

Machine Vision

Lecture 4 Part 3

Image Enhancement.

Point processing

Based on lectures of
Brian Mac Namee

In this lecture we will look at image enhancement point processing techniques:

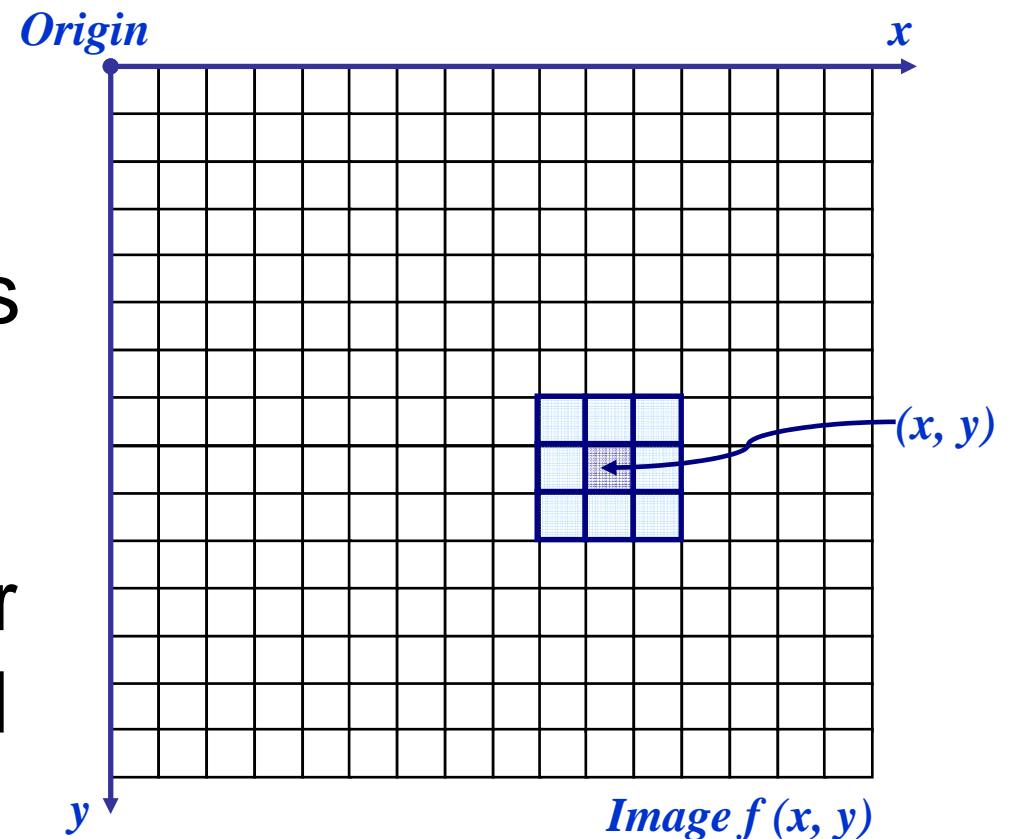
- What is point processing?
- Negative images
- Thresholding
- Logarithmic transformation
- Power law transforms
- Grey level slicing
- Bit plane slicing

Basic Spatial Domain Image Enhancement

Most spatial domain enhancement operations can be reduced to the form

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

where $f(x, y)$ is the input image, $g(x, y)$ is the processed image and T is some operator defined over some neighbourhood of (x, y)



The simplest spatial domain operations occur when the neighbourhood is simply the pixel itself

In this case T is referred to as a *grey level transformation function* or a *point processing operation*

Point processing operations take the form

$$s = T (r)$$

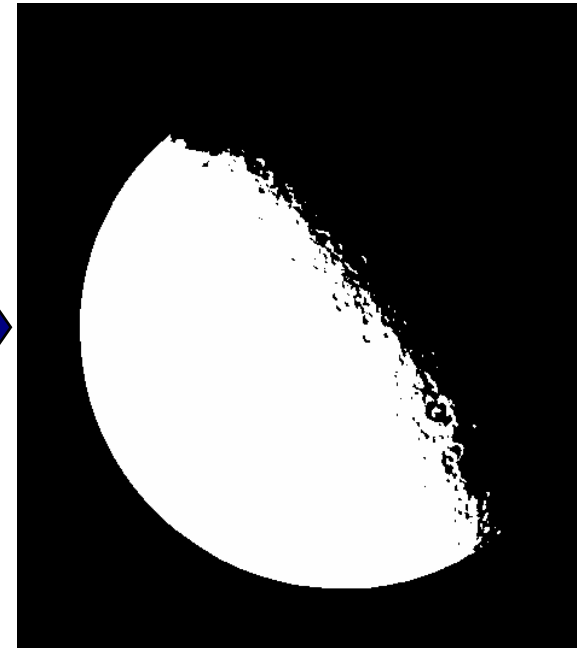
where s refers to the processed image pixel value and r refers to the original image pixel value

Point Processing Example: Thresholding

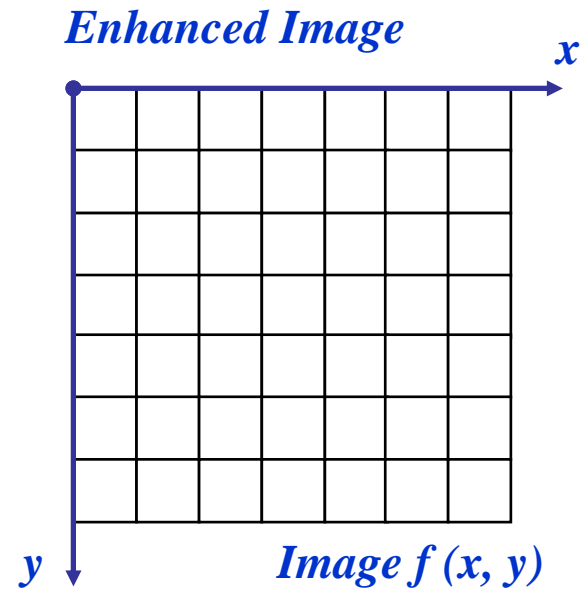
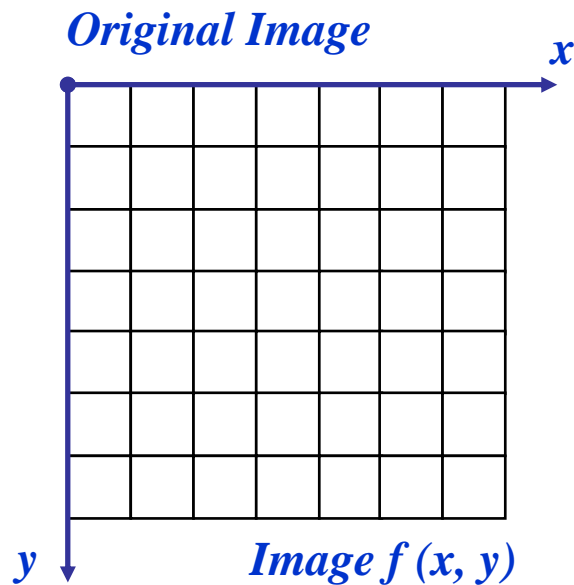
Thresholding transformations are particularly useful for segmentation in which we want to isolate an object of interest from a background



$$s = \begin{cases} 1.0 & r > \text{threshold} \\ 0.0 & r \leq \text{threshold} \end{cases}$$



Point Processing Example: Thresholding (cont...)



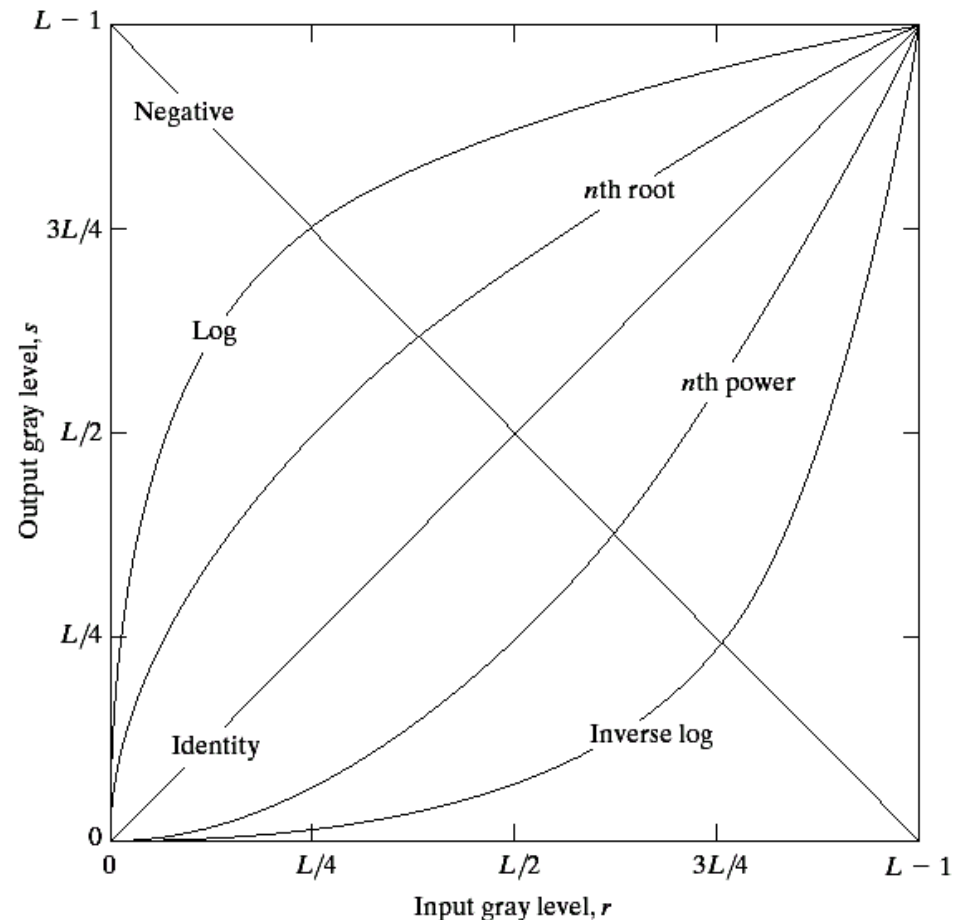
$$s = \begin{cases} 1.0 & r > \text{threshold} \\ 0.0 & r \leq \text{threshold} \end{cases}$$

Basic Grey Level Transformations

There are many different kinds of grey level transformations

Three of the most common are shown here

- Linear
 - Negative/Identity
- Logarithmic
 - Log/Inverse log
- Power law
 - n^{th} power/ n^{th} root



Logarithmic Transformations

The general form of the log transformation is

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

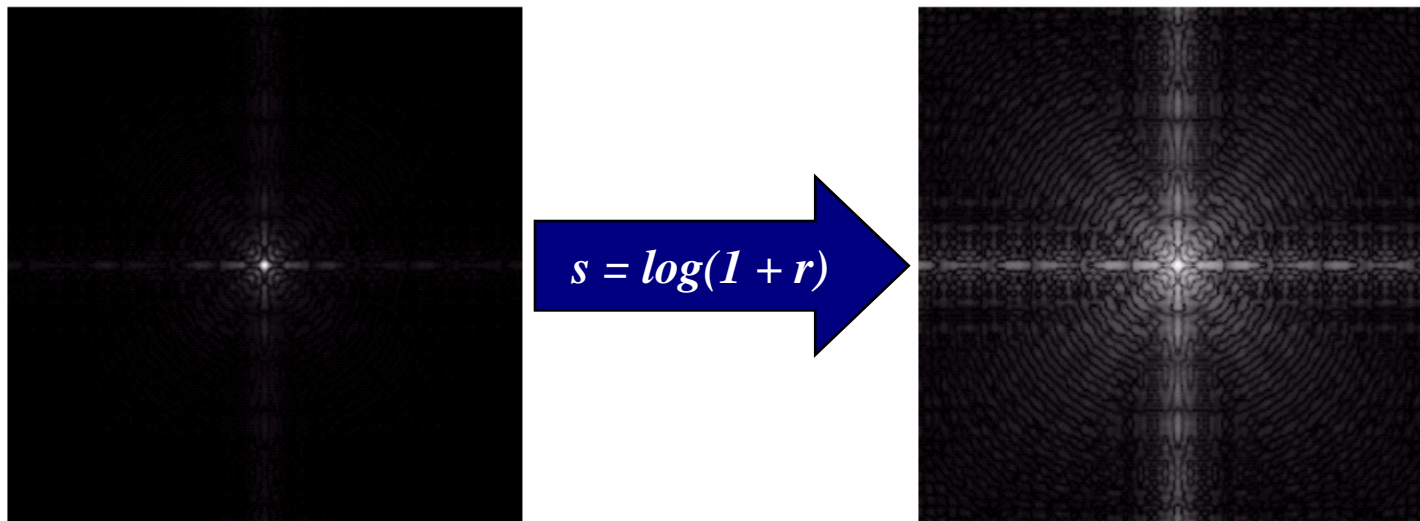
The log transformation maps a narrow range of low input grey level values into a wider range of output values

The inverse log transformation performs the opposite transformation

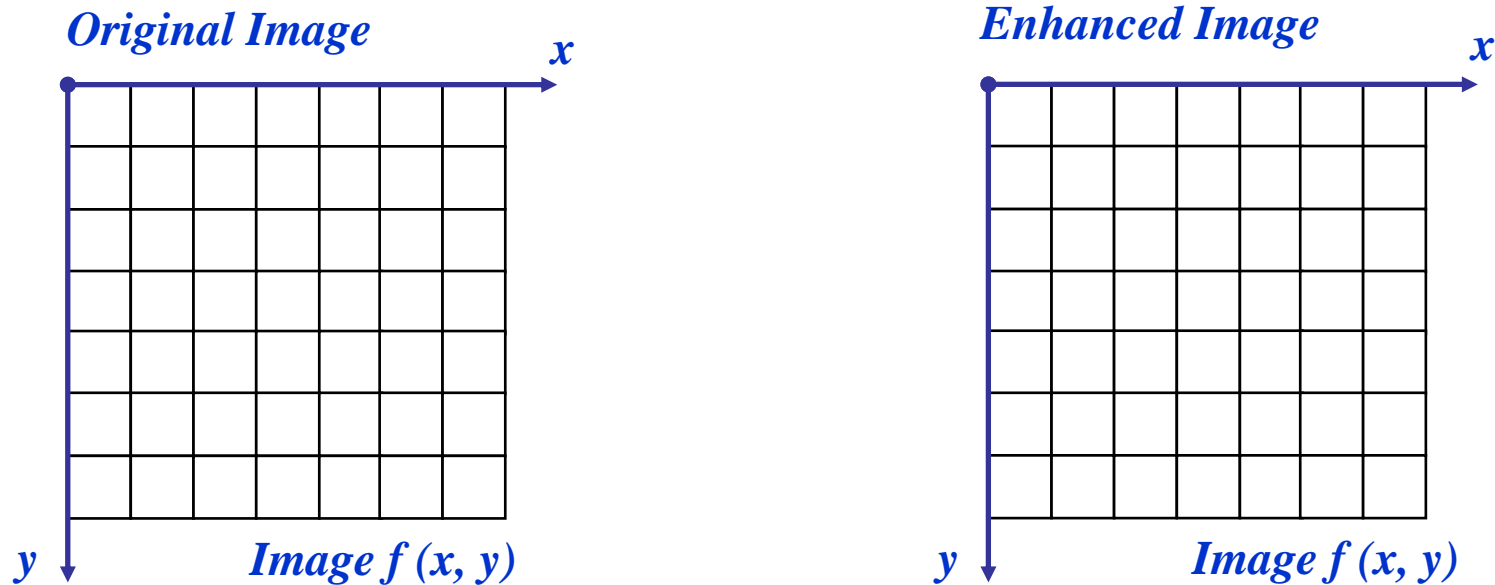
Logarithmic Transformations (cont...)

Log functions are particularly useful when the input grey level values may have an extremely large range of values

In the following example the Fourier transform of an image is put through a log transform to reveal more detail



Logarithmic Transformations (cont...)



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

We usually set c to 1

Grey levels must be in the range [0.0, 1.0]

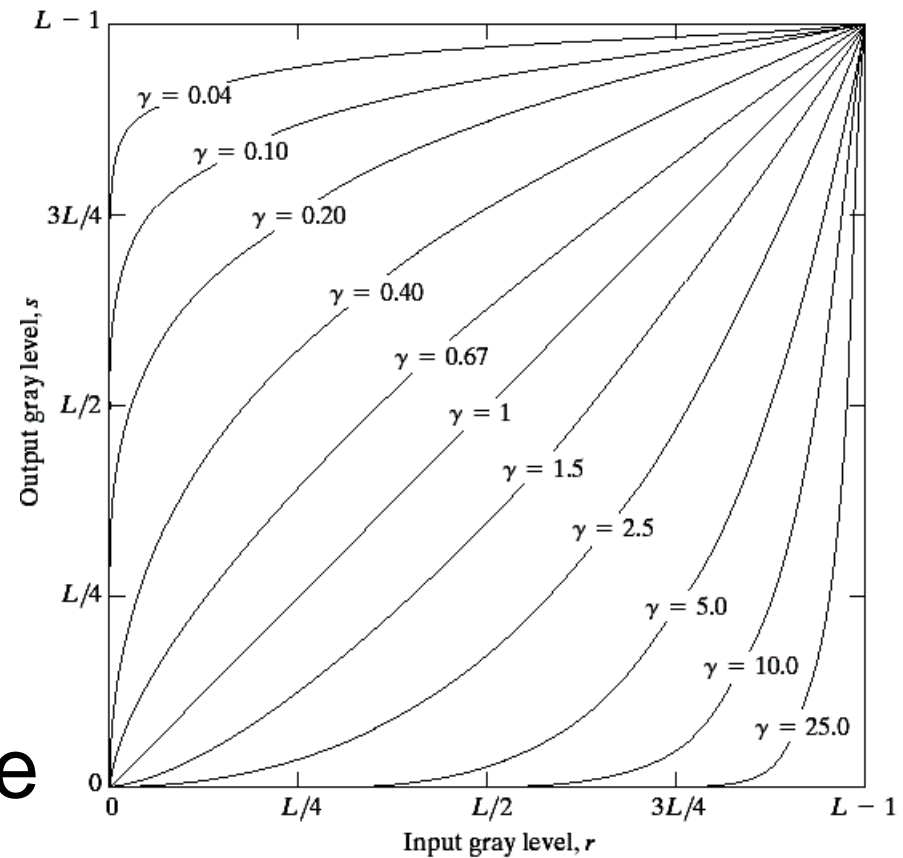
Power Law Transformations

Power law transformations have the following form

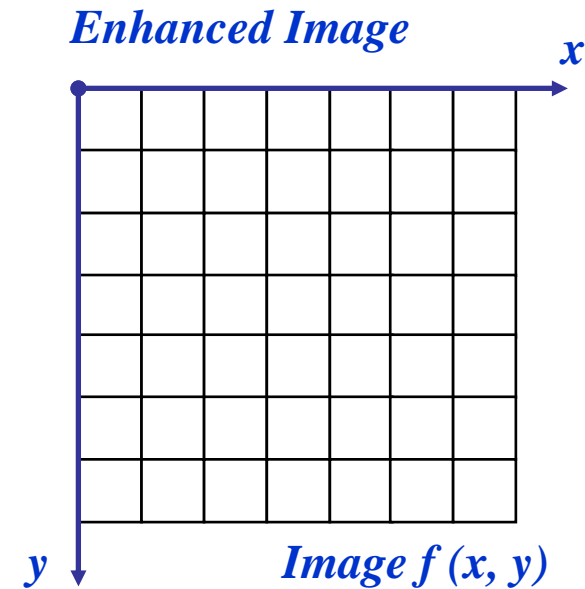
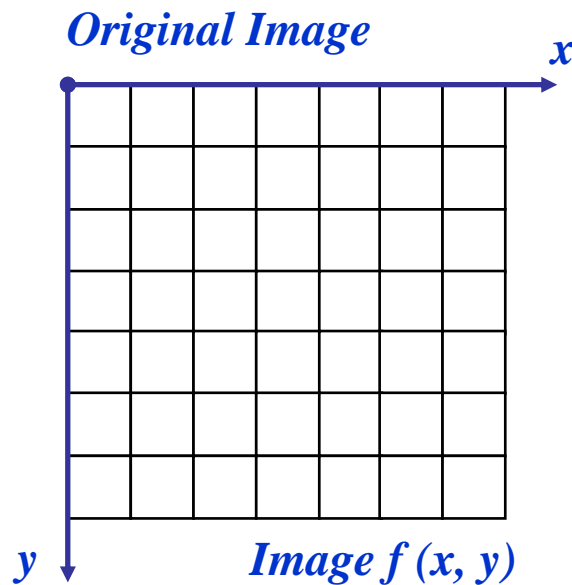
$$s = c * r^\gamma$$

Map a narrow range of dark input values into a wider range of output values or vice versa

Varying γ gives a whole family of curves



Power Law Transformations (cont...)



$$s = r^\gamma$$

We usually set c to 1

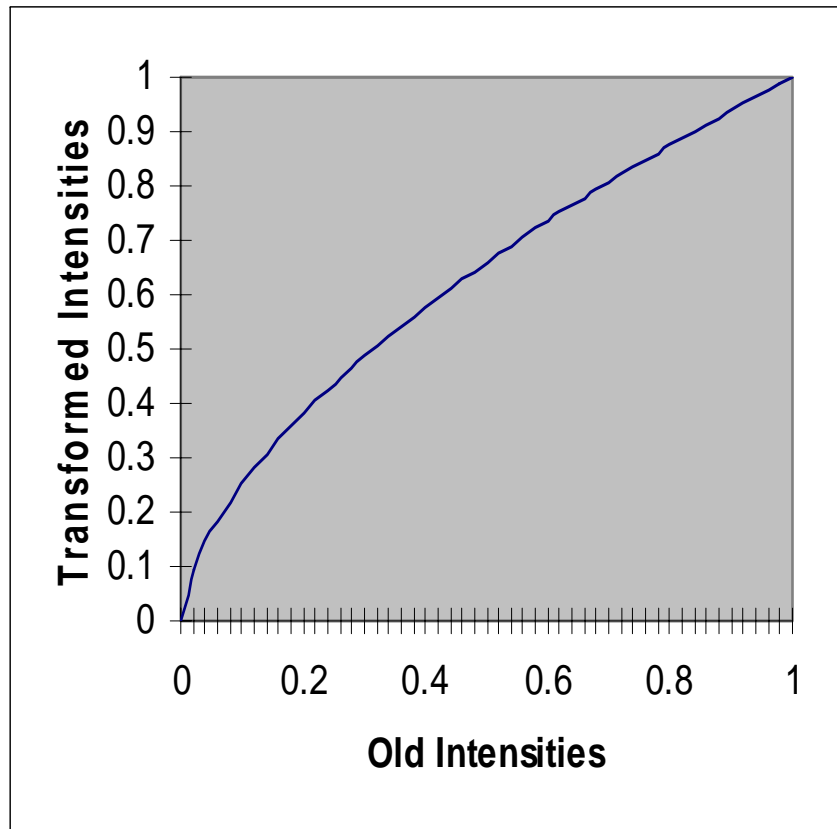
Grey levels must be in the range $[0.0, 1.0]$

Power Law Example



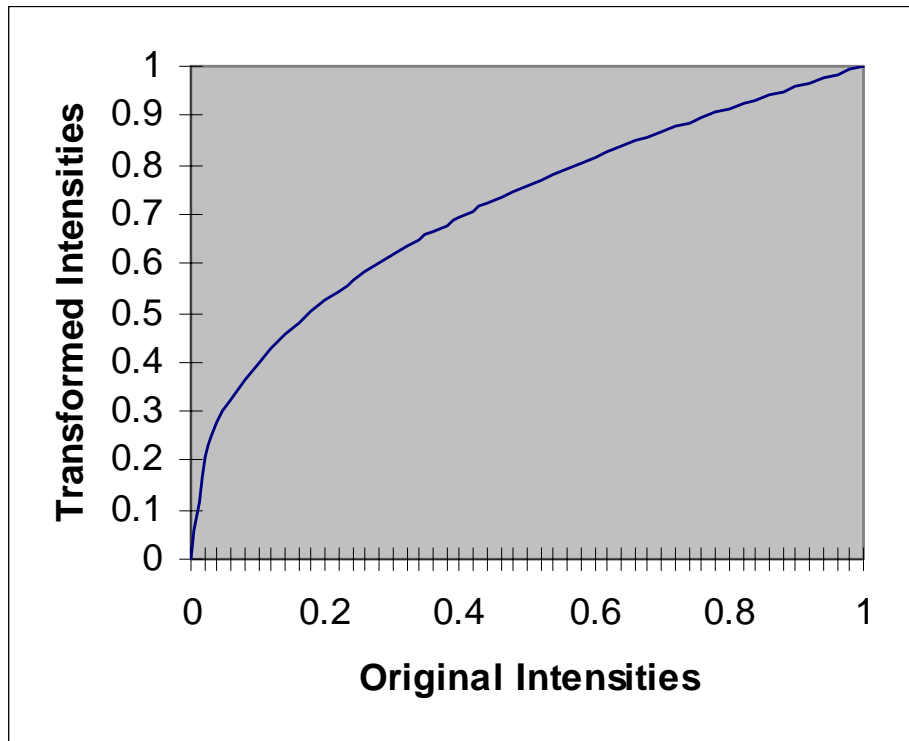
Power Law Example (cont...)

$$\gamma = 0.6$$



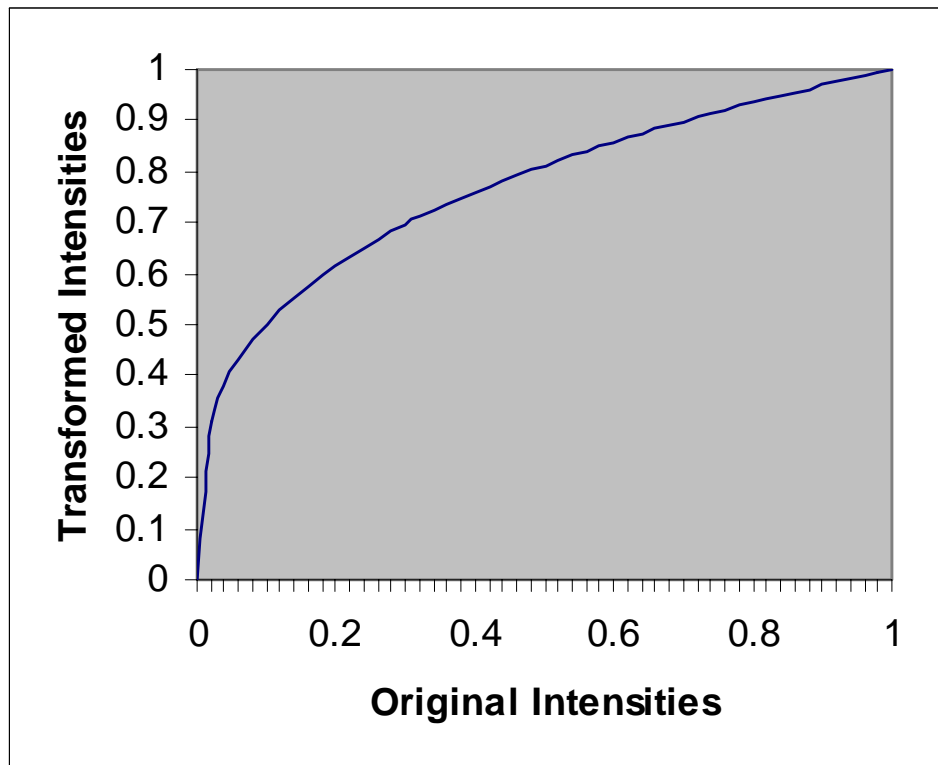
Power Law Example (cont...)

$$\gamma = 0.4$$



Power Law Example (cont...)

$$\gamma = 0.3$$

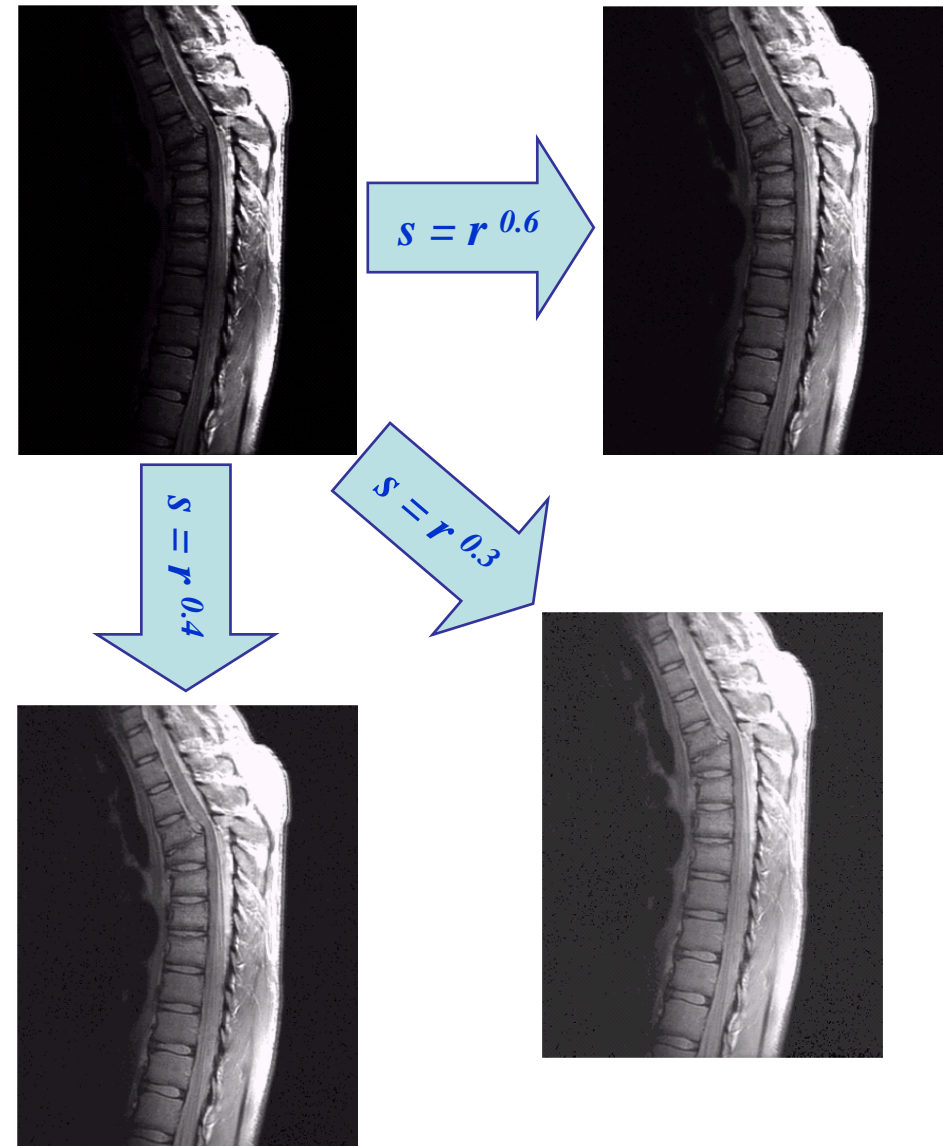


Power Law Example (cont...)

Images taken from Gonzalez & Woods, Digital Image Processing (2002)

The images to the right show a magnetic resonance (MR) image of a fractured human spine

Different curves highlight different detail

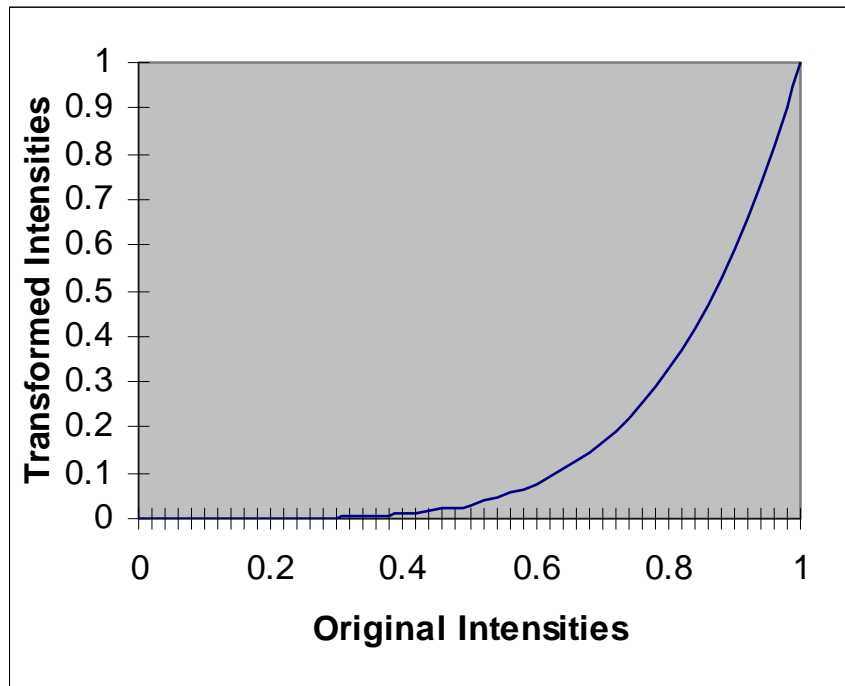


Power Law Example



Power Law Example (cont...)

$$\gamma = 5.0$$

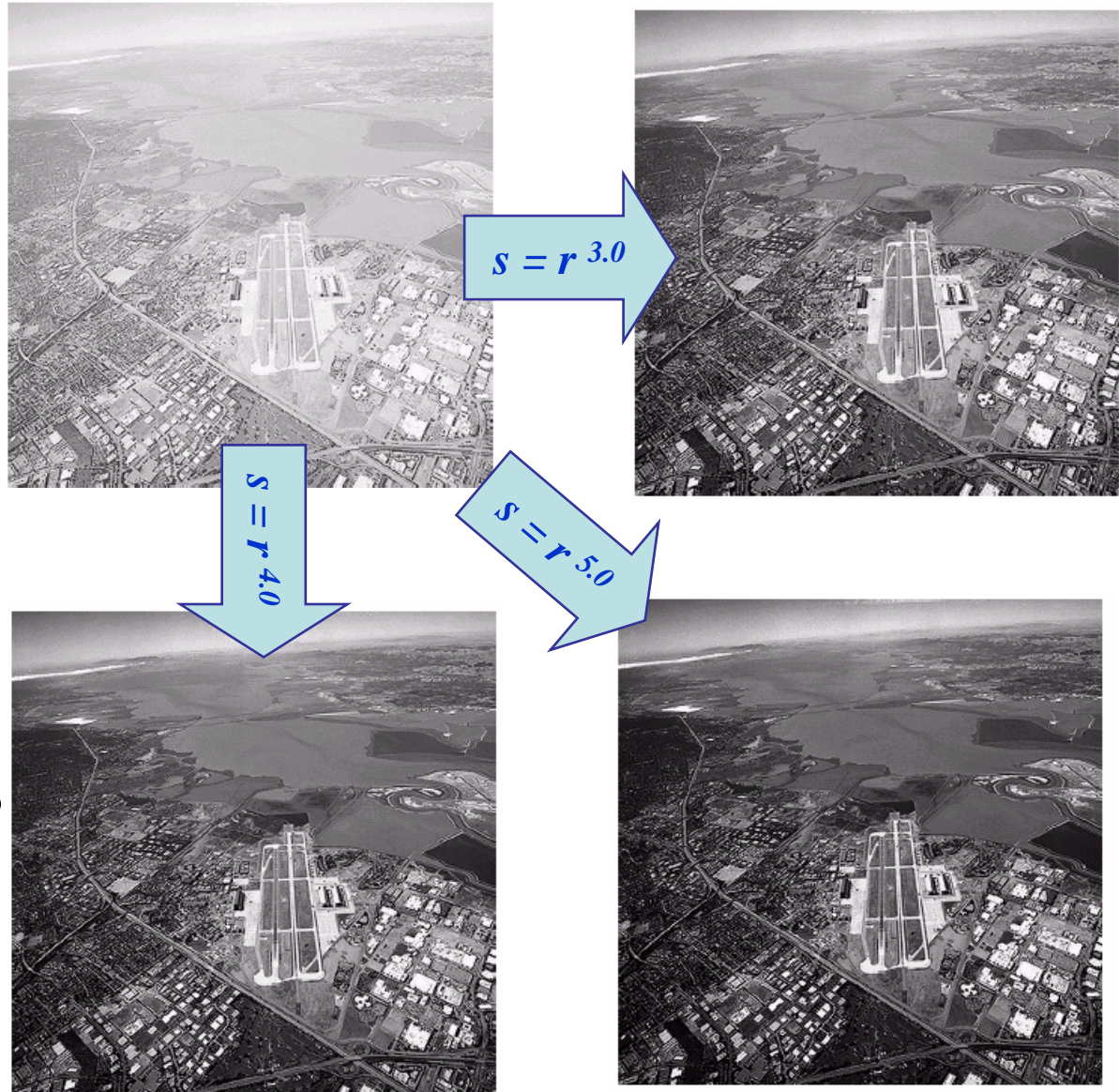


Power Law Transformations (cont...)

An aerial photo of a runway is shown

This time power law transforms are used to darken the image

Different curves highlight different detail

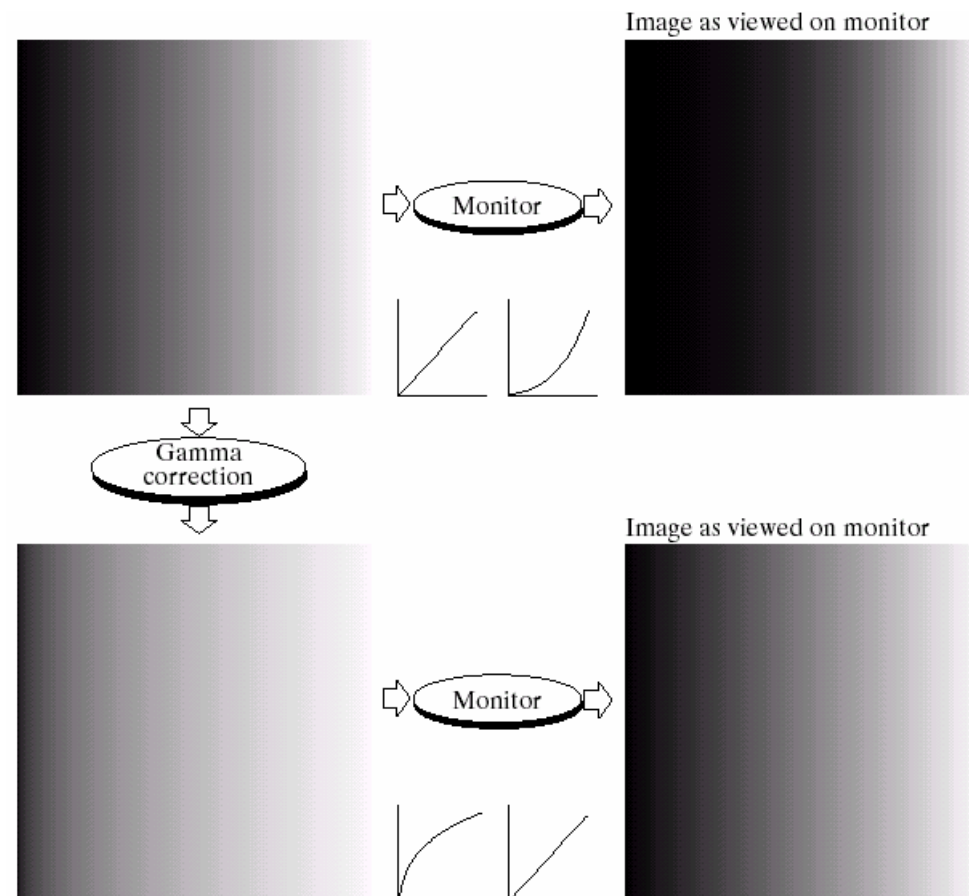


Gamma Correction

Many of you might be familiar with gamma correction of computer monitors

Problem is that display devices do not respond linearly to different intensities

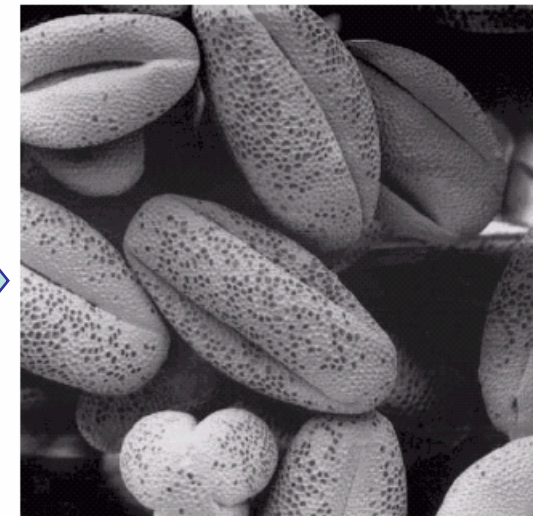
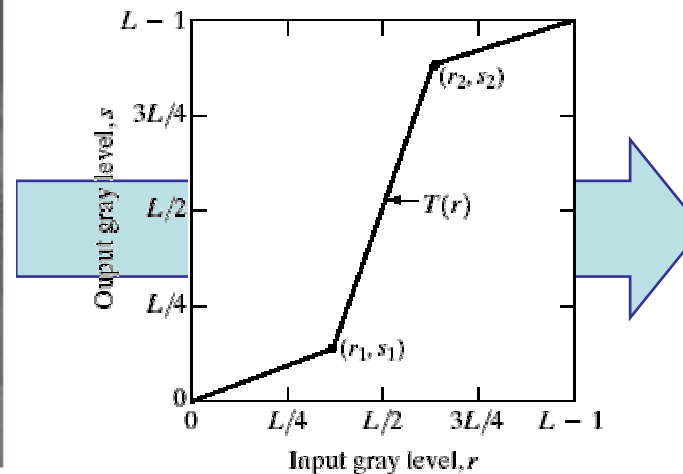
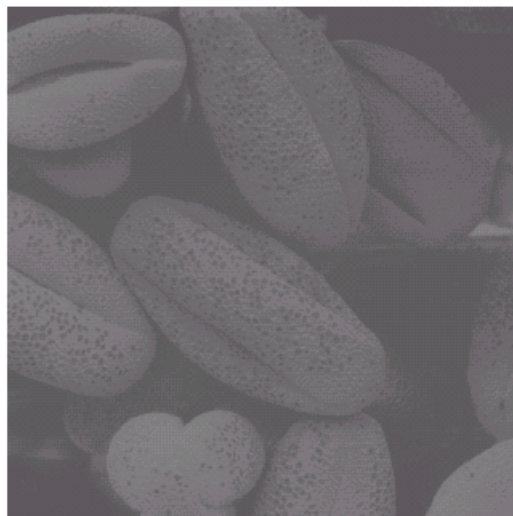
Can be corrected using a log transform



Piecewise Linear Transformation Functions

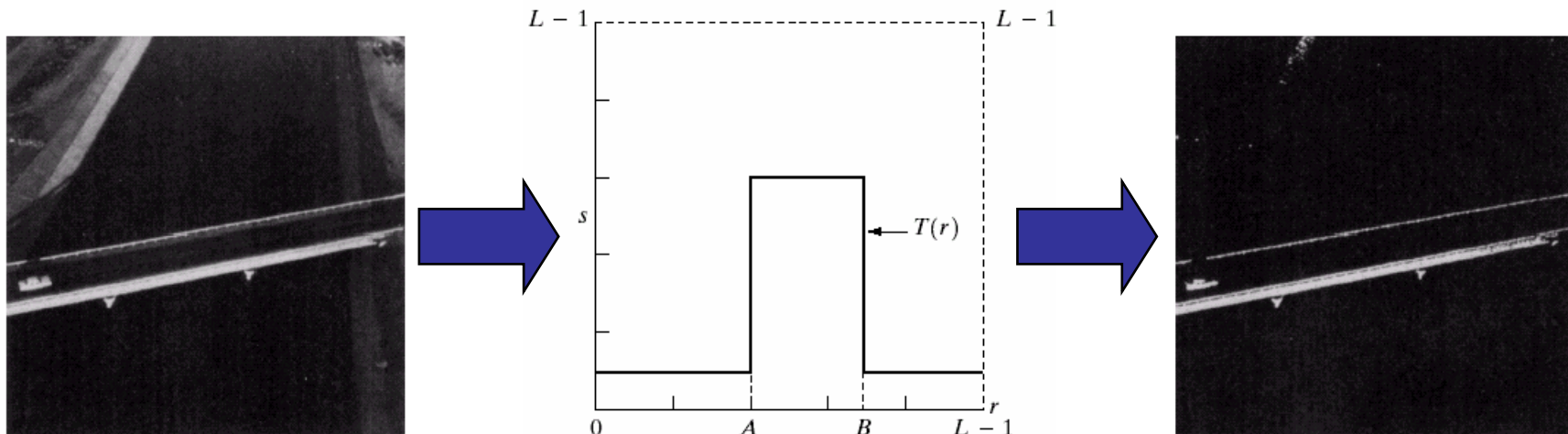
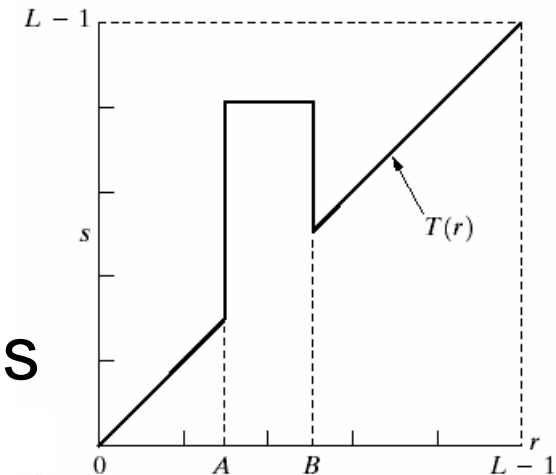
Rather than using a well defined mathematical function we can use arbitrary user-defined transforms

The images below show a contrast stretching linear transform to add contrast to a poor quality image



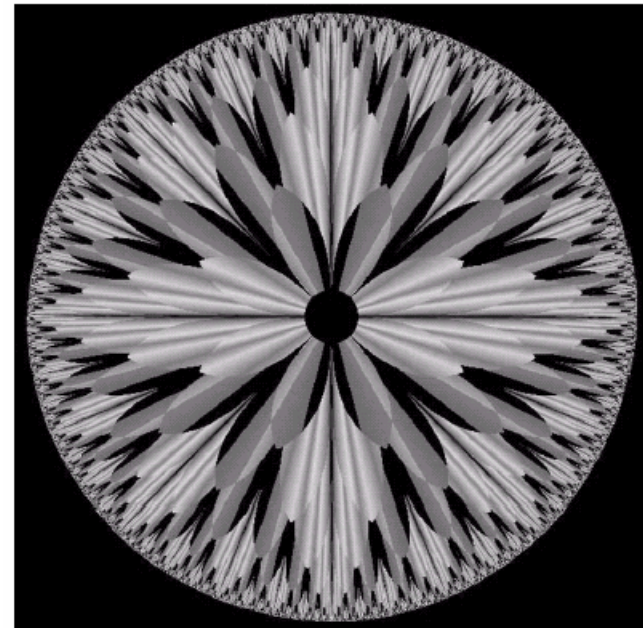
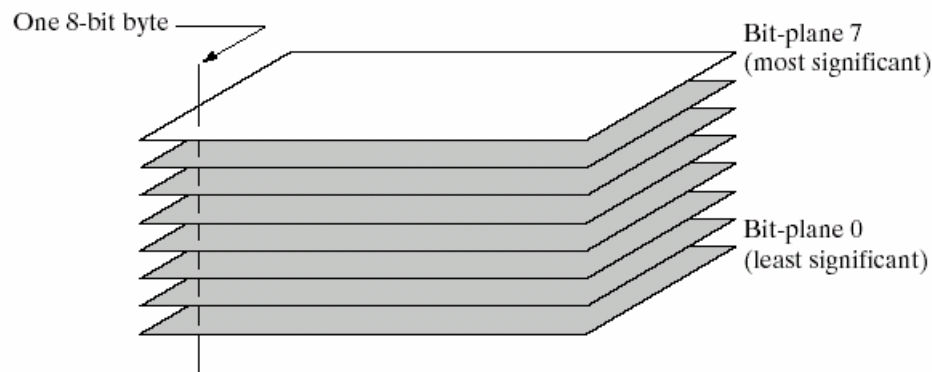
Highlights a specific range of grey levels

- Similar to thresholding
- Other levels can be suppressed or maintained
- Useful for highlighting features in an image



Often by isolating particular bits of the pixel values in an image we can highlight interesting aspects of that image

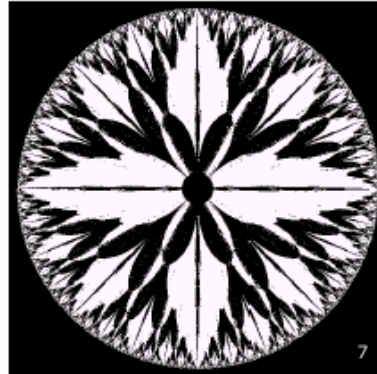
- Higher-order bits usually contain most of the significant visual information
- Lower-order bits contain subtle details



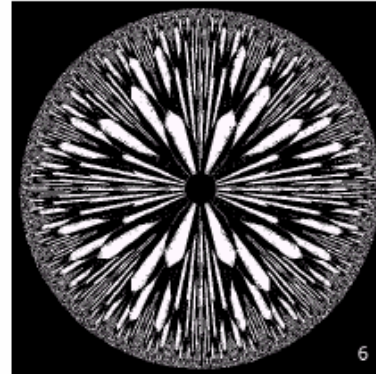
Bit Plane Slicing (cont...)

Images taken from Gonzalez & Woods, Digital Image Processing (2002)

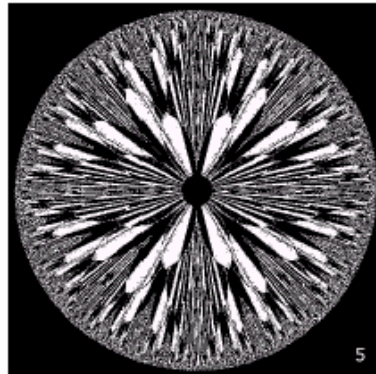
[10000000]



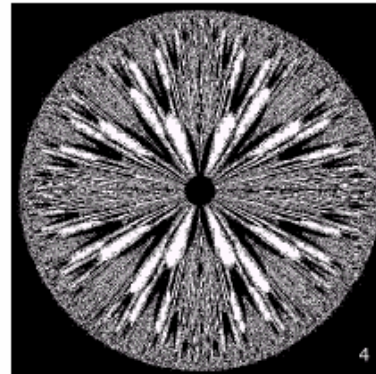
[01000000]



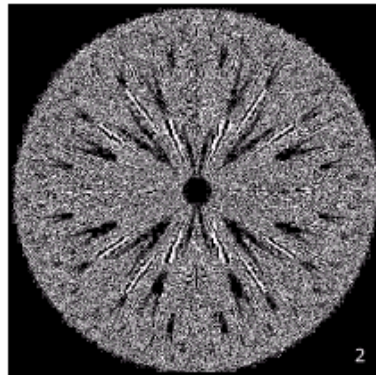
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