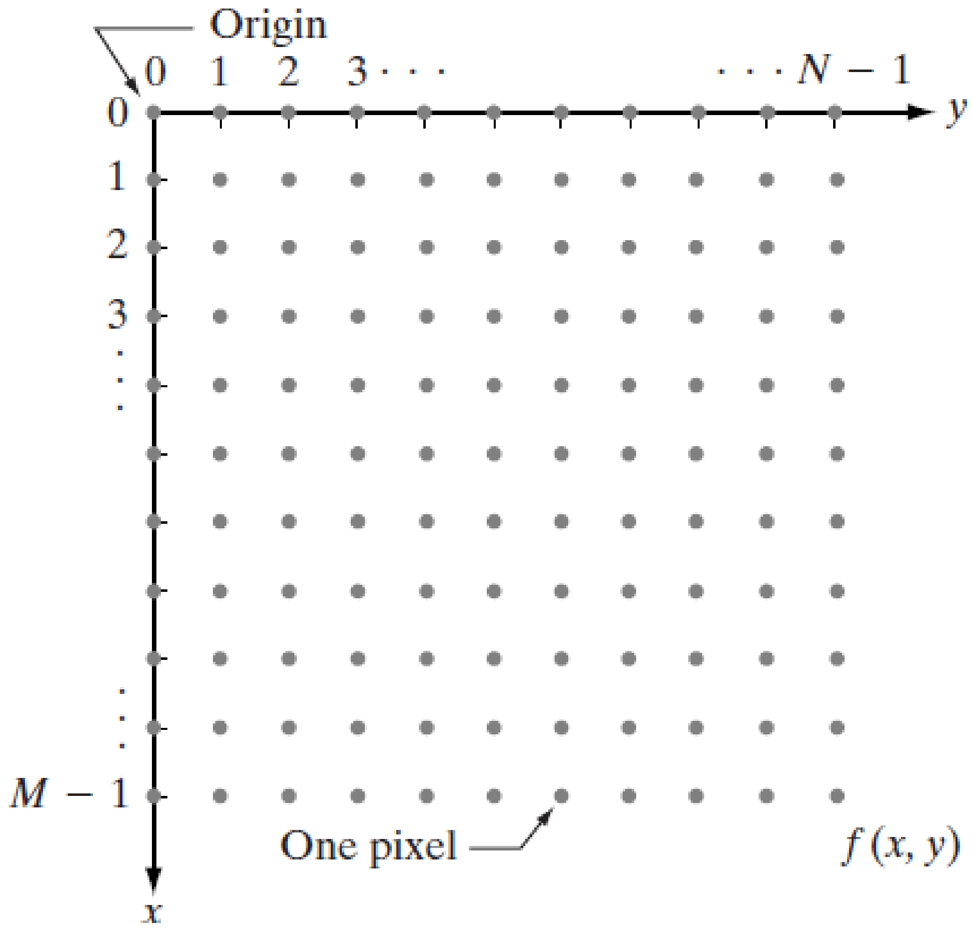
INTENSITY TRANSFORMATIONS

Pixel to Pixel mapping

REPRESENTING DIGITAL IMAGE

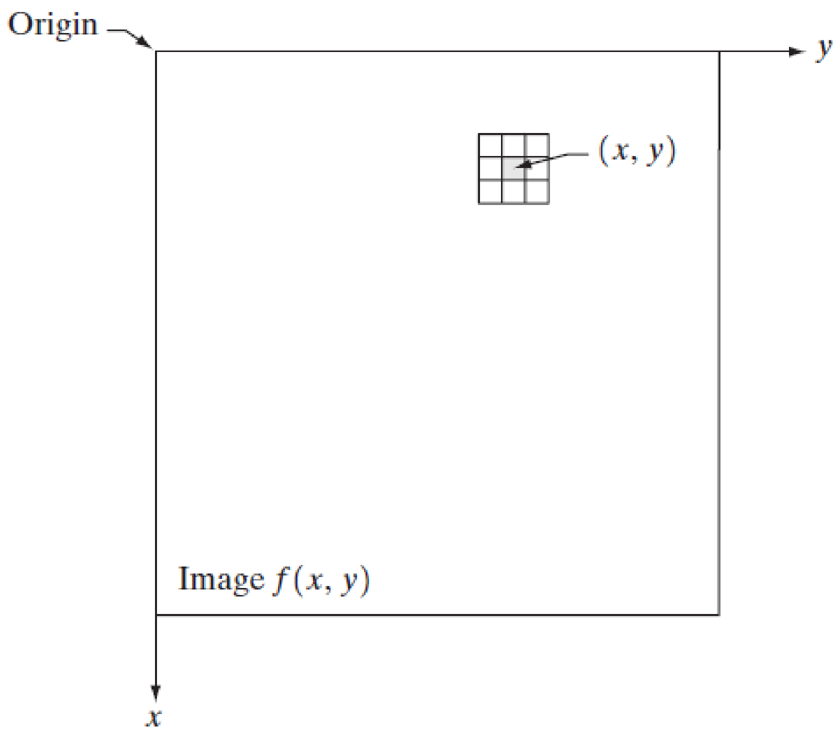
value f(x,y) at each x, y is called ***intensity level*** or ***gray level***



INTENSITY TRANSFORMATIONS AND FILTERS

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

FIGURE 3.1 A 3×3 neighborhood about a point (x, y) in an image.



f(x,y) – input image,
g(x,y) – output image
T is an operator on f defined over a neighborhood of point (x,y)

INTENSITY TRANSFORMATION

1 x 1 is the smallest possible neighborhood.

In this case g depends only on value of f at a single point (x,y)
and we call T an *intensity (gray-level mapping) transformation* and write

$$s = T(r)$$

where r and s denotes respectively the intensity of g and f at any point (x, y).

Thresholding

Padding (0s, 1s, Symmetric, Replicate)

INTENSITY TRANSFORMATION FUNCTIONS

FIGURE 3.3 Some basic gray-level transformation functions used for image enhancement.

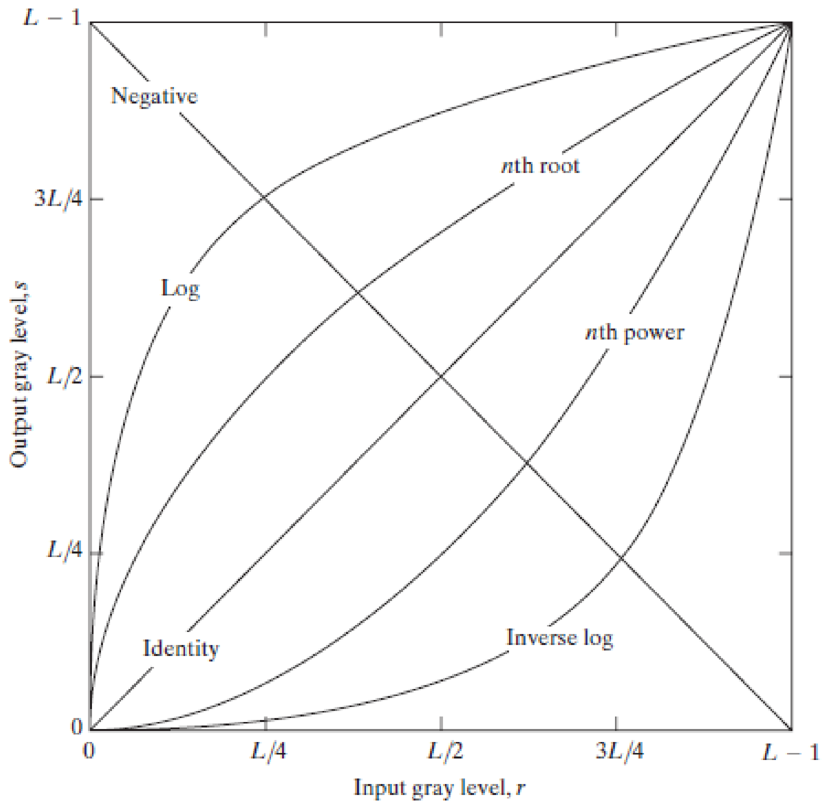
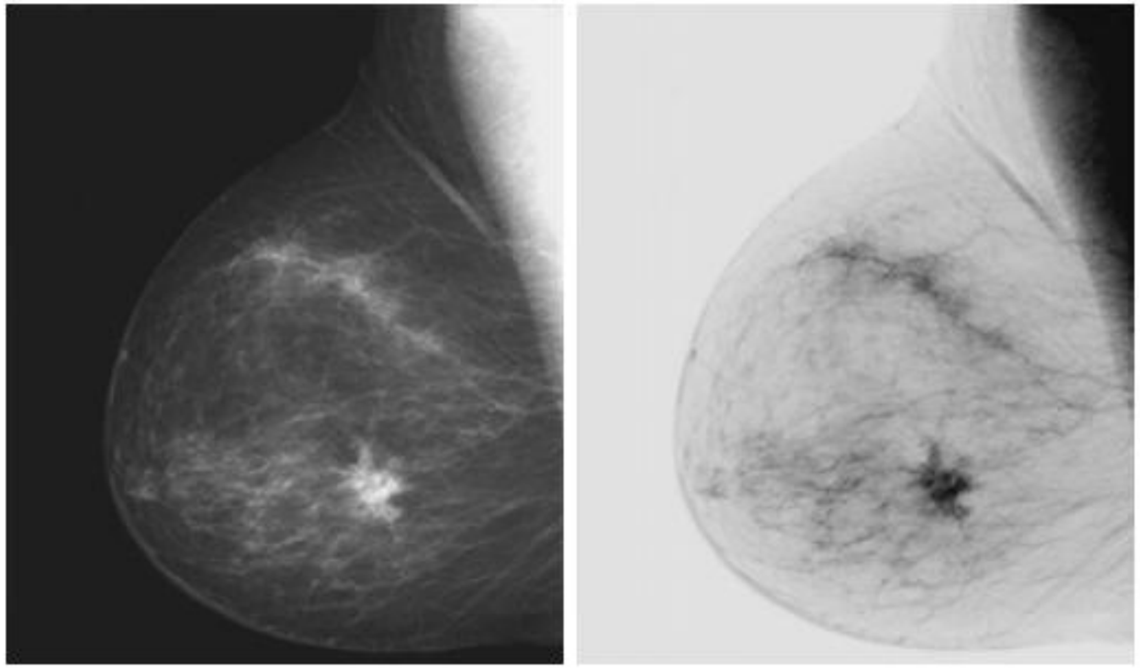


IMAGE NEGATIVES

Denote [0, L-1] intensity levels of the image.

Image negative is obtained by ***s= L-1-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.)

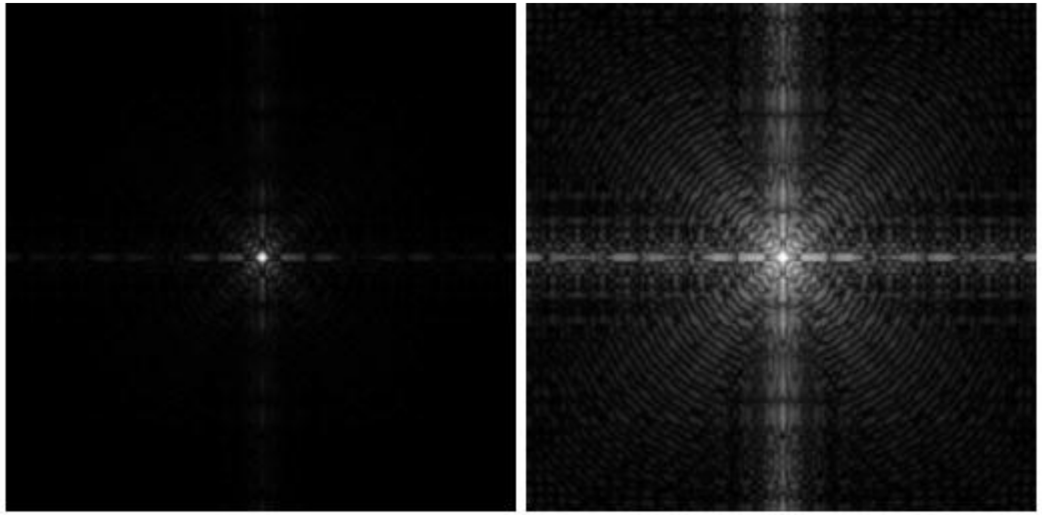
LOG TRANSFORMATIONS

$s = c\log(1+r)$, c – const, $r \geq 0$

Maps a narrow range of low intensity values in the input into a wider range of output levels. The opposite is true for higher values of input levels.

a b

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



POWER–LAW (GAMMA) TRANSFORMATION

$s = cr^{\gamma}$, c, γ –positive constants

curve the grayscale components either to brighten the intensity (when $\gamma < 1$)

or darken the intensity (when $\gamma > 1$).

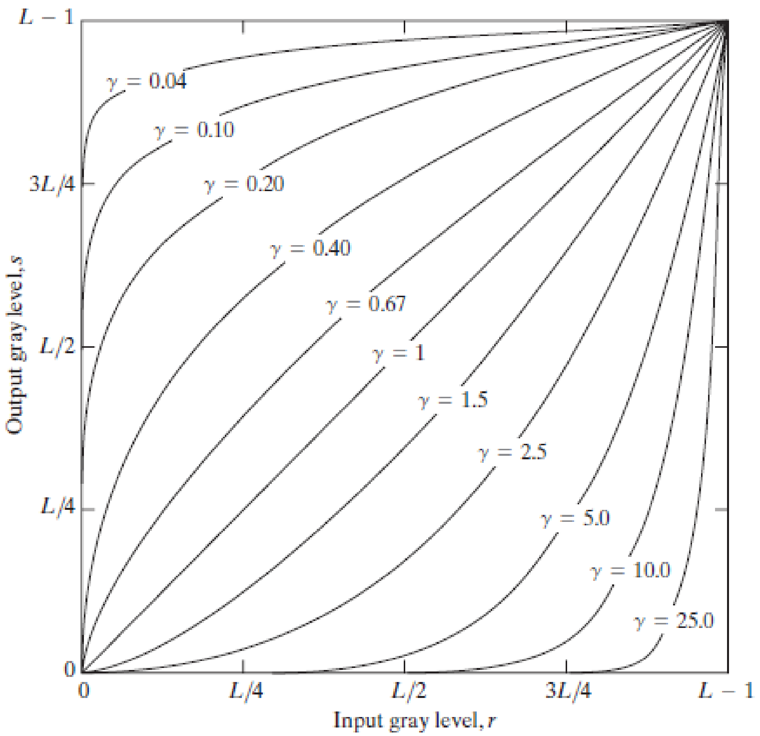
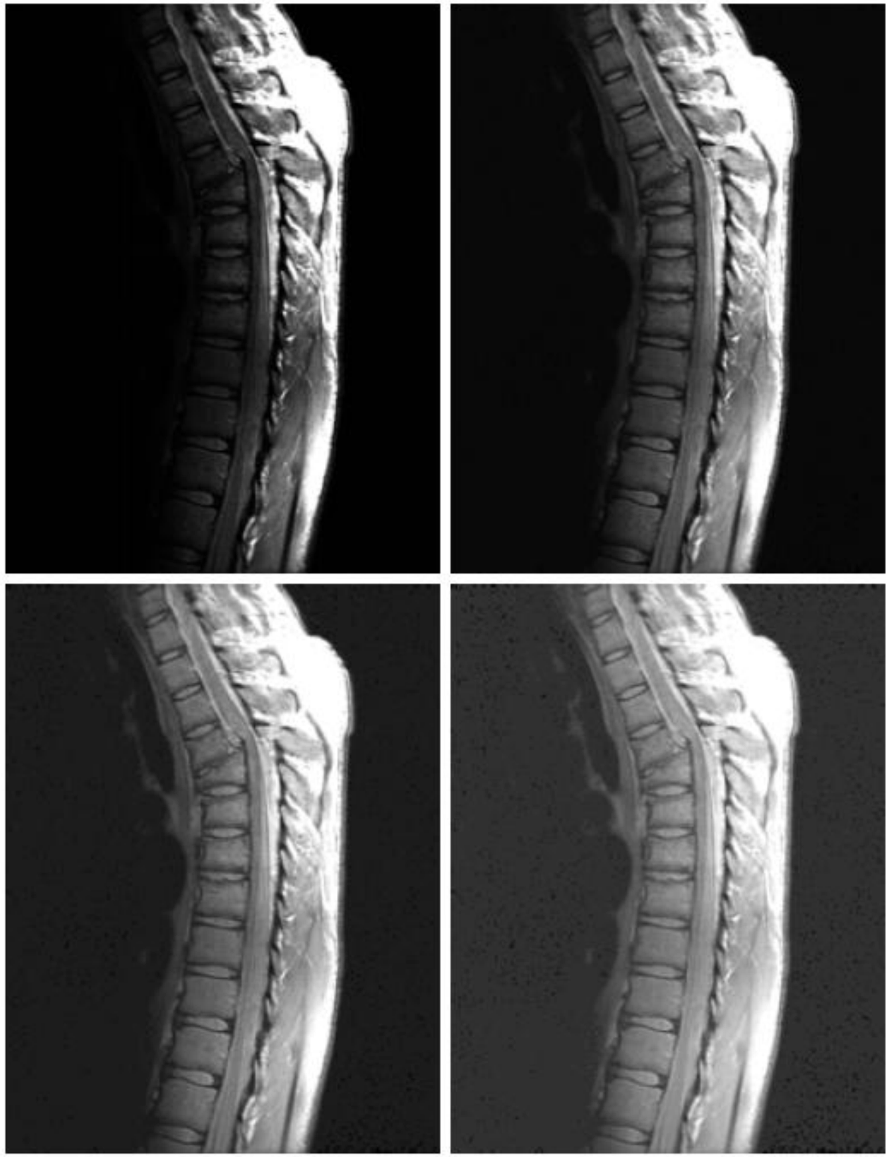


FIGURE 3.6 Plots of the equation $s = cr^{\gamma}$ for various values of γ ($c = 1$ in all cases).

POWER –LAW (GAMMA) TRANSFORMATION



a b
c d

FIGURE 3.8 (a) Magnetic resonance (MR) image of a fractured human spine. (b)–(d) Results of applying the transformation in Eq. (3.2-3) with $c = 1$ and $\gamma = 0.6, 0.4,$ and 0.3, respectively. (Original image for this example courtesy of Dr. David R. Pickens, Department of Radiology and Radiological Sciences, Vanderbilt University Medical Center.)

POWER –LAW (GAMMA) TRANSFORMATION

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.)

Food for thought!

1. What is an intensity (gray-level) transformation in digital image processing?
2. Why are intensity transformations called single-pixel operations?
3. Write the expression for image negative and mention its use.
4. What is the purpose of log transformation in image processing?
5. How does the value of gamma (γ) affect the result of power-law (gamma) transformation?

Programming assignment

- Implement and analyze basic intensity transformation functions to enhance digital images and study their effect on image appearance.
- **Concepts Used**
  - Intensity (gray-level) transformation
  - Image negative
  - Log transformation
  - Power-law (gamma) transformation
  - Single-pixel operations
- **Tasks**
  - Read a grayscale image.
  - Implement image negative transformation.
  - Apply log transformation using a suitable constant.
  - Apply power-law (gamma) transformation for at least two values of γ ($\gamma < 1$ and $\gamma > 1$).
  - Display the original image and all transformed images.

AI supported self-learning (Prompts compatible with ChatGPT)

Active Learners (Learning by Doing)

1. Give me a small grayscale image with pixel values and ask me to compute the image negative using $s = L - 1 - r$. Let me try first, then explain the solution.
2. Create a numerical example where I apply log transformation and gamma transformation to pixel values. Ask me to predict the effect before explaining.

Reflective Learners (Learning by Thinking)

1. Explain intensity (gray-level) transformations step by step and summarize why they are called single-pixel operations.
2. Explain the purpose of image negative, log transformation, and gamma transformation and compare their effects.

Sensing Learners (Concrete & Practical)

1. Explain image negative, log transformation, and gamma transformation using real pixel values and small grayscale matrices.
2. Show practical examples where thresholding and gamma correction improve image visibility.

Intuitive Learners (Concepts & Patterns)

1. Explain the concept of intensity transformation functions and how they reshape gray-level distributions.
2. Explain how changing gamma (γ) affects brightness and contrast and why this behavior occurs.

Visual Learners (Diagrams & Structure)

1. Explain intensity transformations using plots of $s = T(r)$ for image negative, log, and gamma transformations.
2. Visually compare original and transformed images for negative, log, and gamma transformations.

Verbal Learners (Words & Explanation)

1. Explain intensity transformations in simple language using everyday analogies like brightness knobs or camera exposure.
2. Explain why intensity transformations operate on one pixel at a time as if teaching it to a beginner.

Sequential Learners (Step-by-Step Logic)

1. Explain step by step how an intensity transformation maps input pixel values r to output values s.
2. Explain step by step how gamma correction works for $\gamma < 1$ and $\gamma > 1$ and how it affects image brightness.

Global Learners (Big Picture First)

1. First explain the overall role of intensity transformations in image enhancement, then explain individual transformations.
2. Explain why intensity transformations are fundamental before moving to neighborhood-based filtering operations.