Few Terminologies

- Radiance: total amount of light energy that flows from the light source (measured in watts)
- Luminance: a measure of the amount of energy an observer perceives from a light source (measured in lumens)
- Brightness: subjective descriptor of light perception.

Image Formation Model

$$f(x,y) = i(x,y)r(x,y)$$

Reflectance

Transmissivity

illumination

$0 < i(x,y) < \infty$

$0 < r(x,y) < 1$

$\Rightarrow 0 < f(x,y) < \infty$

$l = f(x_0, y_0)$

$L_{min} \leq l \leq L_{max}$

$L_{min} = i_{min} r_{min}$

$L_{max} = i_{max} r_{max}$

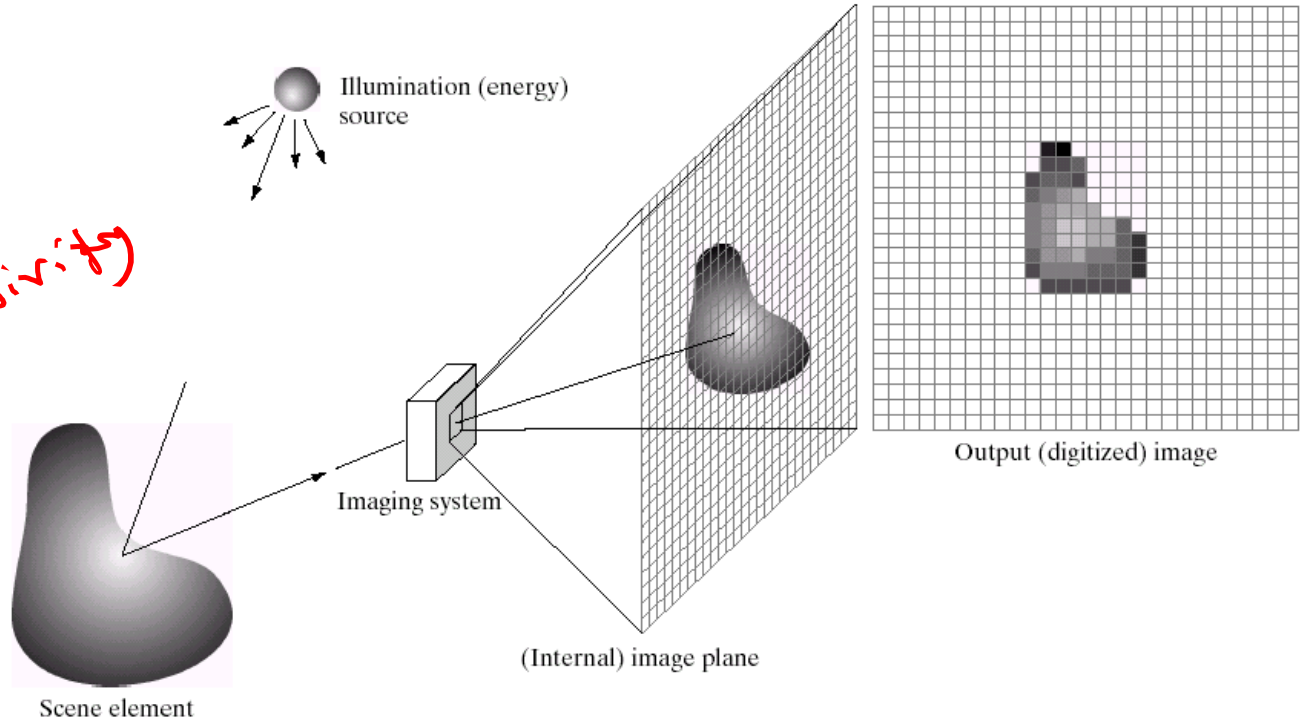
$L_{min} \approx 10$; $L_{max} \approx 1000$

$l = 0 \rightarrow$ Black

$l = L-1$ → White

$[L_{min}, L_{max}]$

Gray scale / Intensity level



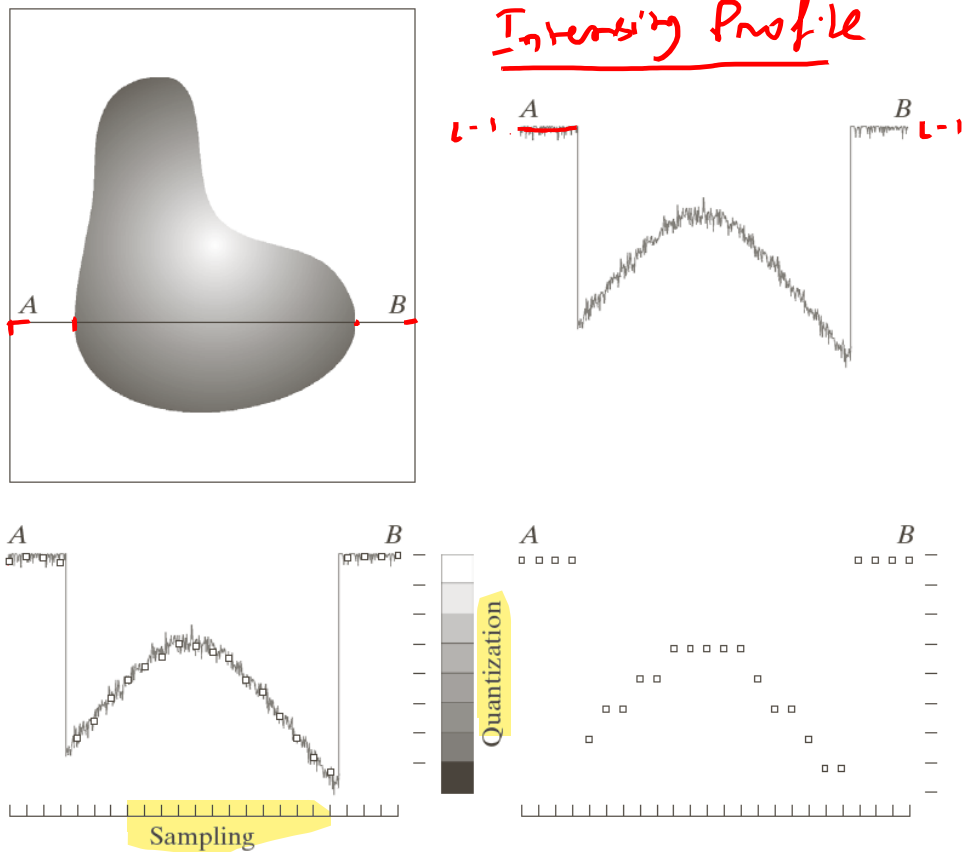
a b c d e

FIGURE 2.15 An example of the digital image acquisition process. (a) Energy ("illumination") source. (b) An element of a scene. (c) Imaging system. (d) Projection of the scene onto the image plane. (e) Digitized image.

Image Digitization: Sampling & Quantization

- The output of most of the sensors is a continuous voltage waveform.
- The amplitude and spatial behaviour are related to the physical phenomenon being sensed.

Intensity Profile



- In case of sensing array, no. of sensors

in the array establishes the limit of sampling

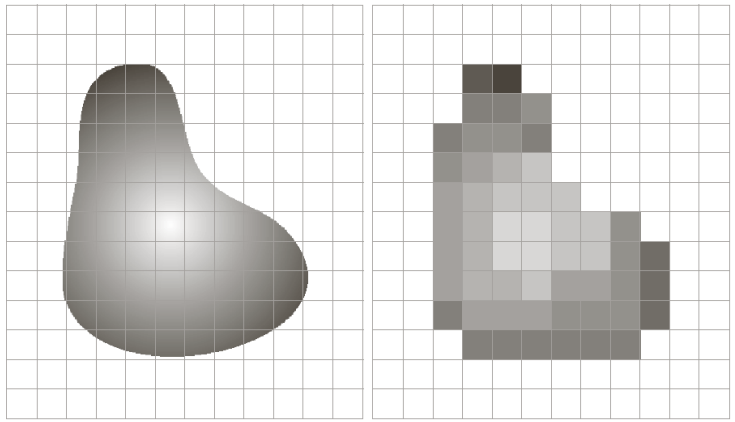
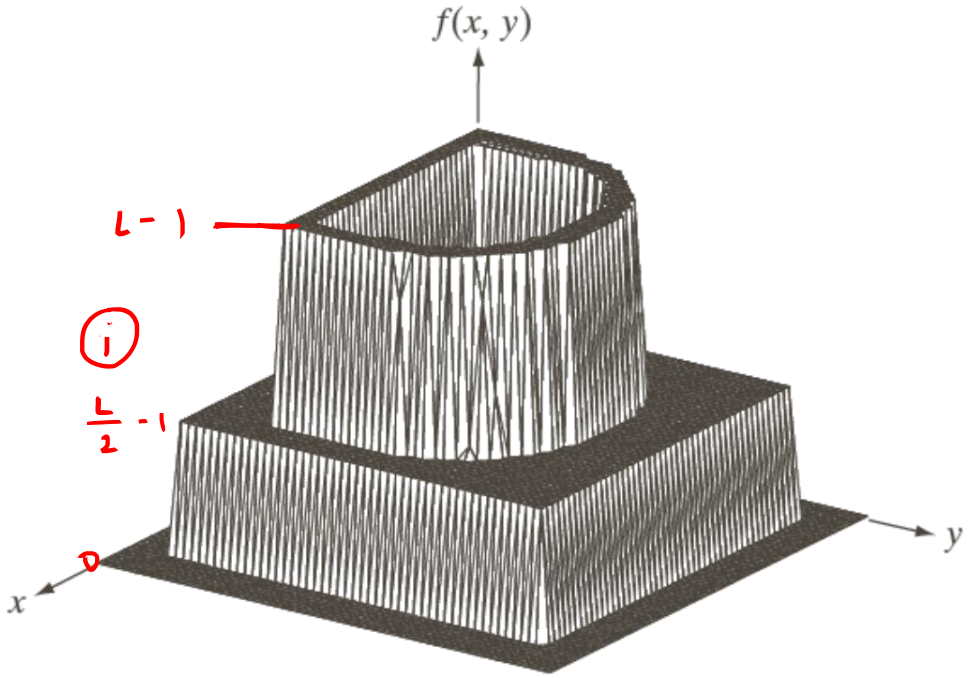


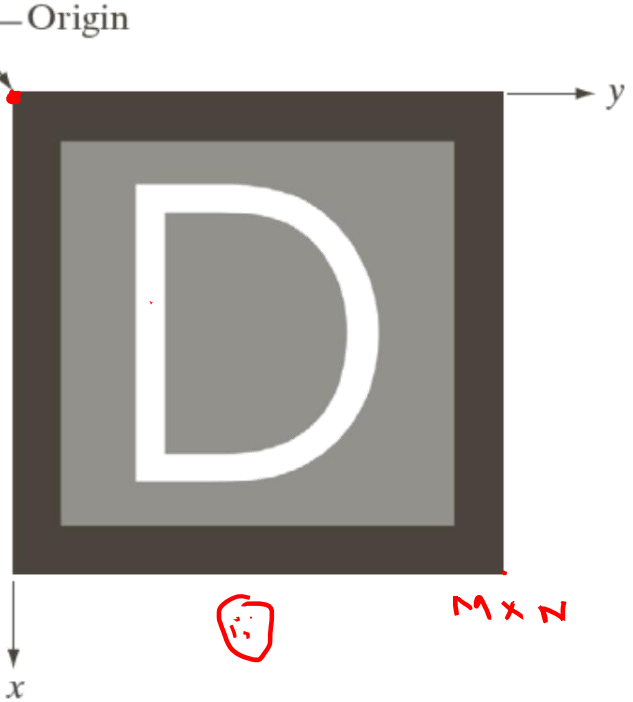
Image Representation

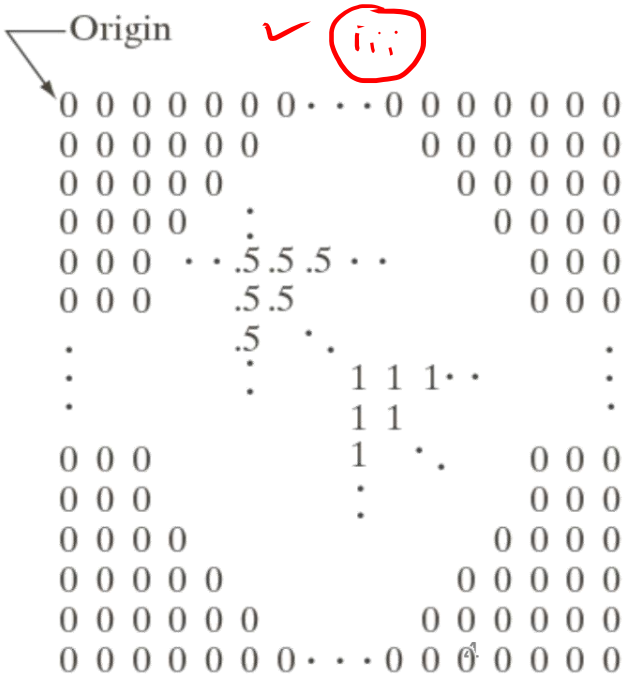
- Sample into a 2D array f(x,y).
- x = 0, 1, 2, ..., M-1

$$f(x,y) = \begin{bmatrix} f(0,0) & f(0,1) & \cdots & f(0,N-1) \\ f(1,0) & f(1,1) & \cdots & f(1,N-1) \\ \vdots & \vdots & & \vdots \\ f(M-1,0) & f(M-1,1) & \cdots & f(M-1,N-1) \end{bmatrix}$$

- Vector representation
- M, N needs to be +ve integers
- Quantization level $L = 2^k$







Memory space requirement of image

- For k-bit image of dimension M*N the space requirement is

$$b = M \times N \times k$$

$$3000 \times 2000 \times 24$$

$$= 144 \times 10^6 \text{ bit}$$

$$= 144 \text{ Mb}$$

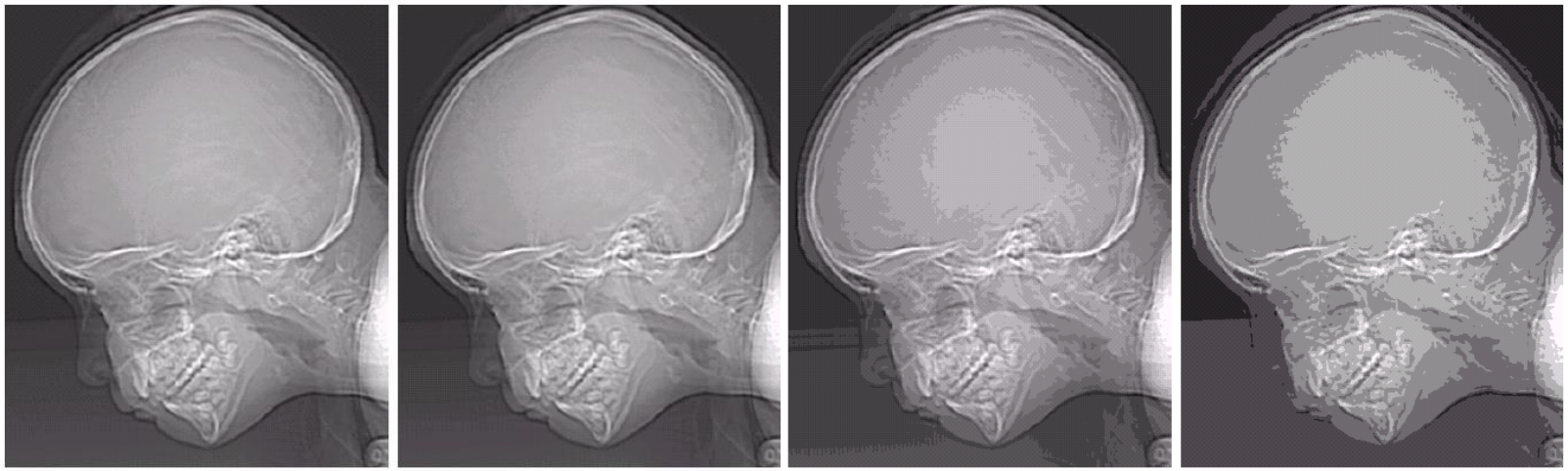
$$= 18 \text{ MB}$$

3MB - 5MB

Importance of k or L

Decreasing the gray-level resolution of a digital image may result in what is known as false contouring. This effect is caused by the use of an insufficient number of gray levels in smooth areas of a digital image.

K = 8 | k=7 | K = 4 | k=3



K = 6 | k=5 | K = 2 | k=1

False Contouring Effect

$L = 2^K$

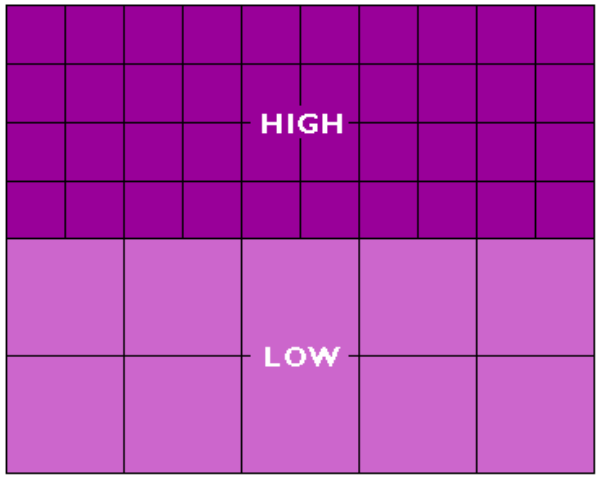
$L = 256$ $(k = 8)$

$2^1 = 2$

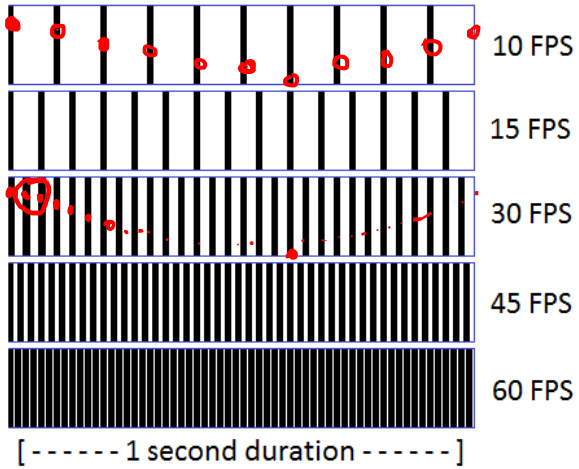
0, 255

Resolution

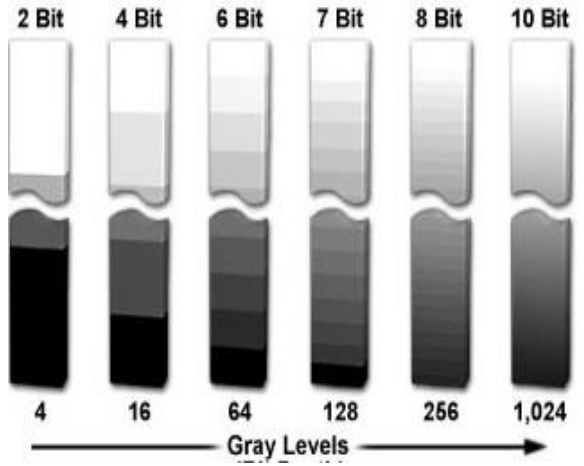
- Smallest discernible detail present in the image.
- Types of resolution: Spatial, temporal, brightness & spectral.



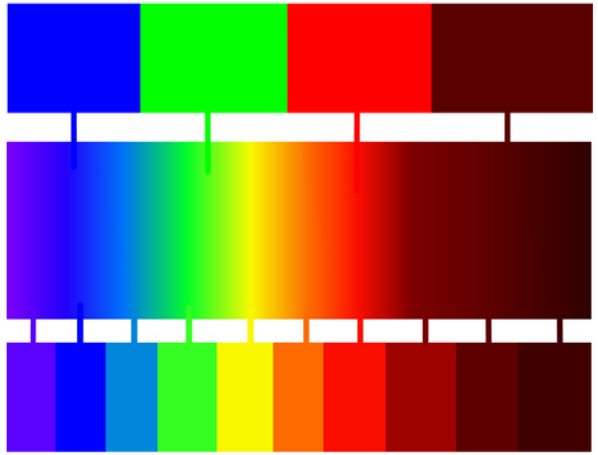
Spatial Resolution



Temporal Resolution

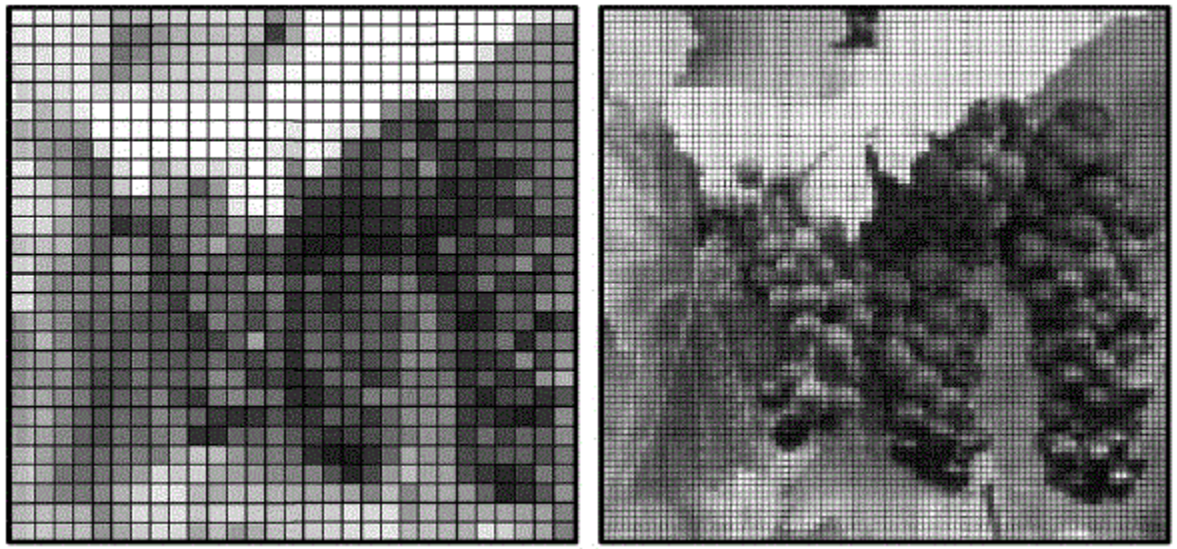


Brightness Resolution



Spectral Resolution

Spatial Resolution



Source: IDC, 2005

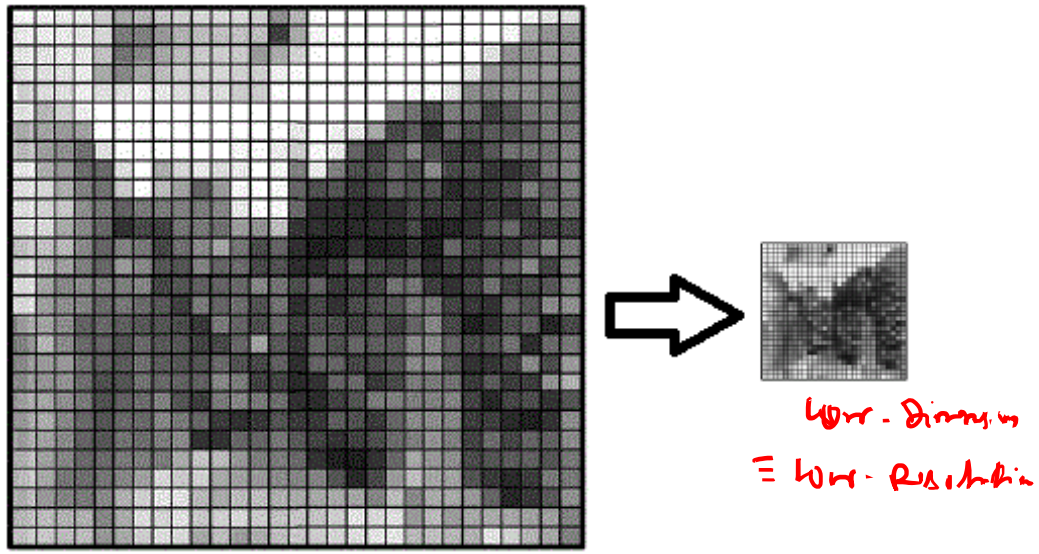
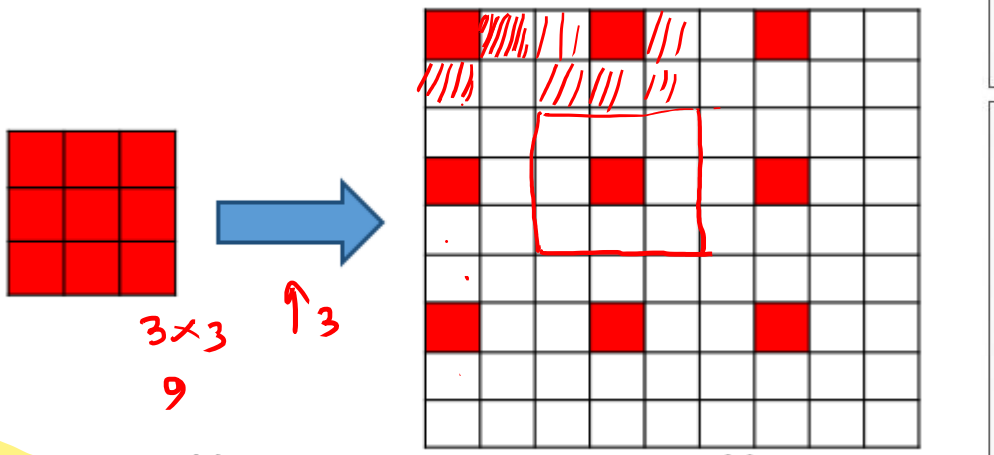


Image Zooming



- Interpolation
  - Nearest Neighbour i-pixel
  - Bi-linear → 4 pixels
  - Bi-cubic → 16 pixels

a b c
d e f

FIGURE 2.24 (a) Image reduced to 72 dpi and zoomed back to its original size (3692 × 2812 pixels) using nearest neighbor interpolation. This figure is the same as Fig. 2.20(d). (b) Image shrunk and zoomed using bilinear interpolation. (c) Same as (b) but using bicubic interpolation. (d)–(f) Same sequence, but shrinking down to 150 dpi instead of 72 dpi [Fig. 2.24(d) is the same as Fig. 2.20(c)]. Compare Figs. 2.24(e) and (f), especially the latter, with the original image in Fig. 2.20(a).

Pixel Relationship

- **Neighbours of a pixel:** $N_4(p)$, $N_D(p)$, $N_8(p)$
- **Adjacency:** 4-adjacency, 8-adjacency, m-adjacency
- **Connectivity:** Two pixels are said to be connected if they are adjacent in some sense:
  - They are neighbours
  - Their intensity values are similar

- 4-connectivity, 8-connectivity, m-connectivity
- **Path:** A path from p(x,y) to q(s,t) is a sequence of distinct pixels.

(x_0,y_0), (x_1,y_1),….(x_n,y_n), where $(x,y) = (x_0,y_0)$ and $(s,t) = (x_n,y_n)$

(x_i,y_i) is adjacent to (x_{i-1},y_{i-1}) for $1<=i<=n$

Pixel Relationship (contd.)

- **Connected Component:** Two pixels p and q are said to be connected in S if there exists a path between them consisting entirely of pixels in S.
- **Region:** Let R be a subset of pixels in an image. R can be said to be a region of the image if R is a connected set.
  - Ri and Rj are said to be adjacent if their union forms a connected set.
  - Regions that are not adjacent are called disjoint.
- **Boundary:** Boundary of a region R is the set of points that are adjacent to the points in the complement of R (global concept)
- **Edge:** Edge is formed from pixels with derivative values that exceed a preset threshold. It is local concept that is a measure of intensity level discontinuity at a point.