Image Preprocessing
Gonzalez
Spatial Preprocessing

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1 Overview and Definitions

Spatial Domain Process Formally is defined as:

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

where T is an operator defined over a neighbourhood of (x, y) on f. Also it can be defined on a set of input images.

Definition of Neighbourhood Usually as a **square or rectangular subimage** centered at (x, y).

Gray-level transformation If neighbourhood radius is equal to 1 then T is a **Gray-level**, or **Intensity** or **Mapping**, transformation function. It is:

$$s = T(r)$$

where s and r are respectively the gray level of $g(x, y)$ and $f(x, y)$. **Techniques using gray-level transformation, as they operate on just a single point, are mostly referred to as *point processing.***

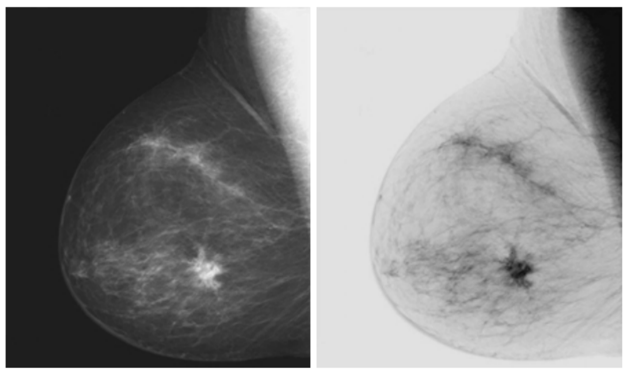
Mask Masks or filters are 2D arrays with a specific size in which inner weights define the application and effect of the mask.

2 Some Basic Gray-level Transformations

Negative Image A negative image of an input image with gray levels in the range [0 , L-1] is defined as:

$$s = (L - 1) - r$$

Following is an example of application:



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.)

Figure 1: This figure illustrates evident contribution of reversing the intensity (negating image) to illustrate existence of lesion in a part of body.

Log Transformation The general form of this transformation is as follows:

$$s = c \log^{(1+r)}$$

This transformation maps a narrow range of low gray-levels in input image to a wider range in output.
This transformation is appropriate for applications in which having more details of darker parts of image along with bright parts makes worthwhile contributions to accomplish the required task.

Power-Law Transformation This kind of transformation has a basic form as follows.

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

This transformation is sort of generalization for log-transformation. As it is displayed in fig3, in which plots of s versus r for various values of γ are shown, with lower values of γ than 1 this transformation operates as a b

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

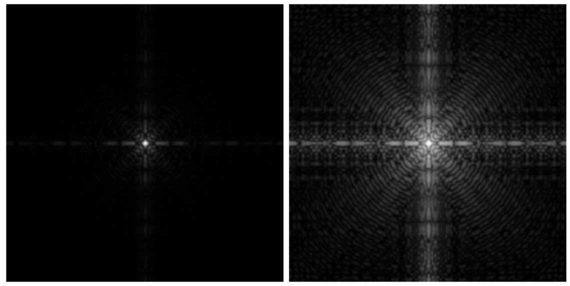


Figure 2: Log transformation effect on input picture

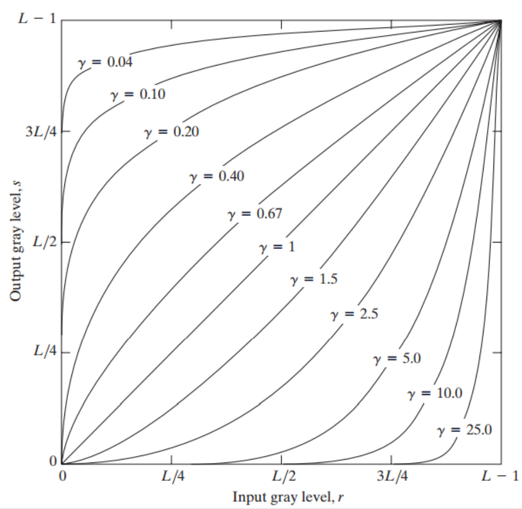


FIGURE 3.6 Plots of the equation $s = cr^{\gamma}$ for various values of γ ($c = 1$ in all cases).

Figure 3: Plots of s versus r for various values of γ

a log-transformation and in cases with γ values larger than 1, it operates totally inversely.

One of the most important and useful applications of this transformation is **gamma correction** in which value ranges in an input image would be mapped to a more appropriate range for certain image displayers to generate fitter images. The value of γ in different applications corresponds to the using device and its properties. In fig4 in gamma correction process is $\gamma = 0.4$.
Note that, varying the value of gamma correction changes not only the brightness, but also the ratios of red to green to blue.

Note that, power-law transformation also affects image's contrast. Fig5

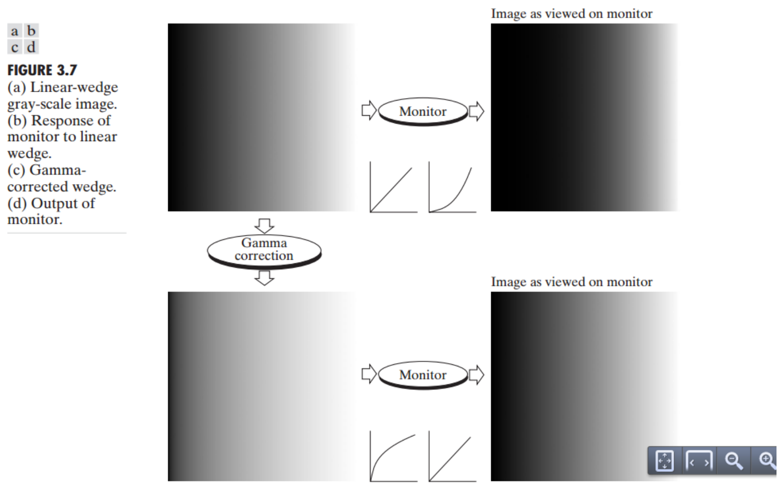


Figure 4: Power-Law Transformation result and effect on an input image

illustrate the effect of this transformation on image's contrast. In this picture, the value of γ increases in each case.

Piecewise-Linear Transformation Functions This kind of transformation, fragments a transformation range to several subtransformations each specified in a disjoint range of overall transformation's definition range. Thus in each subtransformation any of above-mentioned transformations are applicable. Event though, this method provides us a great opportunity to make more complex and more advantageous transformations, it needs more user input.
There are some examples of this method's applications.

Contrast Stretching Creating a transformation function which is partially defined for different ranges for (r, s) pairs. Fig6 demonstrates such an example function.

Gray-Level Slicing This kind of transformation is widely used in making a specified gray-level range of input image more salience.

Bit-Plane Slicing Separating bit planes of an image can make worthwhile contribution in achieving better results in applications. Fig7 displays application of such transformation on an input image of a fractal.

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.)

Figure 5: An illustration of power-law transformation's effect on image contrast.

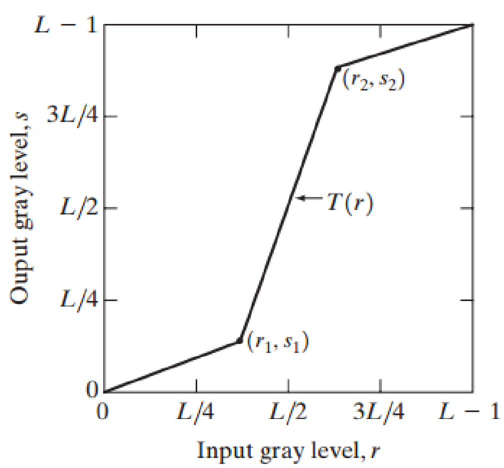


Figure 6: An example of piecewise-transformation function for contrast stretching.

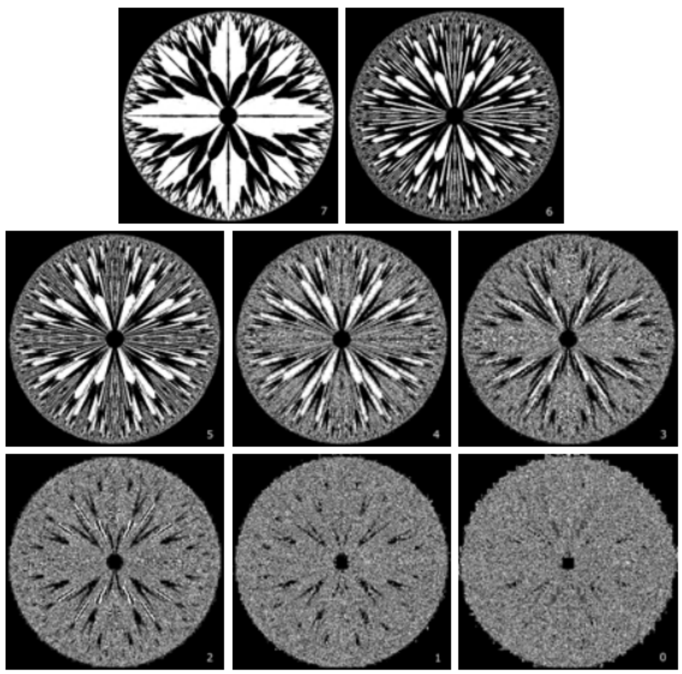


FIGURE 3.14 The eight bit planes of the image in Fig. 3.13. The number at the bottom, right of each image identifies the bit plane.

Figure 7: Applying a bit-plane slicing transformation on bit planes of a fractal image in order to separate bit-planes.