doesn't have an effect on an image, it was included in the graph only for completeness
- Its expression:

$$s = r$$

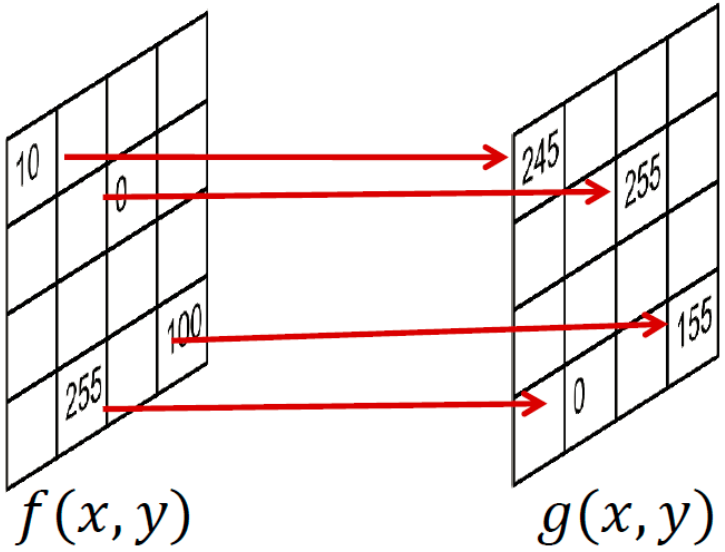


1. Linear (Image Negatives)

- applied in medical imaging & photograph film.
- Used for enhancing white or gray detail embedded in dark region of an image.

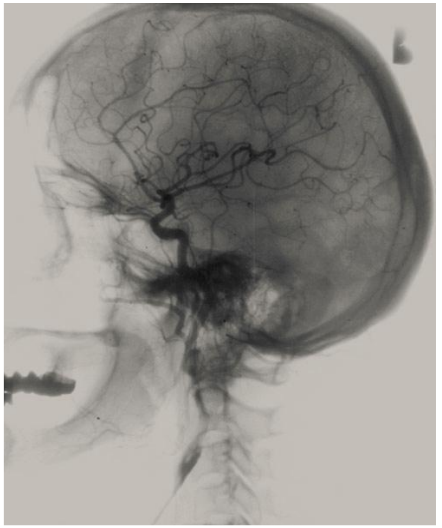
$$s = L - 1 - r$$

- **Negatives**



$$g(x,y) = 255 - f(x,y)$$

X-ray Image



Processed image

Example 1 (angiogram – X-ray of blood vessels)

1. Linear (Image Negatives)

Example : convert the following image into complement image

$$\begin{matrix} & 0 & 50 & 255 \\ r = & 125 & 100 & 0 \\ & 201 & 23 & 150 \end{matrix}$$

$$T = L - 1 - r$$

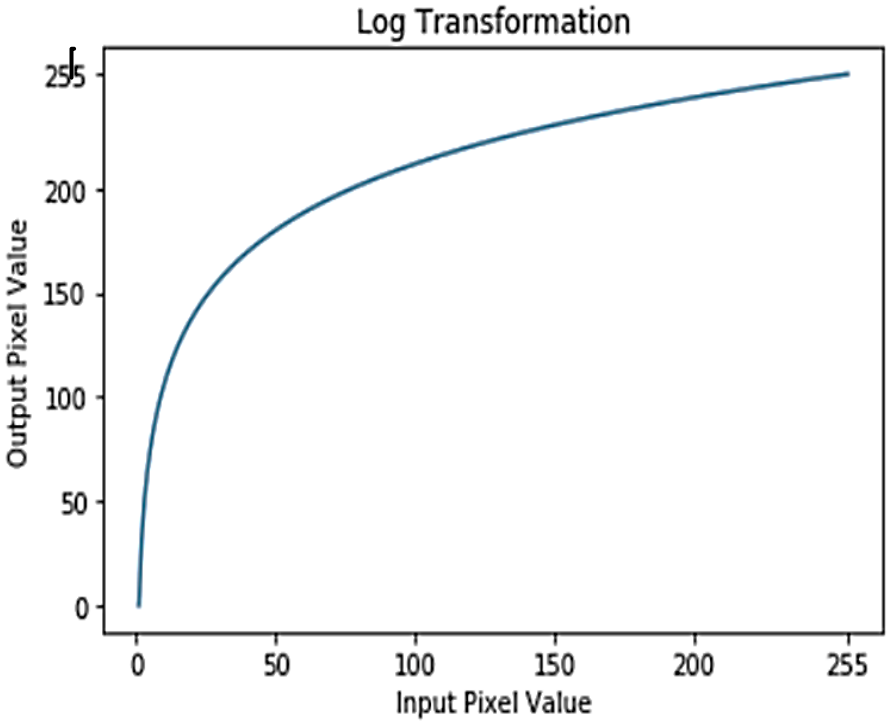
$$T = 256 - 1 - r$$

$$T = 255 - r$$

$$\begin{matrix} & 255 & 205 & 0 \\ T = & 130 & 155 & 255 \\ & 54 & 232 & 105 \end{matrix}$$

2. Log Transformation (Non-linear)

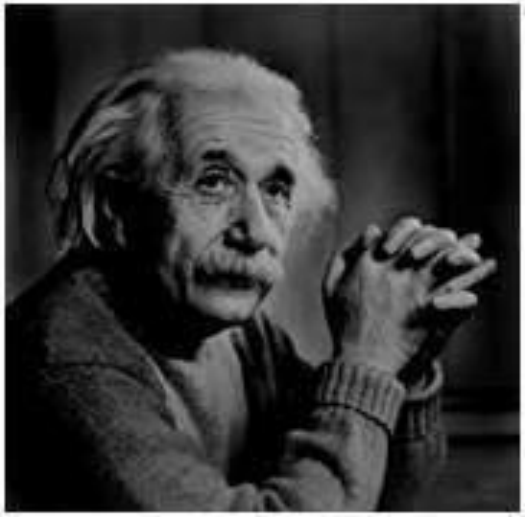
- Maps a narrow range of low input gray-level to wider range of output gray-level and
- Maps a wider range of high input gray-level to narrow range of output gray-level.
- For lower amplitudes of input image the range of gray levels is expanded, For higher amplitudes of input image the range of gray levels is compressed
- Classic used for displaying Fourier spectrum image.



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

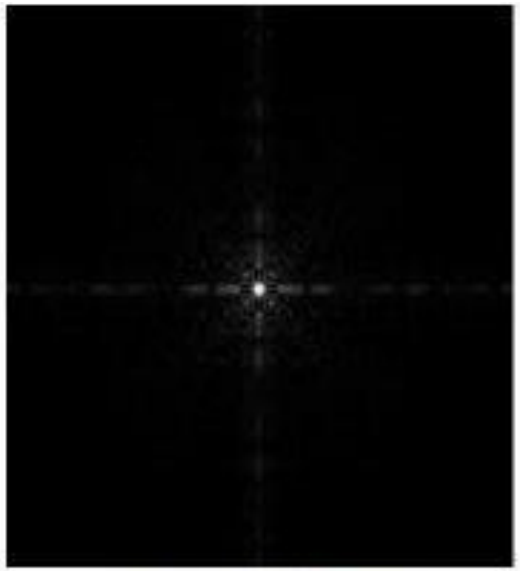
c is a constant

2. Log Transformation (Non-linear)

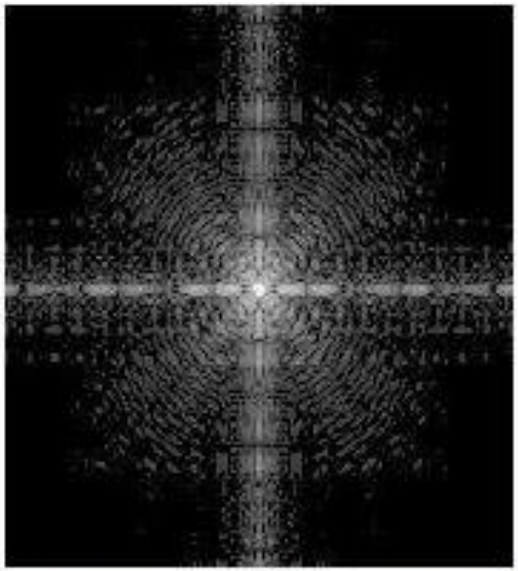


(a) Original

(b) Result of log transform



(a) Original image

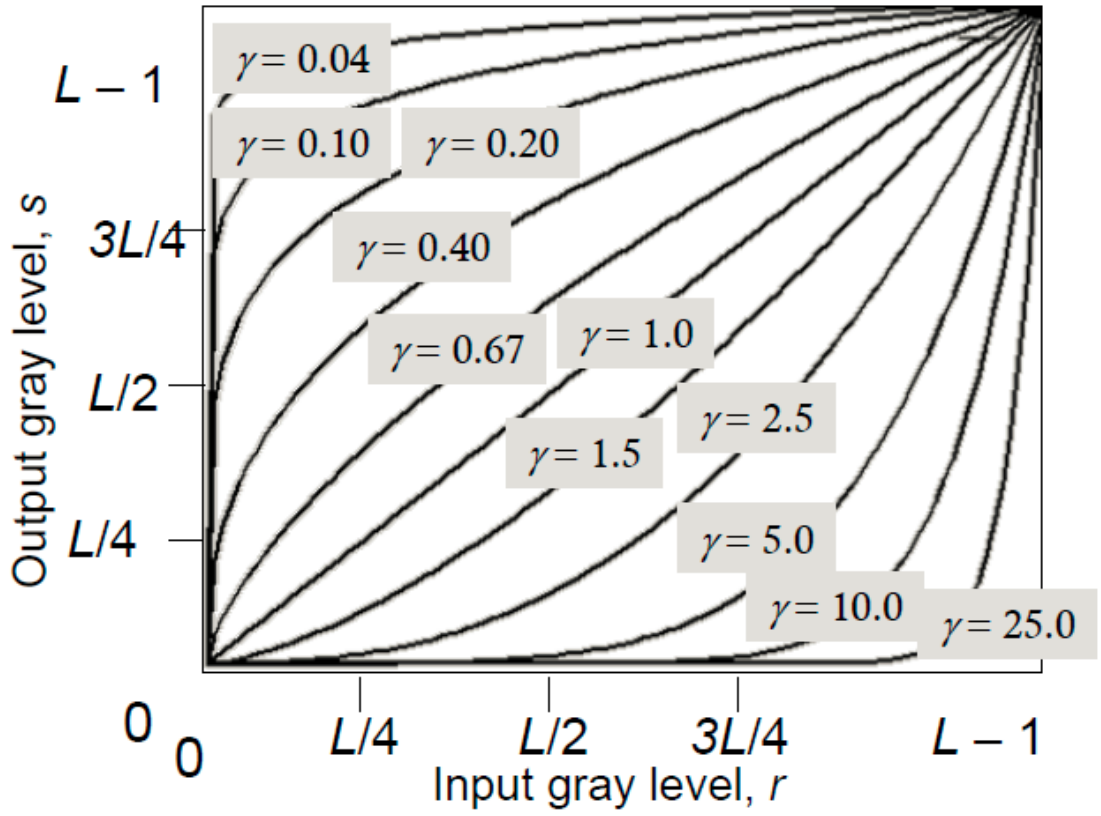


(b) Result of Log transform with $c = 1$

3. Power-Law Transformation (Non-linear)

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

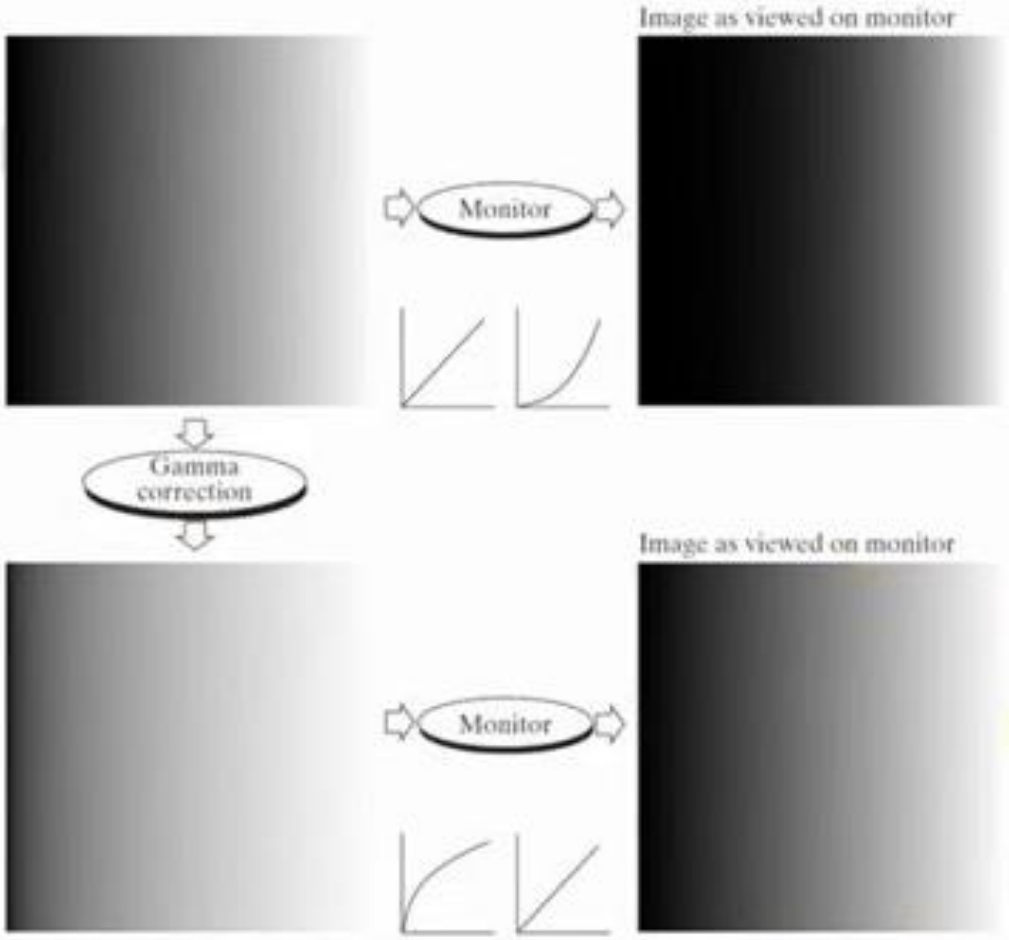
- where c and γ are positive constants. Various γ yields various plots.



3. Power-Law Transformation (Non-linear)

- For γ <1, narrow range of dark input is mapped to wider range output while wider range of bright input is mapped to narrow range.
- For γ >1, the effect is the opposite to γ < 1.
- The process used to correct this power-law response phenomena is called gamma correction.
- Important in displaying image correctly so that the image would not appear darker than the original.
- Applied in web images – viewers have different monitors and/or monitor settings.
- Used for general-purpose contrast manipulation
- This type of transformation is used for enhancing images for different type of display devices. The gamma of different display devices is different. For example Gamma of CRT lies in between of 1.8 to 2.5, that means the image displayed on CRT is dark.

3. Power-Law Transformation (Non-linear)



(a) Linear-wedge gray-scale image.

(b) Response of monitor to linear wedge.

(c) Gamma-corrected wedge.

(d) Output of monitor.

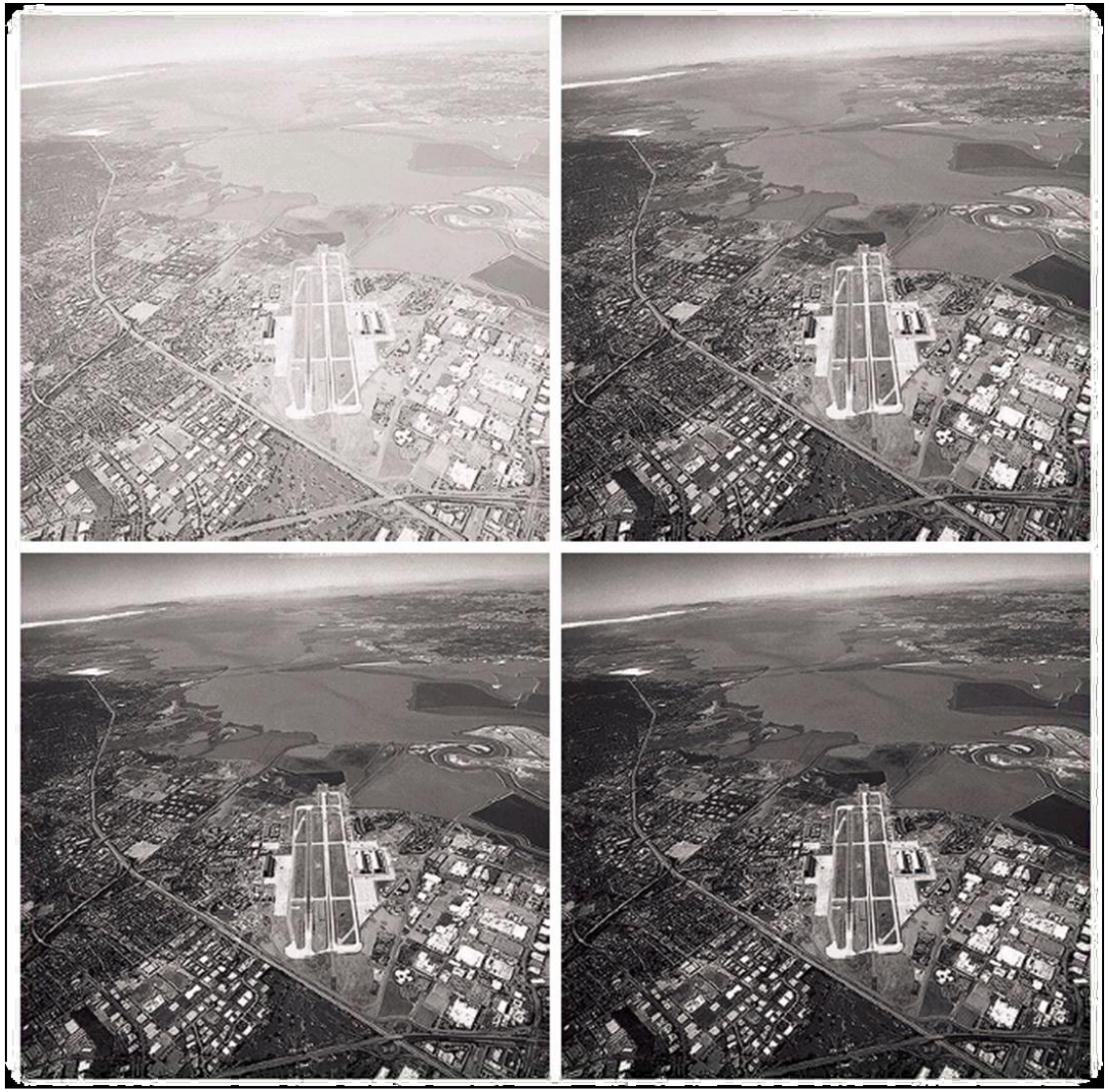
3. Power-Law Transformation (Non-linear)

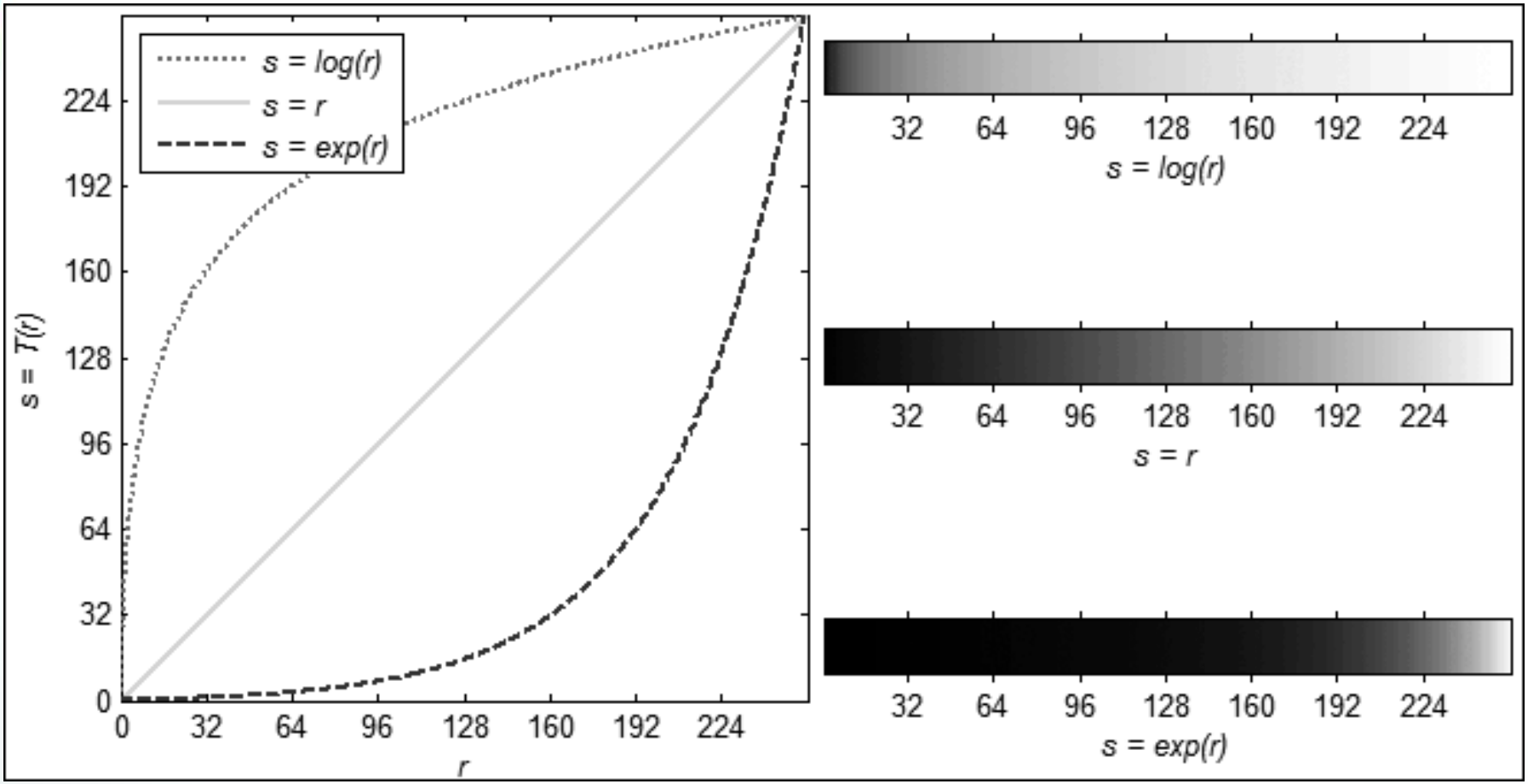
(a)	(b)
(c)	(d)

(a) Aerial image (poor contrast).

(b) – (d) Results of applying power-law transformation with c = 1 and γ = 3.0, 4.0 and 5.0, respectively.

•Result using γ = 4.0 is more appealing as it has better contrast. Result using γ = 5.0 has areas that are too dark and hence some details are lost (upper left quadrant). What do you think?




s = log(r)
s = r
s = exp(r)
s = T(r)
r
0
32
64
96
128
160
192
224
s = log(r)
s = r
s = exp(r)

End of Lecture