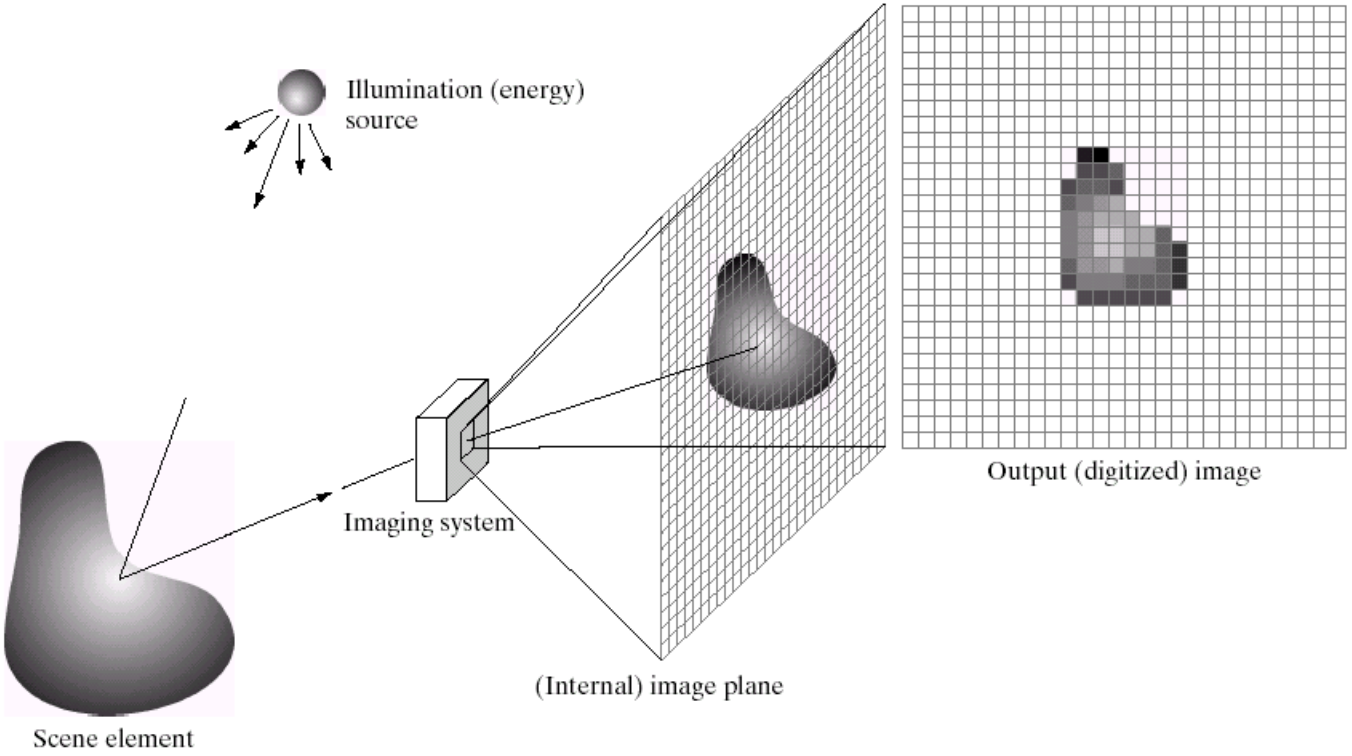
Image processing (basic concepts)

INTRODUCTION TO INTELLIGENT SYSTEMS 17/18

Image Formation



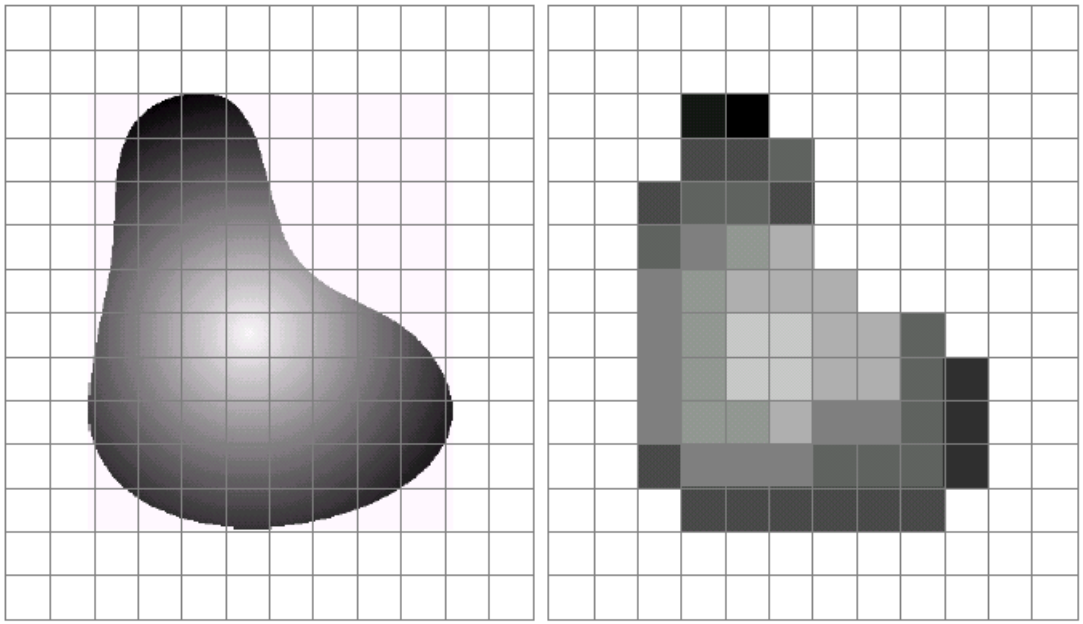
a
b c d e

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.

*f(x,y) = reflectance(x,y) * illumination(x,y)*

Reflectance in [0,1], illumination in [0,inf]

Sampling and Quantization



a b

FIGURE 2.17 (a) Continuos image projected onto a sensor array. (b) Result of image sampling and quantization.

Sampling

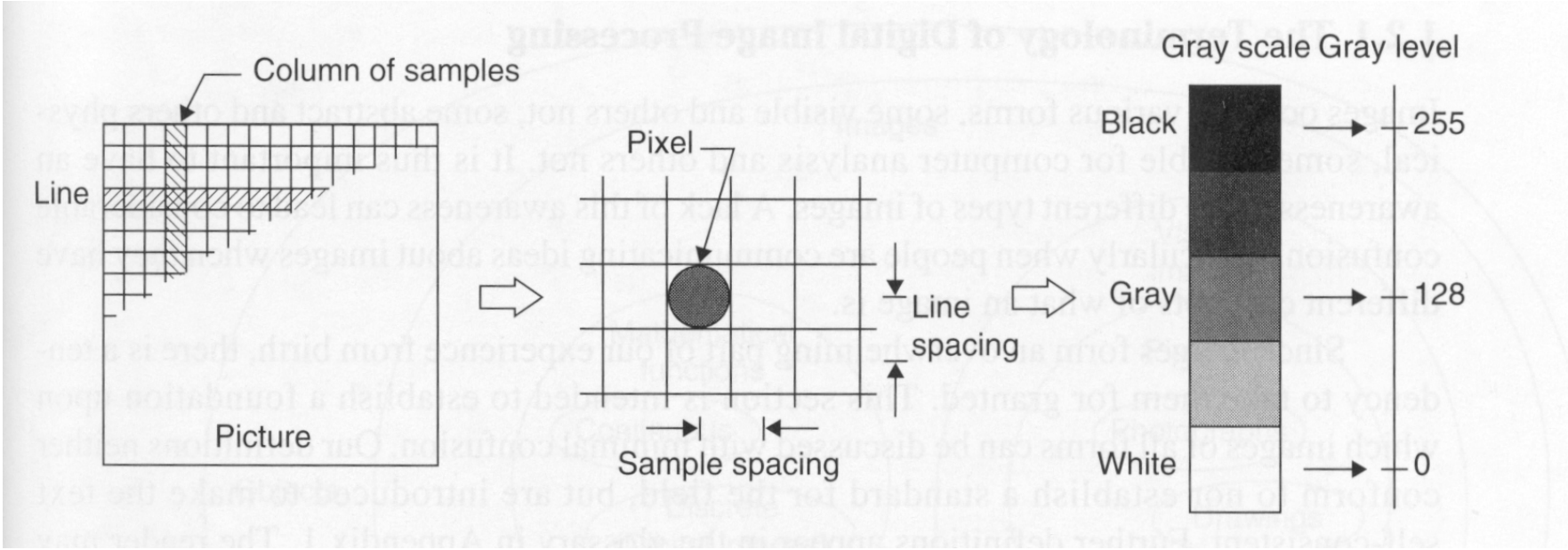

Column of samples
Line
Picture
Pixel
Line spacing
Sample spacing
Gray scale Gray level
Black
Gray
White
255
128
0

Image quantization(example)

256 gray levels (8bits/pixel)

32 gray levels (5 bits/pixel)

16 gray levels (4 bits/pixel)

8 gray levels (3 bits/pixel)

4 gray levels (2 bits/pixel)

2 gray levels (1 bit/pixel)

What is an image?

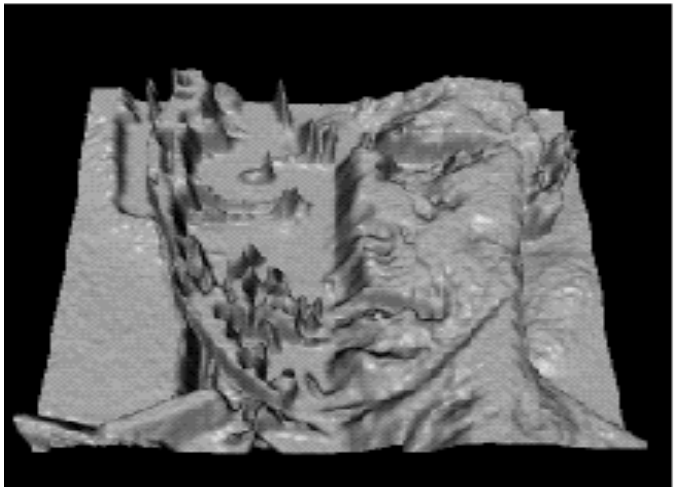
We can think of an **image** as a function, f, from R^2 to R:

- $f(x, y)$ gives the **intensity** at position (x, y)
- Realistically, we expect the image only to be defined over a rectangle, with a finite range:
  - f: $[a,b]$x$[c,d]$ → $[0,1]$

A color image is just three functions pasted together. We can write this as a "vector-valued" function:

$$f(x,y) = \begin{bmatrix} r(x,y) \\ g(x,y) \\ b(x,y) \end{bmatrix}$$

Images as functions



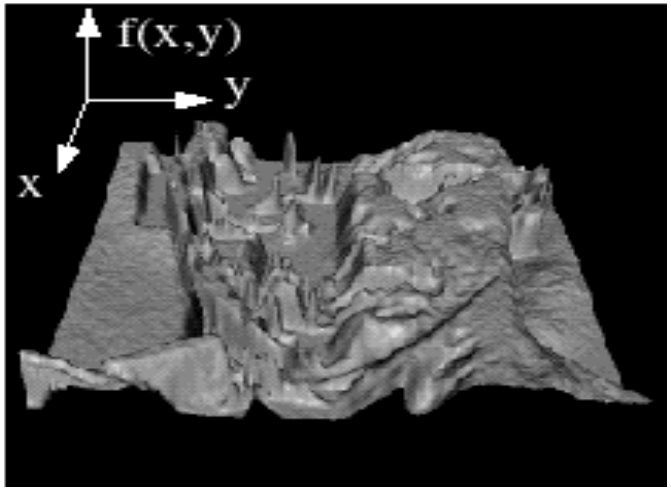


Image processing

An **image processing** operation typically defines a new image g in terms of an existing image f.

We can transform either the range of f.

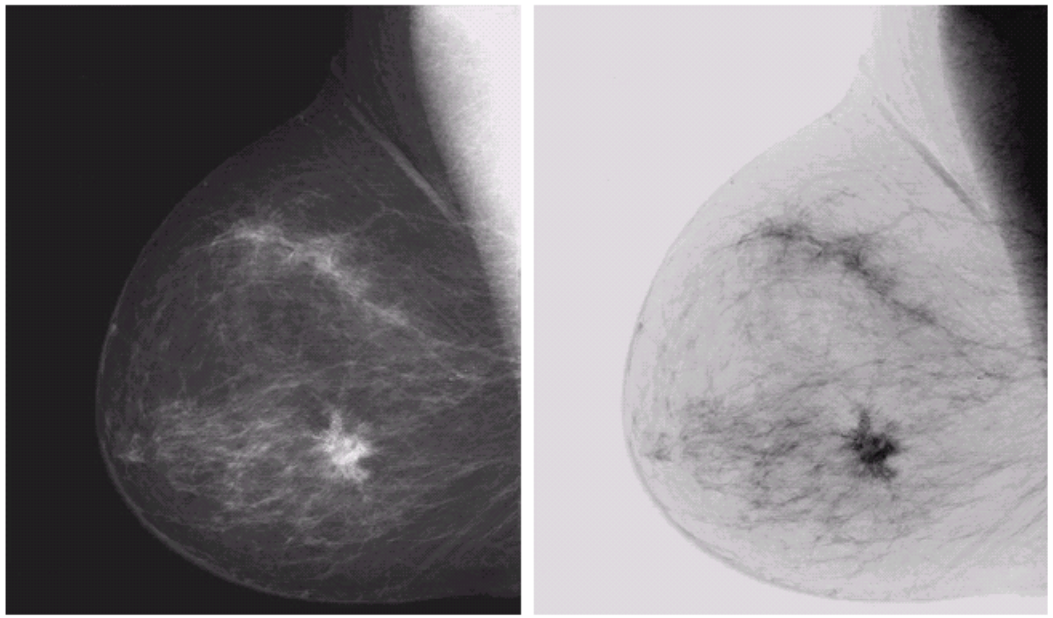
$$g(x, y) = t(f(x, y))$$

Or the domain of f:

$$g(x, y) = f(t_x(x, y), t_y(x, y))$$

What kinds of operations can each perform?

Negative (inverted) image



a b

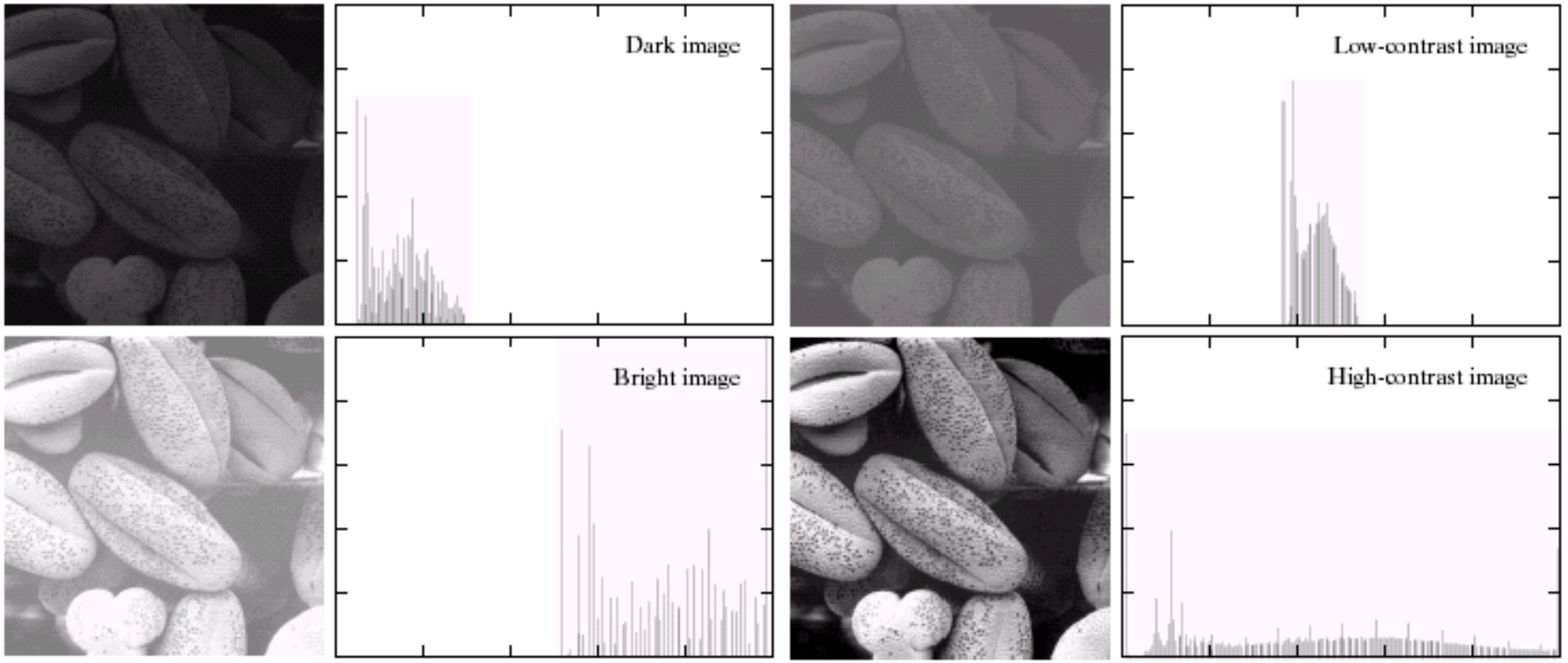
FIGURE 3.4
(a) Original digital mammogram. (b) Negative image obtained using the negative transformation in Eq. (3.2-1). (Courtesy of G.E. Medical Systems.)

Image Enhancement

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.)

Image Histograms



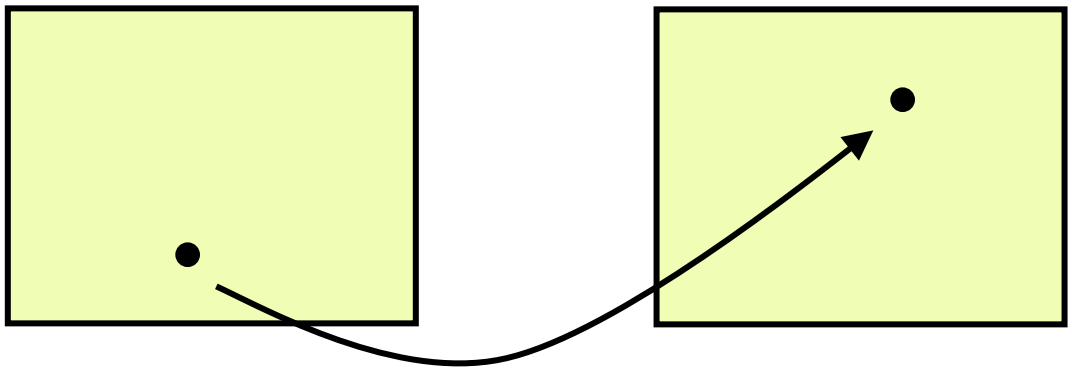
a b

FIGURE 3.15 Four basic image types: dark, light, low contrast, high contrast, and their corresponding histograms. (Original image courtesy of Dr. Roger Heady, Research School of Biological Sciences, Australian National University, Canberra, Australia.)

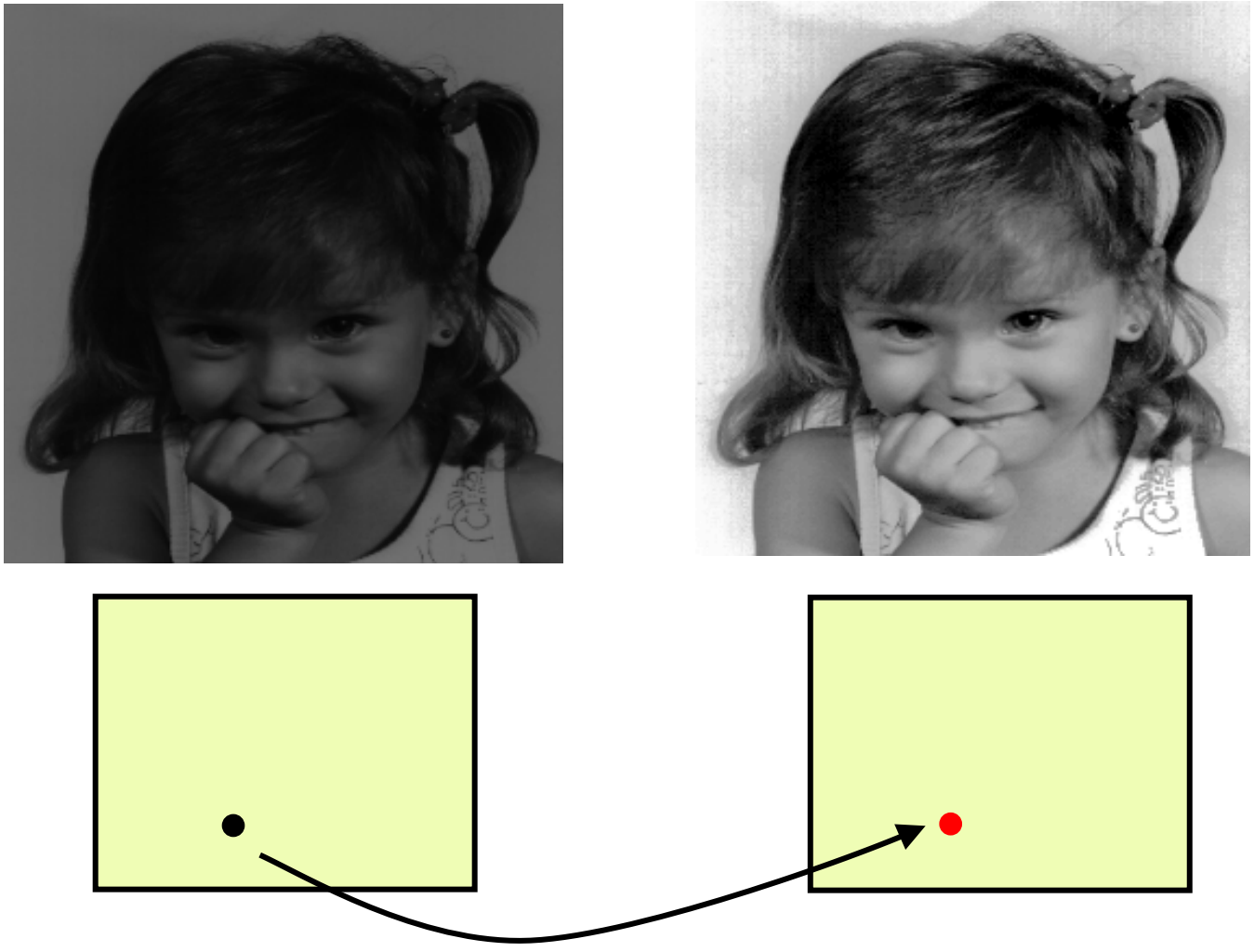
Image Operations

- Geometric Operations (Transformations)
- Point Operations
- Spatial Operations
- Global Operations (Freq. domain)
- Multi-Resolution Operations

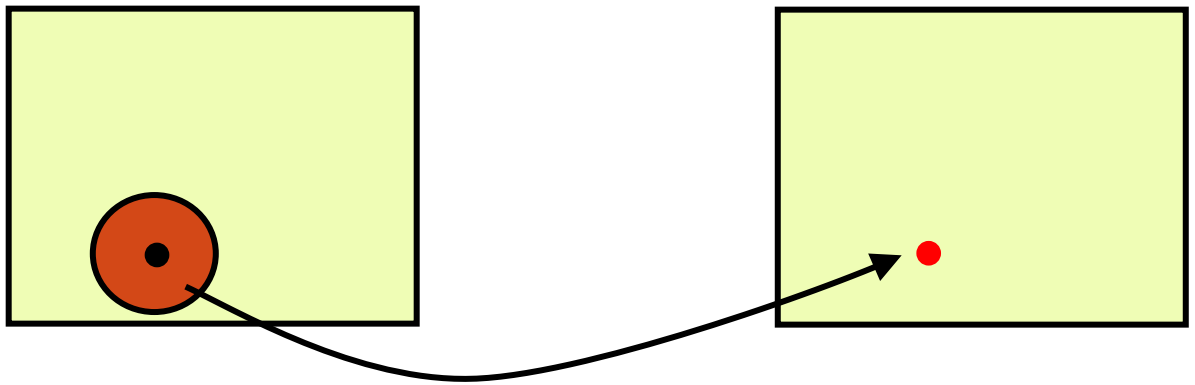
Geometric operations



Point Operations



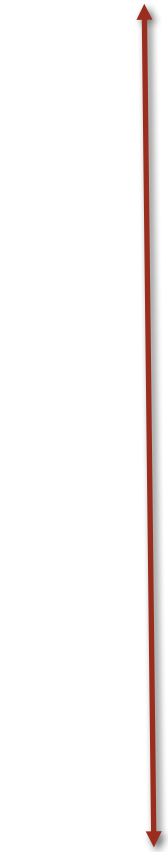
Spatial Operations



Global Operations

Multi-Resolution

Low resolution



High resolution