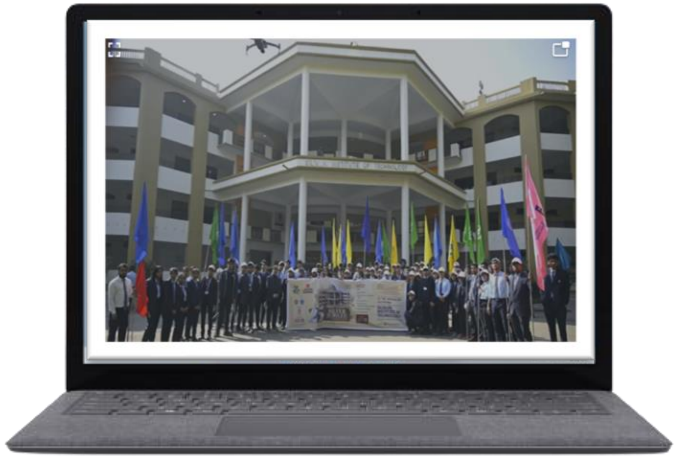


Intensity Transformation and Spatial Filtering

Spatial Domain Processing

- The term spatial domain refers to the image plane itself, and image processing methods in this category are based on direct manipulation of pixels in an image.
- Two principal categories of spatial processing are intensity transformations and spatial filtering.
- Intensity transformations operate on single pixels of an image for tasks such as contrast manipulation and image thresholding. Spatial filtering performs operations on the neighborhood of every pixel in an image.

Spatial Domain Processing

- Intensity transformations are used for image enhancement. Intensity transformation refers to the process of transforming the intensity values of the pixels in the image.
- Each intensity value gets mapped to a new value. The intensity mapping can be applied uniformly to all pixels, or may vary from one pixel to another depending on the neighborhood context.
- $s = T(r)$ [Point operation]
- The former is called as point operation and the latter is called as neighborhood operation.
- $g(x,y) = T[f(x,y)]$ [Neighbourhood operation]

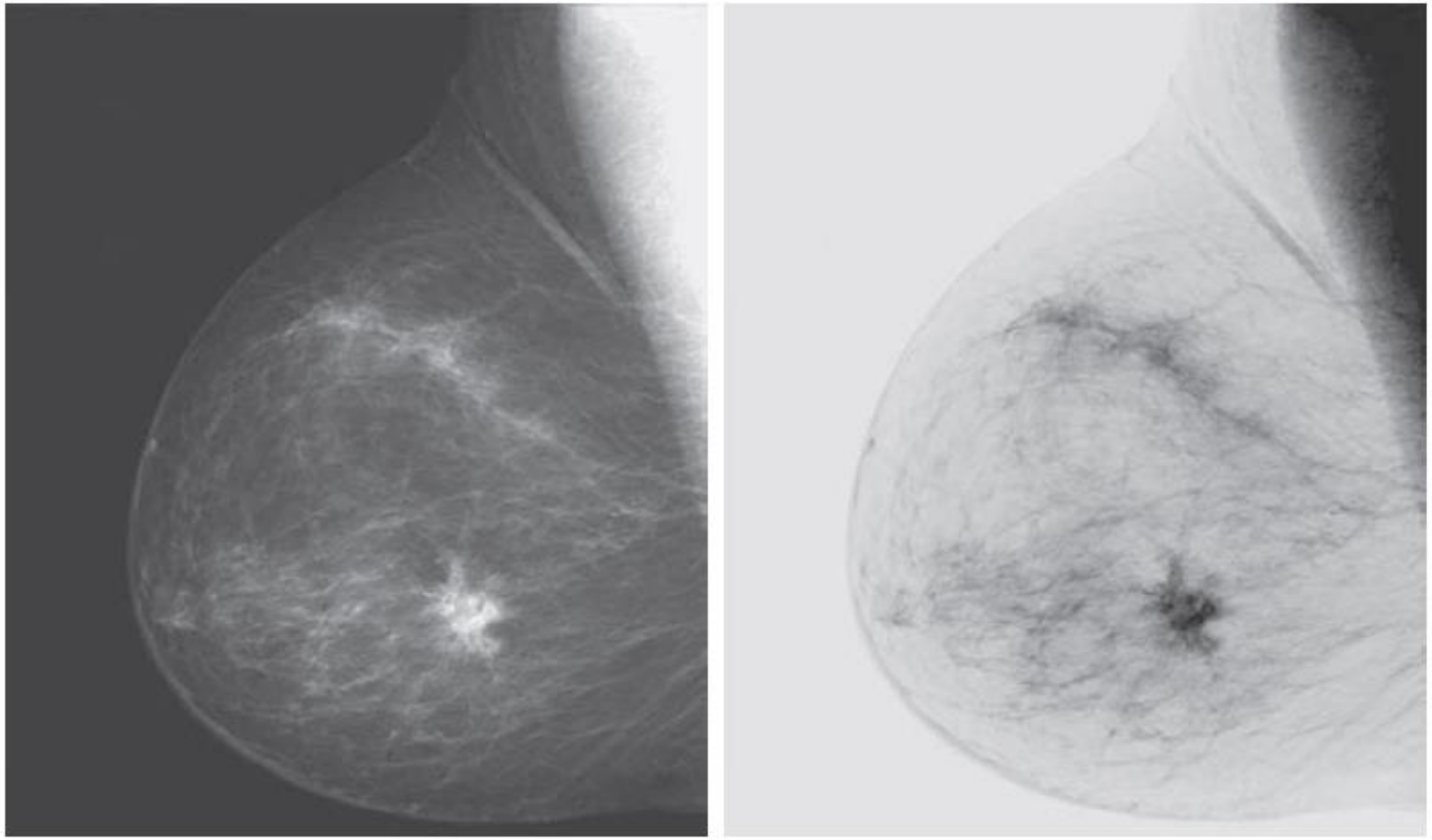
Spatial Domain Processing

- Point processing techniques mainly find use in contrast enhancement, region highlighting, etc.,
- Neighborhood processing techniques find use for tasks such as image smoothing, sharpening, etc.
- The gray level transformation function can be continuous or piecewise continuous.

Continuous Intensity Transformation: Negative Transformation

- The negative of an image with intensity levels in the range [0,L – 1] is obtained by using the negative transformation function: $s = L - 1 - r$
- Reversing the intensity levels of a digital image in this manner produces the equivalent of a photographic negative.
- This type of processing is used, for example, in enhancing white or gray detail embedded in dark regions of an image, especially when the black areas are dominant in size.

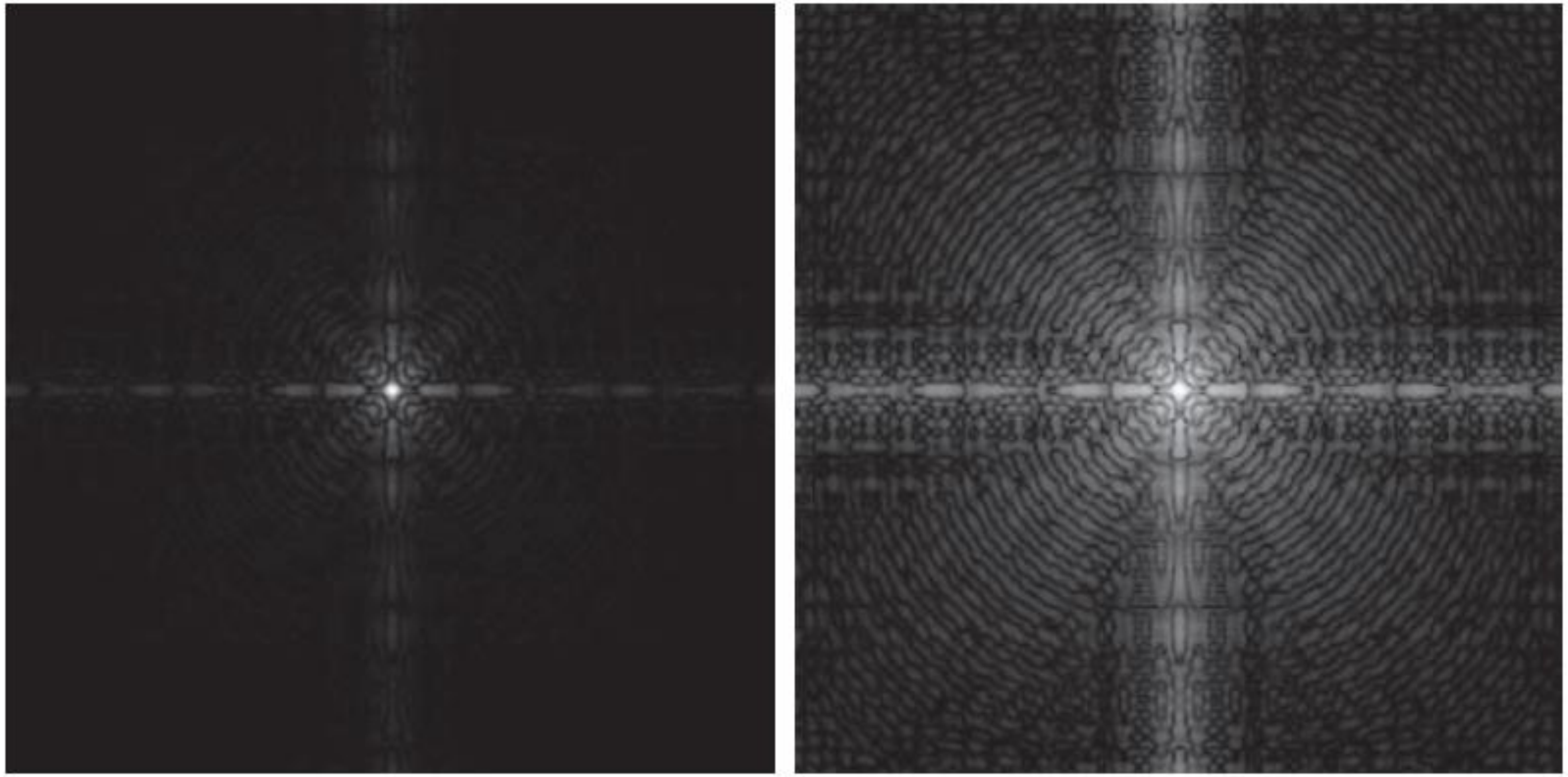
Continuous Intensity Transformation: Negative Transformation



Continuous Intensity Transformation: Log Transformation

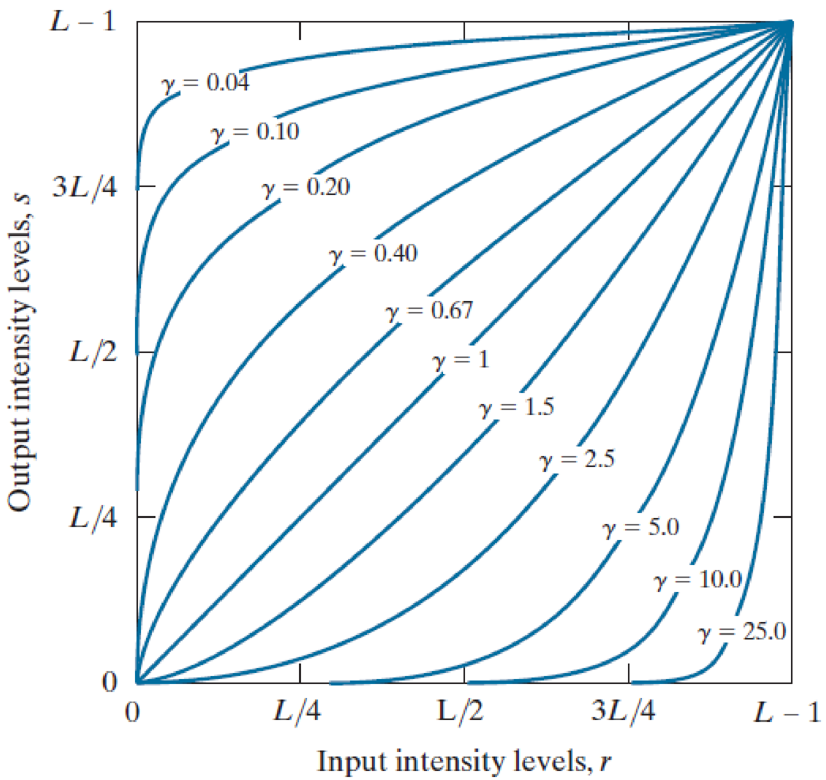
- The general form of the log transformation is defined as $s = clog(1 + r)$
- where c is a constant and it is assumed that $r \geq 0$.
- use to expand the values of dark pixels in an image, while compressing the higher-level values. The opposite is true of the inverse log (exponential) transformation.

Continuous Intensity Transformation: Log Transformation



Continuous Intensity Transformation: Power-law (Gamma) Transformations

- Power-law transformations have the form $s = cr^{\gamma}$
- power-law curves with fractional values of g map a narrow range of dark input values into a wider range of output values, with the opposite being true for higher values of input levels.

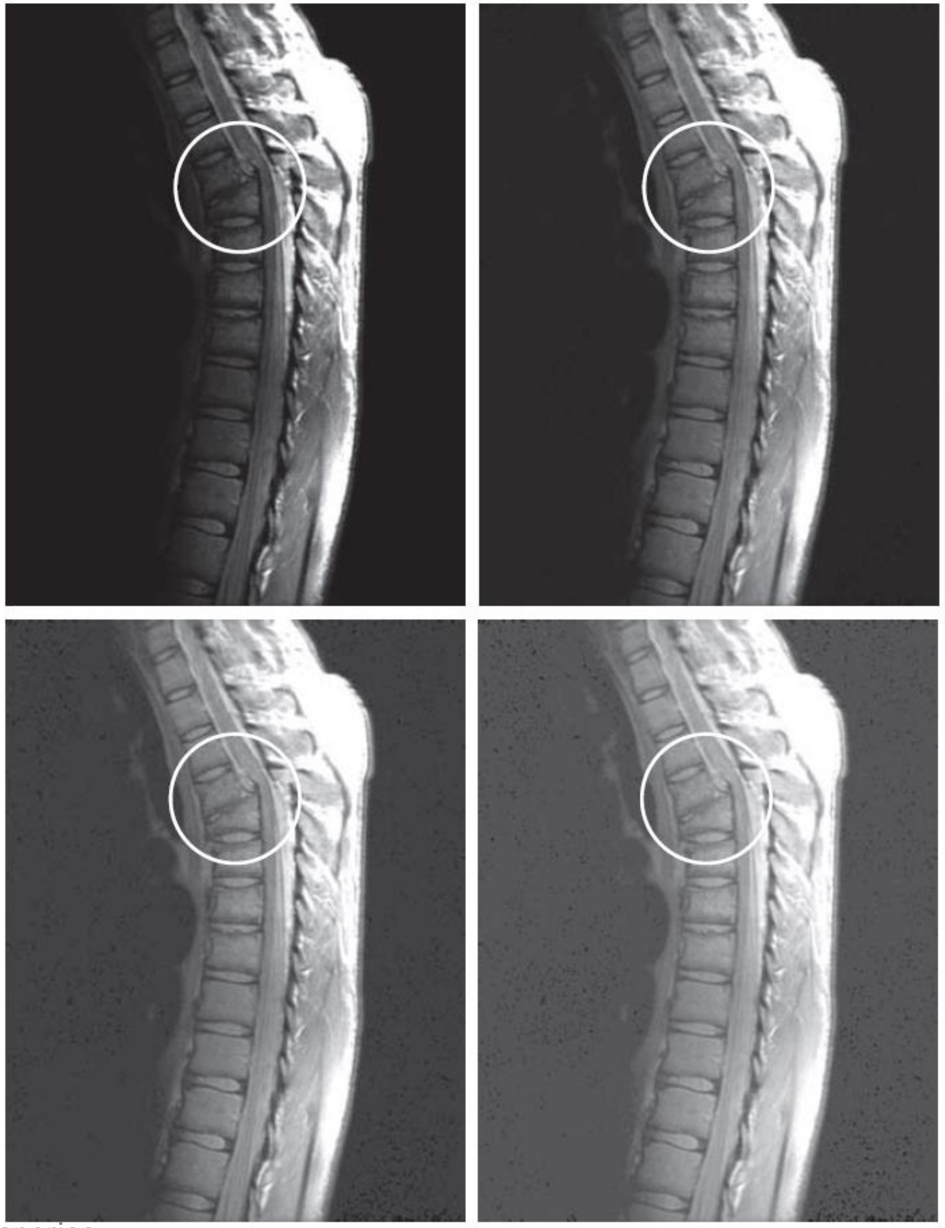


Power-law (Gamma) Transformations

ab

cd

Results of applying the gamma transformation with c = 1 and g = 0 6 . , 0.4, and 0.3, respectively.



Power-law (Gamma) Transformations

ab

cd

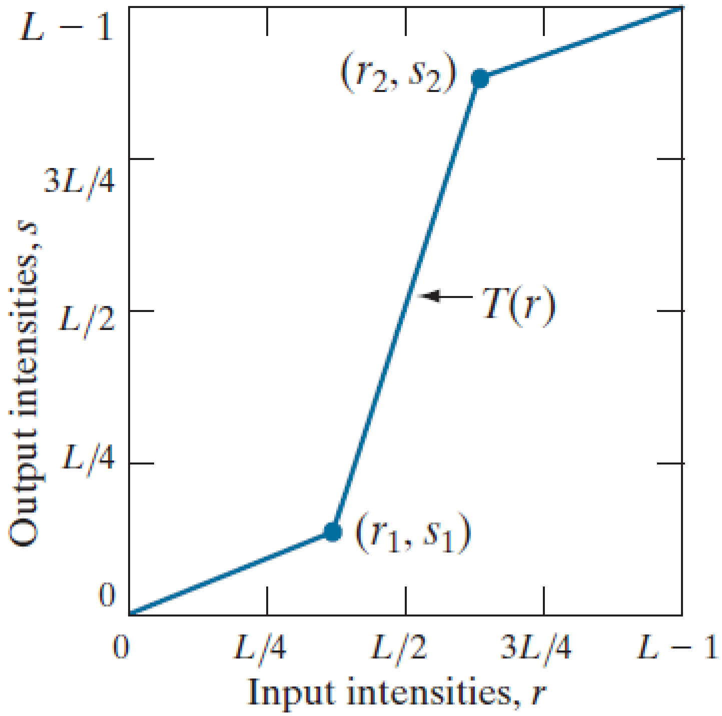
Results of applying the gamma transformation with c = 1 and g = 3.0, 4.0, and 5.0, respectively.

Piecewise Linear Transformation Functions

- The advantage of these functions over those discussed thus far is that the form of piecewise functions can be arbitrarily complex.
- a practical implementation of some important transformations can be formulated only as piecewise linear functions.
- The main disadvantage of these functions is that their specification requires considerable user input.

Piecewise Linear Transformation Function: Contrast Stretching

- Figure shows a typical transformation used for contrast stretching.
- The locations of points (r_1, s_1) and (r_2, s_2) control the shape of the transformation function.
- If $r_1 = s_1 and\ r_2 = s_2$ the transformation is a linear function that produces no changes in intensity.
- If $r_1 = r_2, s_1 = 0\ and\ s_2 = L - 1$ the transformation becomes a thresholding function that creates a binary image



Piecewise Linear Transformation Function: Contrast Stretching

A low contrast electron microscope image of pollen, magnified 700 times. (c) Result of contrast stretching. (d) Result of thresholding.

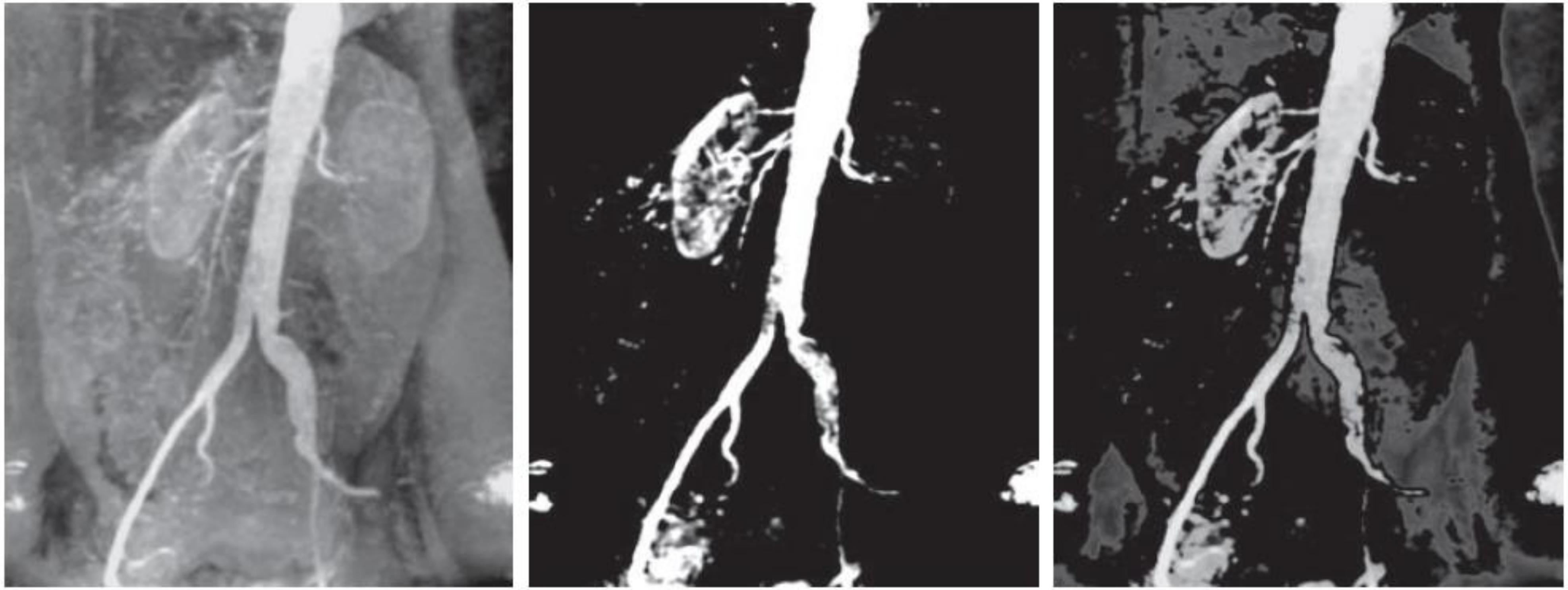
Piecewise Linear Transformation Function: Intensity Level Slicing

- Make certain ranges of intensity values look more prominent in the image.
- This is done by making a range of intensities more brighter or darker compared to the background.
- The appropriate parameters for these transformations are tuned by manual adjustments so that the desirable effect is produced.

Piecewise Linear Transformation Function: Intensity Level Slicing

- intensity-level slicing, can be implemented in several ways, but most are variations of two basic themes.
- One approach is to display in one value (say, white) all the values in the range of interest and in another (say, black) all other intensities. This transformation, shown in Fig (a), produces a binary image.
- The second approach, based on the transformation in Fig.(b), brightens (or darkens) the desired range of intensities, but leaves all other intensity levels in the image unchanged.

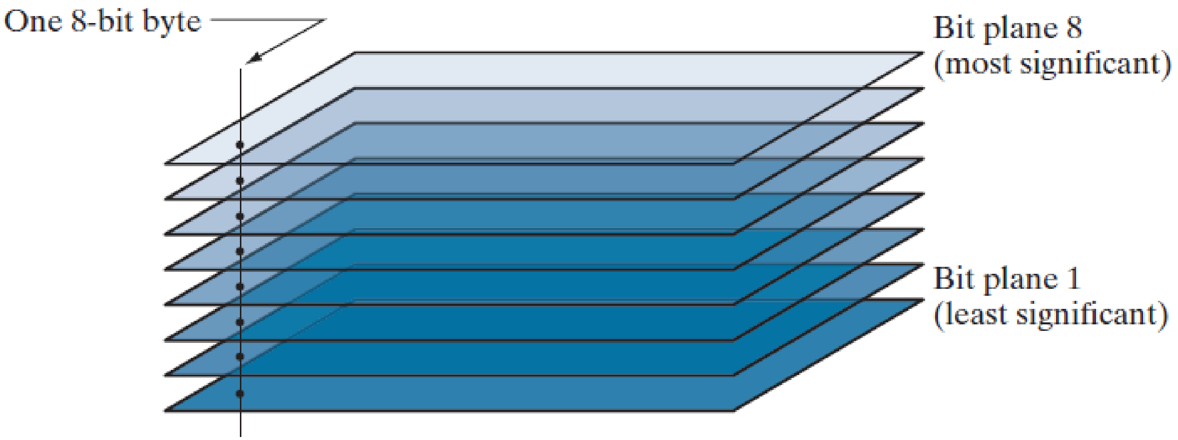
Piecewise Linear Transformation Function: Intensity Level Slicing



(a) Aortic angiogram. (b) Result of using a slicing transformation of the type illustrated in Fig. (a), with the range of intensities of interest selected in the upper end of the gray scale. (c) Result of using the transformation in Fig. (b), with the selected range set near black, so that the grays in the area of the blood vessels and kidneys were preserved.

Piecewise Linear Transformation Function: Bit Level Slicing

- Instead of highlighting intensity-level ranges, we could highlight the contribution made to total image appearance by specific bits.
- An 8-bit image may be considered as being composed of eight one-bit planes, with plane 1 containing the lowest-order bit of all pixels in the image, and plane 8 all the highest-order bits.



Piecewise Linear Transformation Function: Intensity Level Slicing

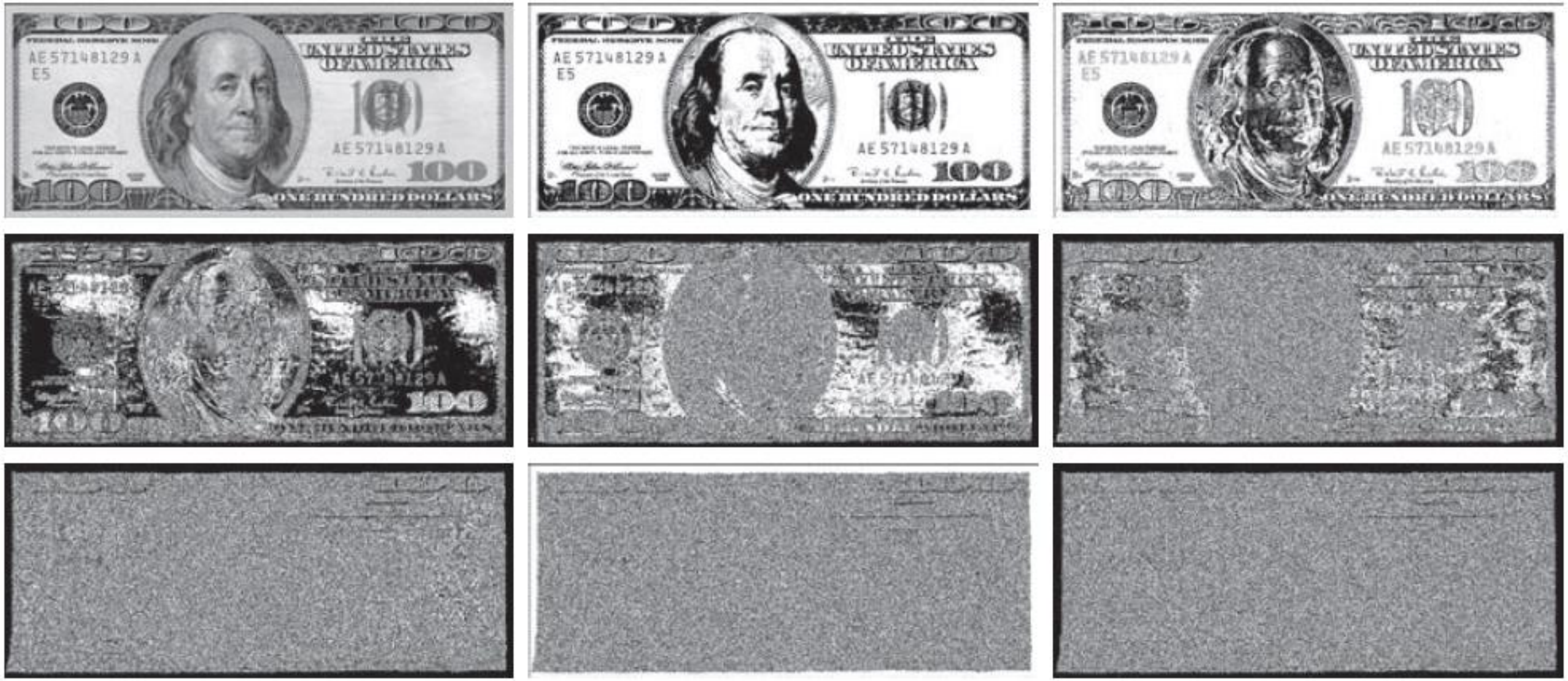


Image Reconstruction

- Decomposing an image into its bit planes is useful for analyzing the relative importance of each bit in the image.
- this type of decomposition is useful for image compression in which fewer than all planes are used in reconstructing an image.
- The reconstruction is done by multiplying the pixels of the nth plane by the constant 2n−1.

abc Image reconstructed from bit planes: (a) 8 and 7; (b) 8, 7, and 6; (c) 8, 7, 6, and 5.

Reference

- E Woods, Richard, and Rafael C Gonzalez. "Digital image processing." (2008).