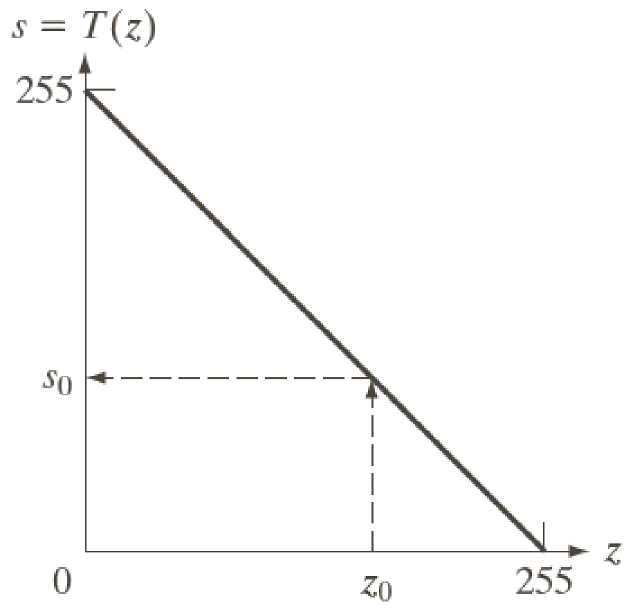
Image Transformations: Fundamentals

Single Pixel Operations

- Altering the pixel values based on their intensities
- $s = T(z)$
- Estimating image negative of an 8-bit image



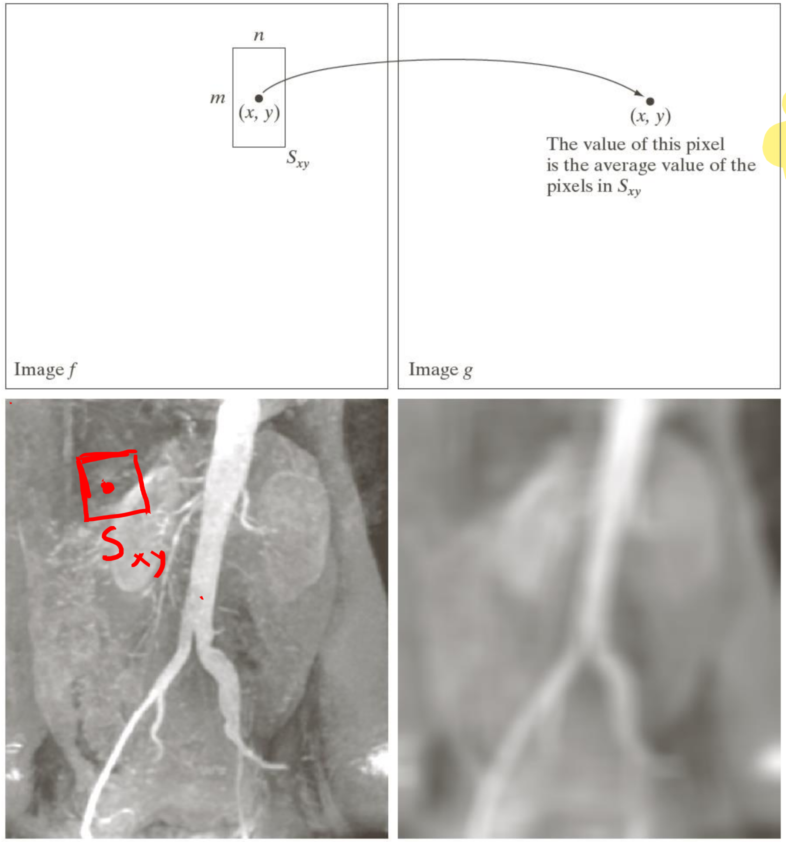
Neighbourhood Operations

- S_{xy} be the set of coordinates of a neighbourhood centered on an arbitrary point (x, y) in an image f
- $g(x, y) = \frac{1}{mn} \sum_{(r,c) \in S_{xy}} f(r, c)$

mn

m = n = 41

41 × 41



a b
c d

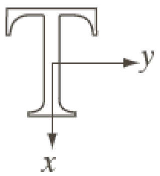
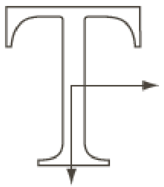
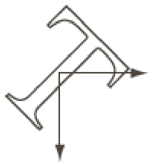
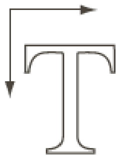
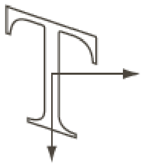
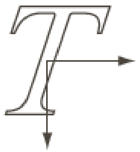
FIGURE 2.35 Local averaging using neighborhood processing. The procedure is illustrated in (a) and (b) for a rectangular neighborhood. (c) The aortic angiogram discussed in Section 1.3.2. (d) The result of using Eq. (2.6-21) with $m = n = 41$. The images are of size 790 × 686 pixels.

Geometric Spatial Transformations

- Geometric transformations (*rubber-sheet*) modify the spatial relationship between pixels in an image.
- Two main steps
  - i • Spatial transformation of coordinates
  - ii • Intensity interpolation that assigns intensity values to the spatially transformed pixels
- $(x, y) = T\{(v, w)\}$
- **Affine transformation** is the most commonly used spatial coordinate transform.

$$[x\ y\ 1] = [v\ w\ 1]\mathbf{T} = [v\ w\ 1]\begin{bmatrix} t_{11} & t_{12} & 0 \\ t_{21} & t_{22} & 0 \\ t_{31} & t_{32} & 1 \end{bmatrix}$$

TABLE 2.2
Affine transformations based on Eq. (2.6.–23).

Transformation Name	Affine Matrix, T	Coordinate Equations	Example
Identity	$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$	$x = v$ $y = w$	
Scaling	$\begin{bmatrix} c_x & 0 & 0 \\ 0 & c_y & 0 \\ 0 & 0 & 1 \end{bmatrix}$	$x = c_x v$ $y = c_y w$	
Rotation	$\begin{bmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$	$x = v\cos\theta - w\sin\theta$ $y = v\cos\theta + w\sin\theta$	
Translation	$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ t_x & t_y & 1 \end{bmatrix}$	$x = v + t_x$ $y = w + t_y$	
Shear (vertical)	$\begin{bmatrix} 1 & 0 & 0 \\ s_v & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$	$x = v + s_v w$ $y = w$	
Shear (horizontal)	$\begin{bmatrix} 1 & s_h & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$	$x = v$ $y = s_h v + w$	

- Affine transformation can scale, rotate, translate, or sheer a set of coordinate points
- It relocates pixels to new locations
- Intensity values are assigned to the new location using interpolation technique

NOTE - make sure the x axis and y axis direction

- Image transformation
- Image Registration
- Image Interpolation