CS457 DIGITAL IMAGE PROCESSING

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Lecture Series 2

- Image Enhancement (Point Processing)

BASIC SPATIAL DOMAIN IMAGE ENHANCEMENT

Digital Image Processing

Image Enhancement
(Point Processing)

POINT PROCESSING

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

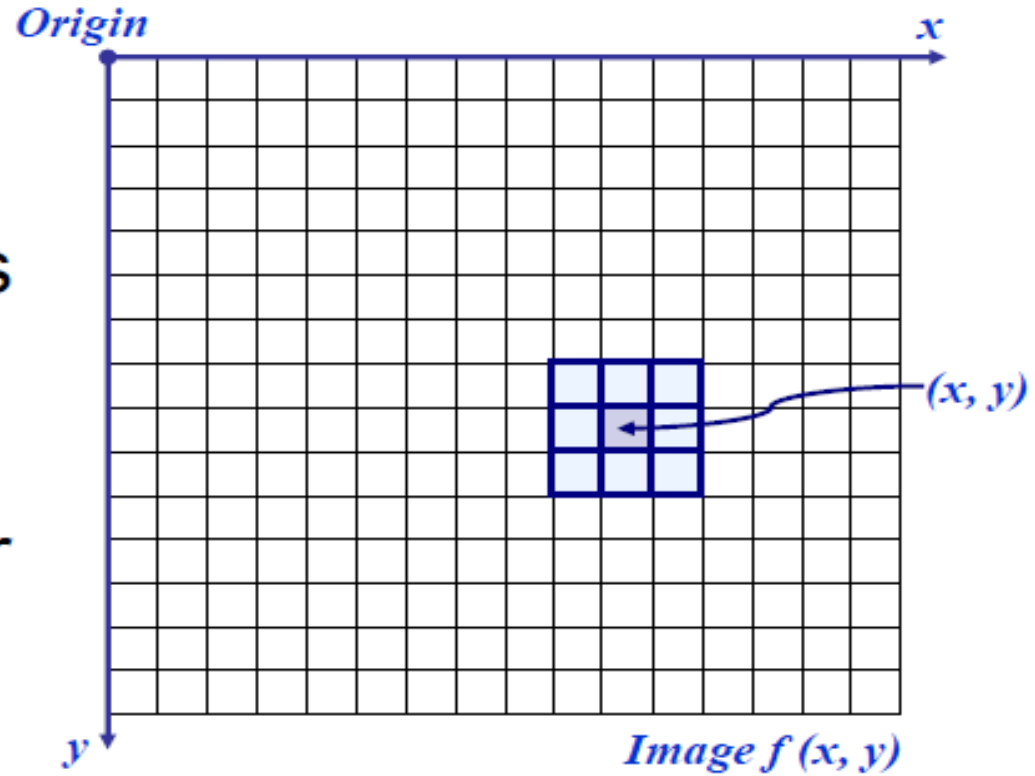
- What is point processing?
- Negative images
- Thresholding
- Logarithmic transformation
- Power law transforms

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)



POINT PROCESSING

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

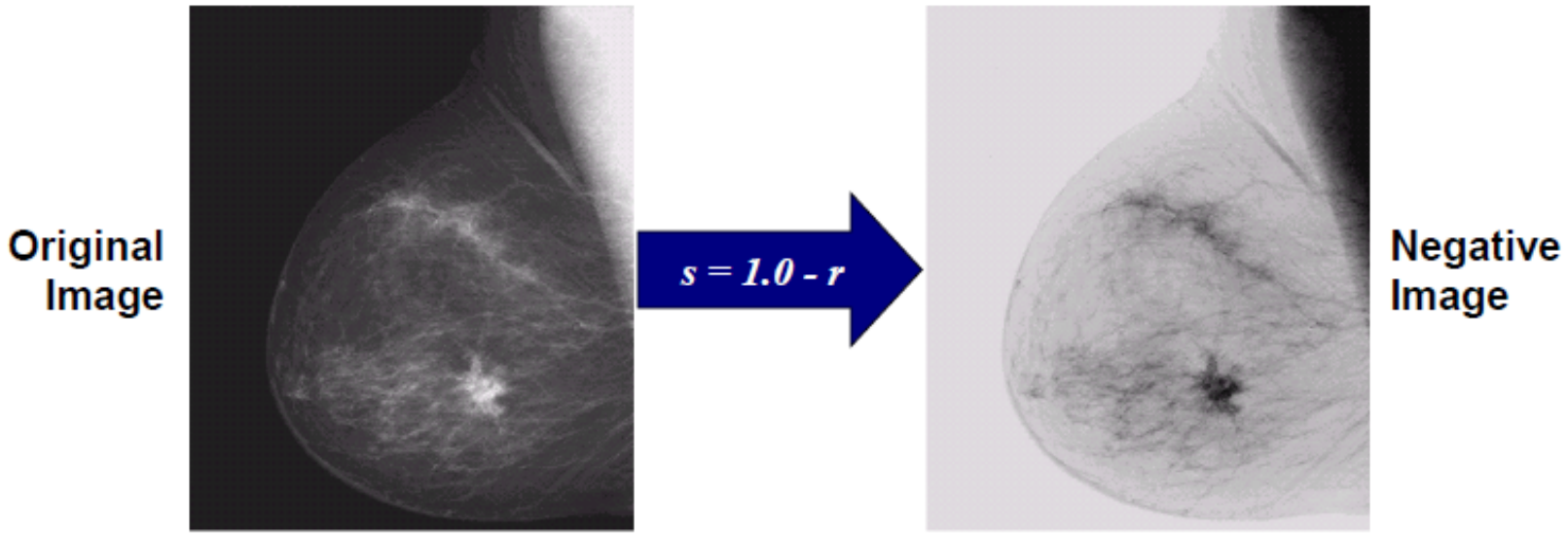
$$s = T(r)$$

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

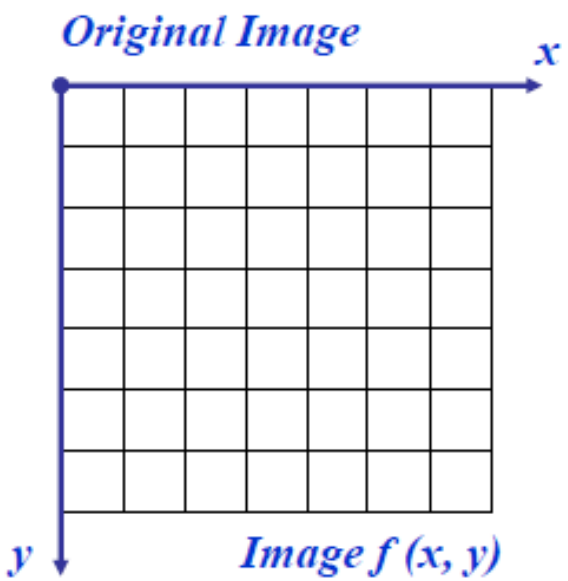
NEGATIVE IMAGE

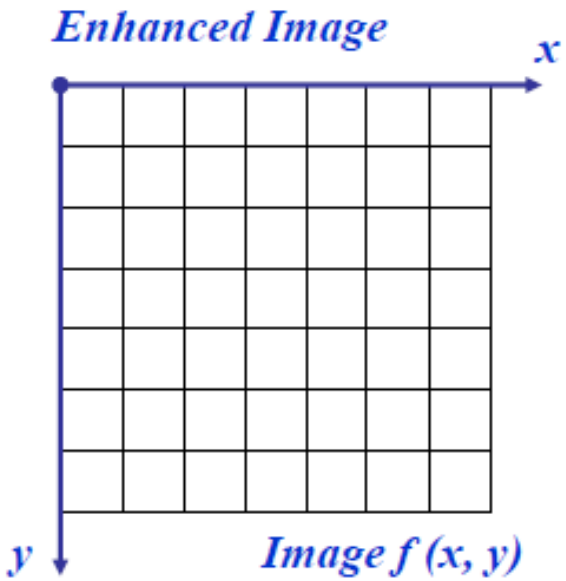
Negative images are useful for enhancing white or grey detail embedded in dark regions of an image

- Note how much clearer the tissue is in the negative image of the mammogram below



NEGATIVE IMAGE

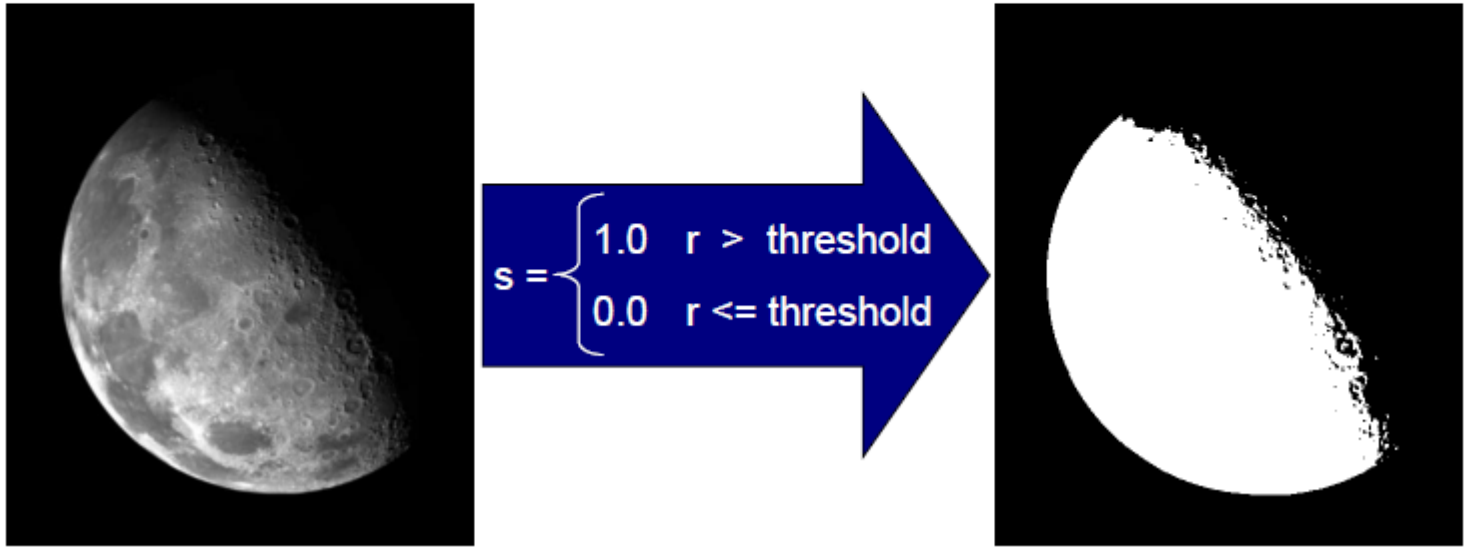




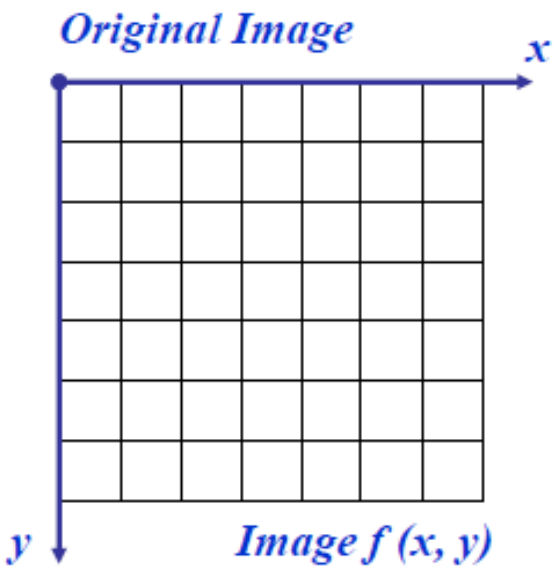
$$s = intensity_{max} - r$$

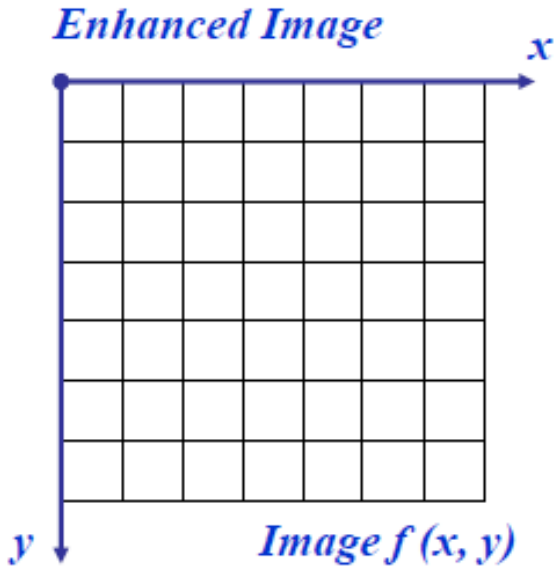
THRESHOLDING

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



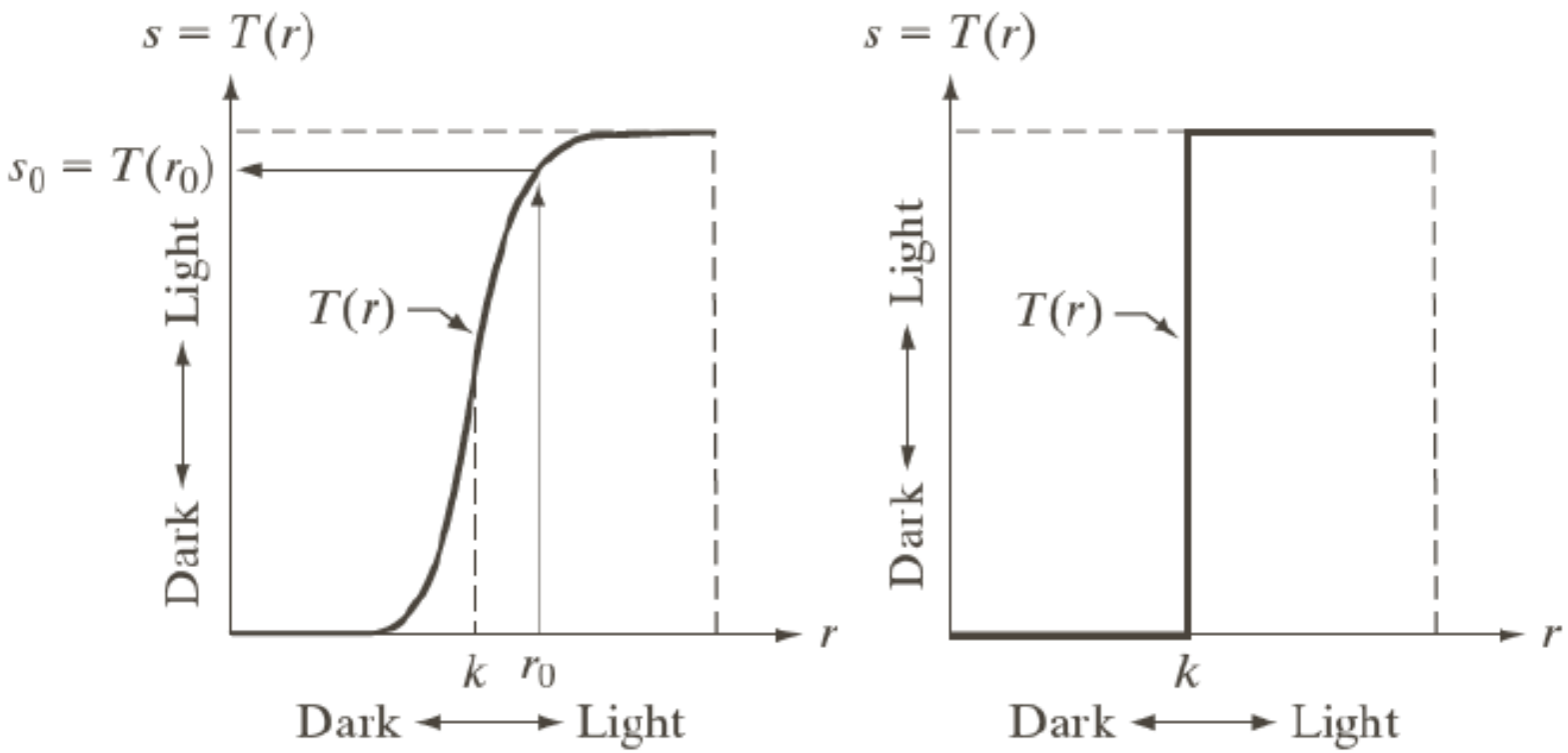
THRESHOLDING





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

INTENSITY TRANSFORMATIONS

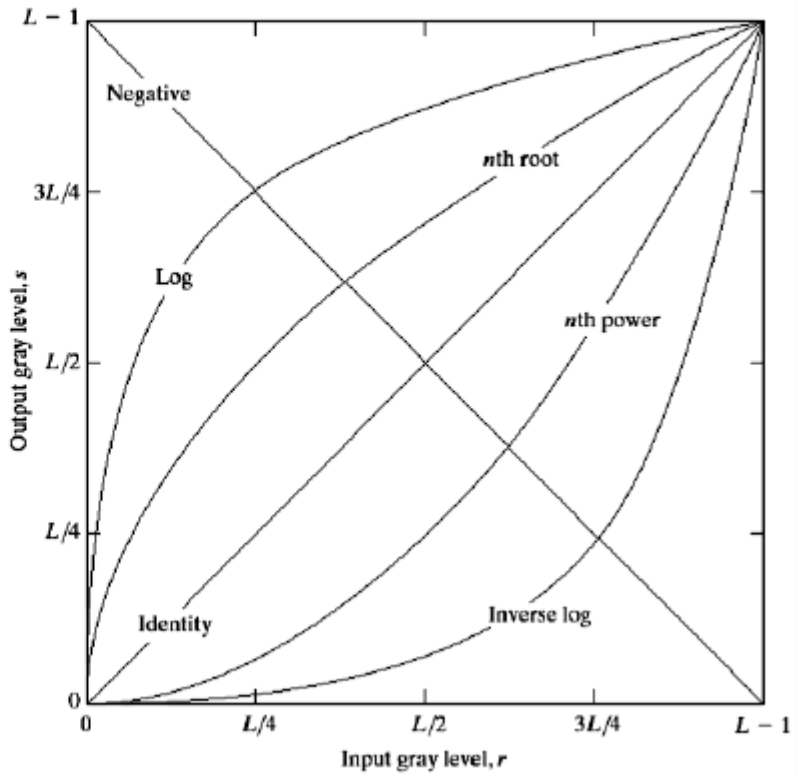


GRAY LEVEL TRANSFORMATIONS

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

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

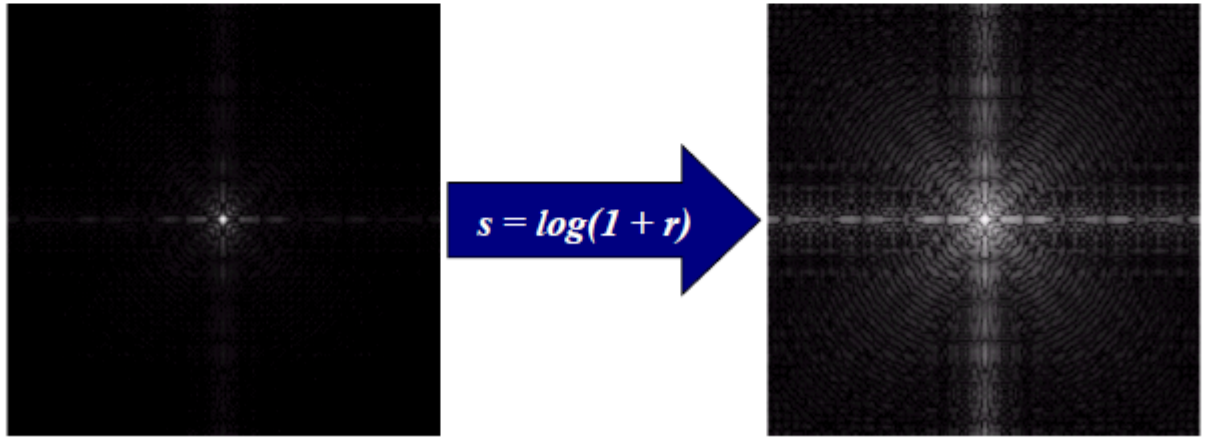
The log transformation maps a narrow range of low input grey level values into a wider range of output values

The inverse log transformation performs the opposite transformation

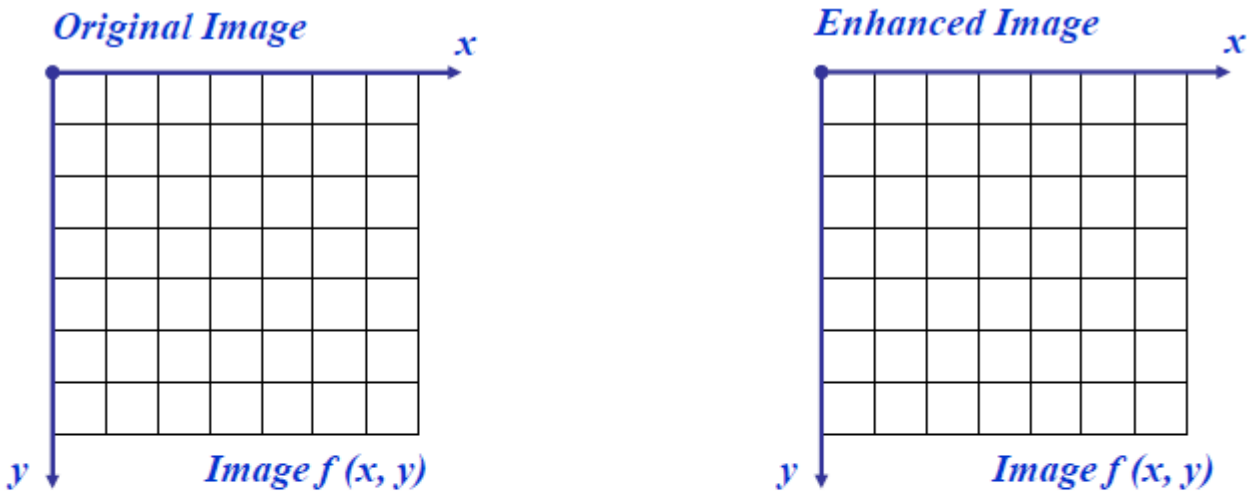
LOGARITHMIC TRANSFORMATIONS

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



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

We usually set c to 1

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

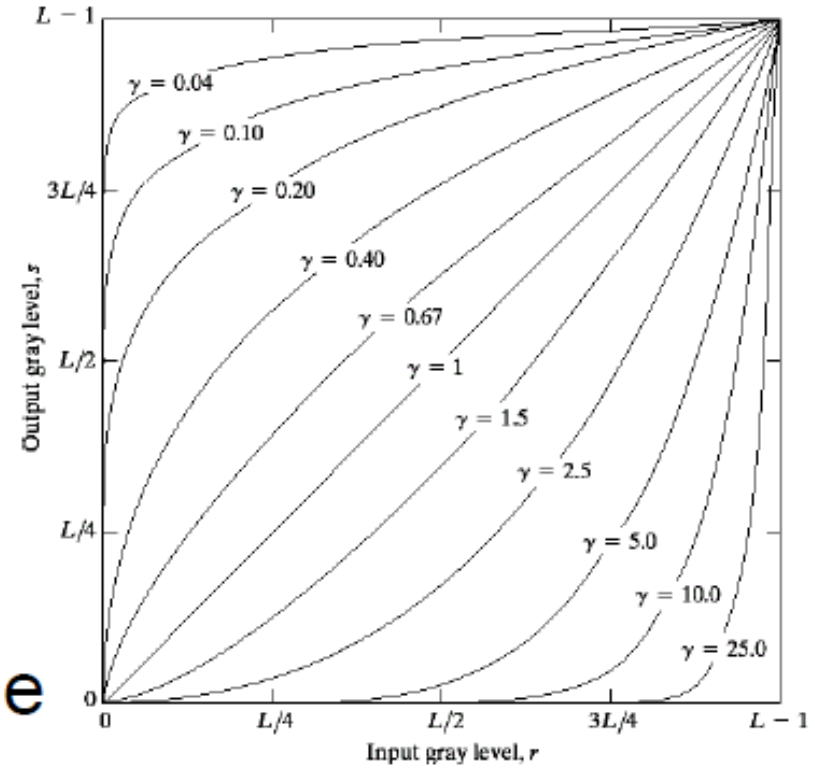
POWER LAW TRANSFORMATIONS

Power law transformations have the following form

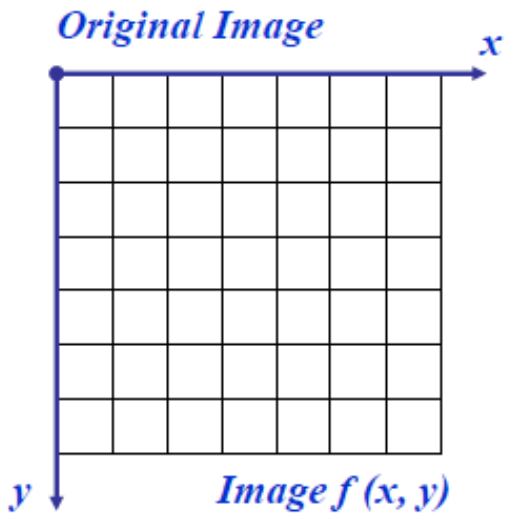
$$s = c * r^{\gamma}$$

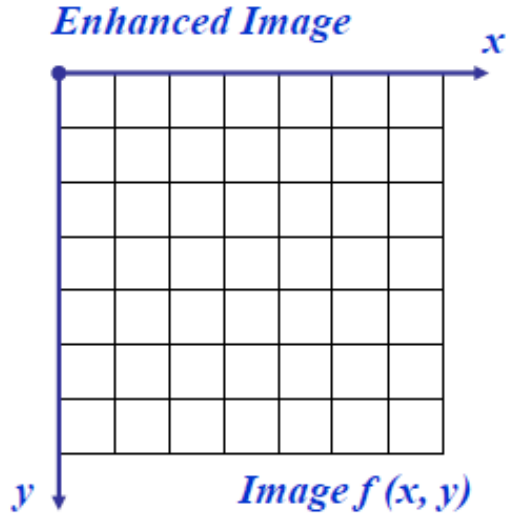
Map a narrow range of dark input values into a wider range of output values or vice versa

Varying γ gives a whole family of curves



POWER LAW TRANSFORMATIONS





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

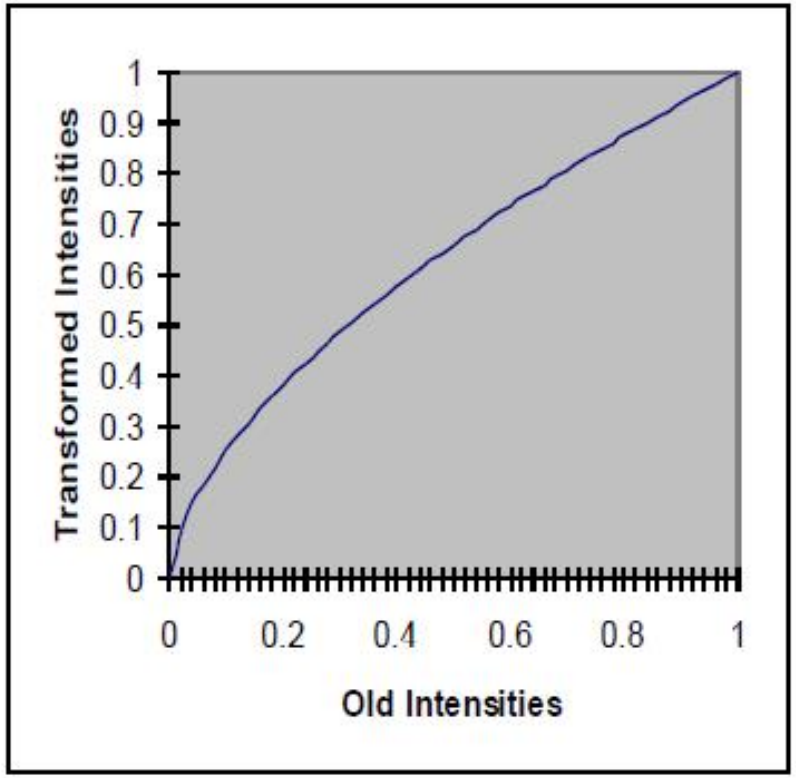
We usually set c to 1

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

POWER LAW EXAMPLE

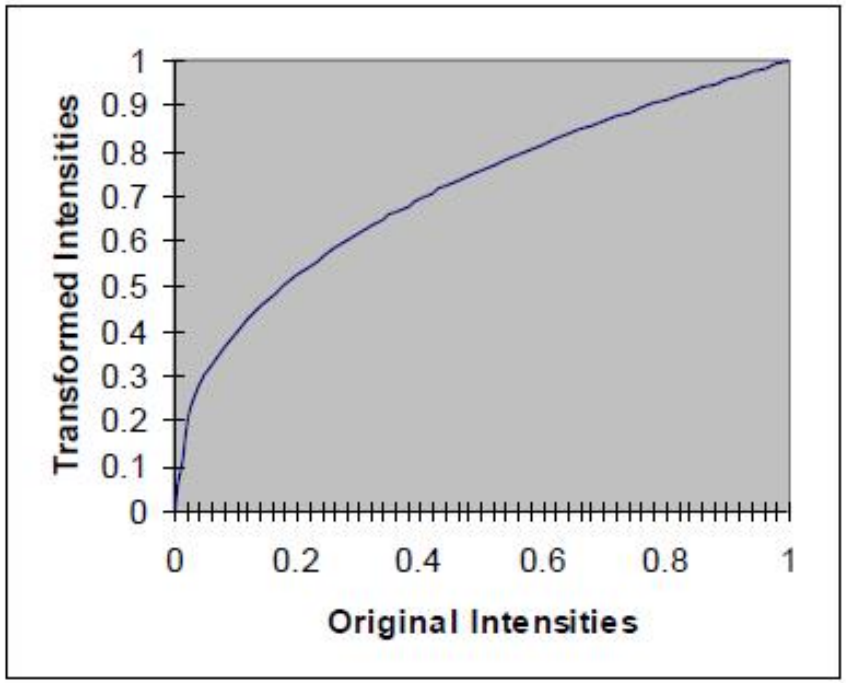
POWER LAW EXAMPLE

$$\gamma = 0.6$$



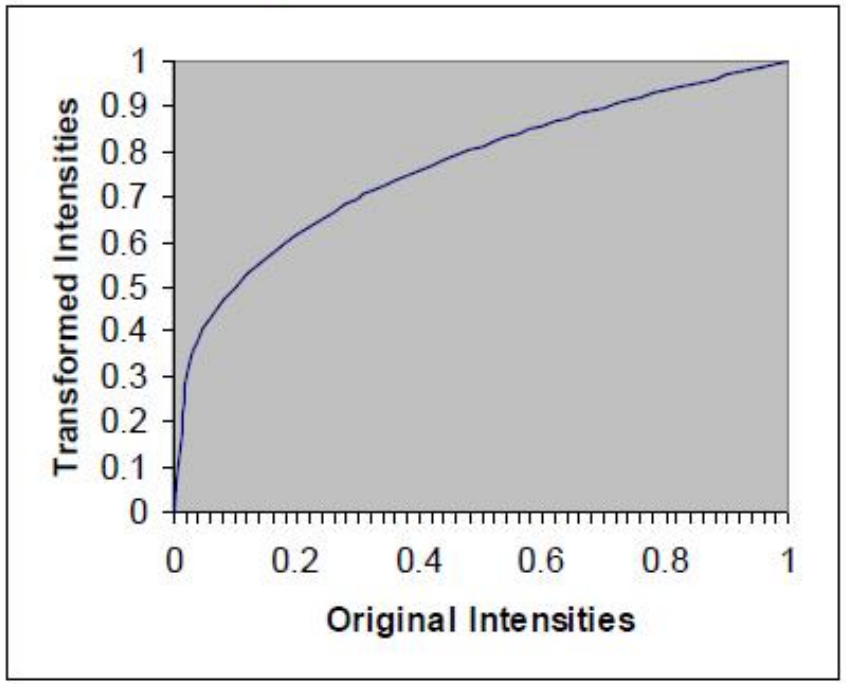
POWER LAW EXAMPLE

$$\gamma = 0.4$$



POWER LAW EXAMPLE

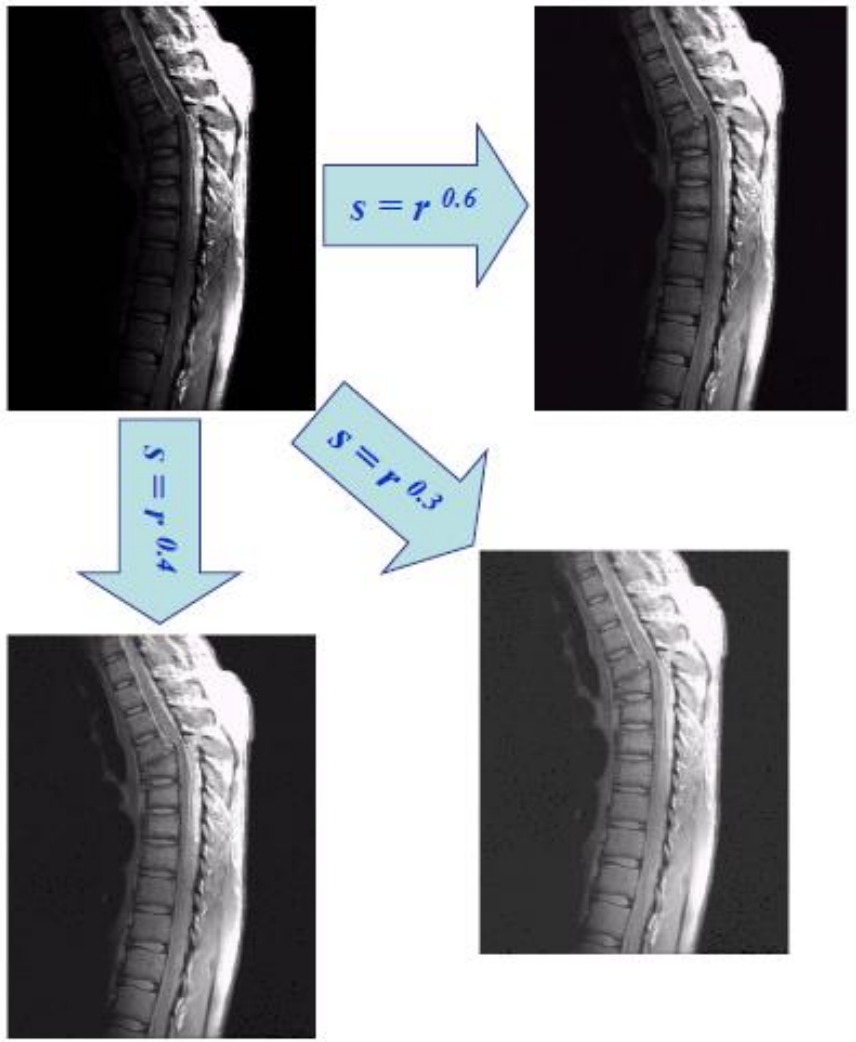
$$\gamma = 0.3$$



POWER LAW EXAMPLE

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

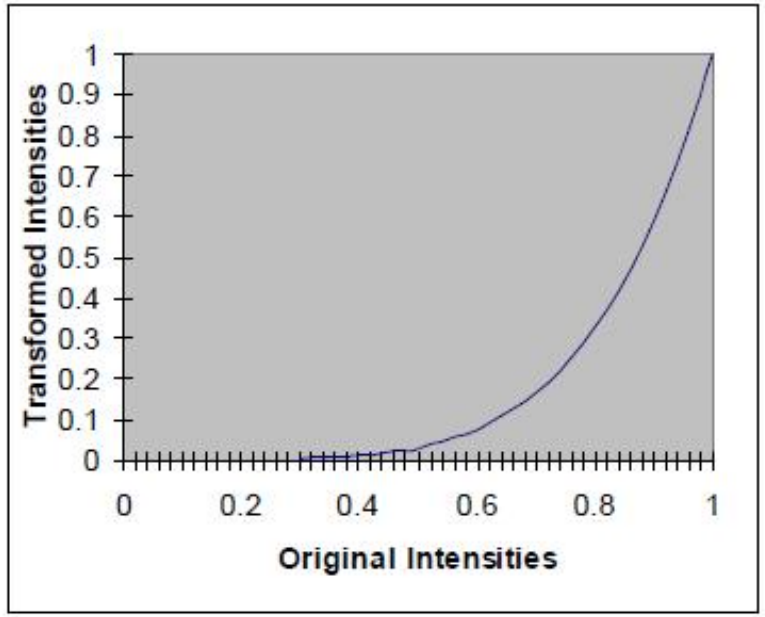
Different curves highlight different detail



POWER LAW EXAMPLE

POWER LAW EXAMPLE

$$\gamma = 5.0$$



POWER LAW EXAMPLE

An aerial photo of a runway is shown

This time power law transforms are used to darken the image

Different curves highlight different detail