Enabling Technologies for Sports (5XSF0)
Module 1

Spatial filtering
Part 2

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What is a digital image and digital image processing?

* Digital image is an image for which spatial coordinates x, y and intensity (gray level) $f(x,y)$ are finite, discrete quantities
  - Digital image is composed of a finite number of elements – picture elements (pixels)
* Digital image processing is processing digital images by means of a digital computer

(The slides are based on "Digital Image Processing Using Matlab", R. C. Gonzalez, R. E. Woods, S. L. Eddins)

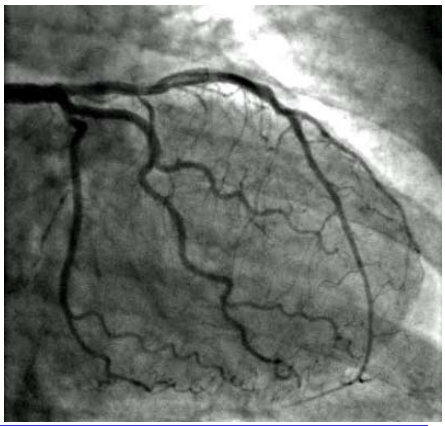
From image processing to computer vision

* Low-level: both inputs and outputs are images
  – Primitive image processing operations: noise reduction, contrast enhancement, image sharpening
* Mid-level: inputs are images, outputs are attributes extracted from the images (edges, contours)
  – Segmentation, object recognition
* Higher-level: “making sense” of an ensemble of recognized objects

From image processing to computer vision: example from medical imaging – (1)

* Low-level: both inputs and outputs are images
  – Primitive image processing operations: noise reduction, contrast enhancement, image sharpening

Coronary angiogram

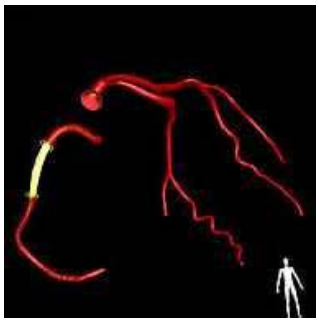


Source: www.heart-valve-surgery.com

From image processing to computer vision: example from medical imaging – (2)

* Mid-level: inputs are images, outputs are attributes extracted from the images
  – Segmentation, object recognition

Segment of a coronary artery



Source: http://www.dannyruijters.nl/docs/EMBS_XCT_full.pdf

From image processing to computer vision: example from medical imaging – (3)

* Higher-level: "making sense" of an ensemble of recognized objects
  – Automatic volume annotation within volume rendering

Future of full heart modelling

Source: http://incenter.medical.philips.com

Introduction to spatial domain techniques – (1)

* include
  - Intensity (gray-level) transformations
  - Spatial filtering (or neighborhood processing, or spatial convolution)
* can be denoted by the expression

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

where $f(x,y)$ – input image, $g(x,y)$ – output (processed) image, T – operator defined on a neighborhood around (x,y)

Introduction to spatial domain techniques – (2)

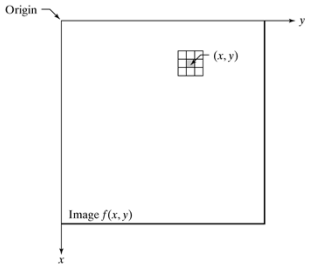
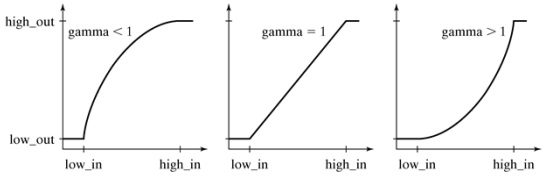


FIGURE 3.1 A neighborhood of size 3 × 3 about a point (x, y) in an image.

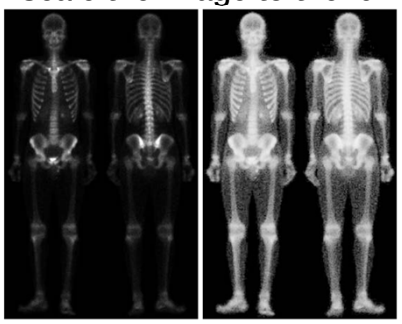


a b c

FIGURE 3.2 The various mappings available in function `imadjust`.

Intensity transformation functions – (1)

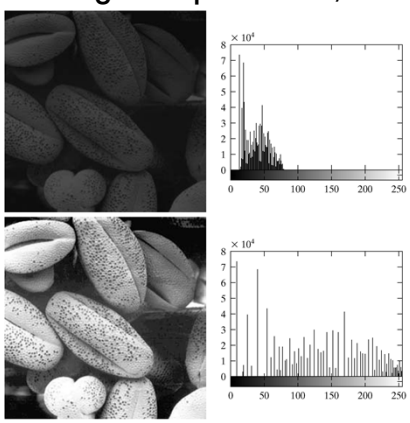
* **`imadjust`** – intensity transformations for gray-scale images
* logarithmic and contrast-stretching transformations
* **`gscale`** – scale the image to the full maximum range



a b
FIGURE 3.6 (a) Bone scan image. (b) Image enhanced using a contrast-stretching transformation. (Original image courtesy of G. E. Medical Systems.)

Intensity transformation functions – (2)

* **`imhist`** – plot a histogram
* **`histeq`** – histogam equilization, histogram matching



a b
c d
FIGURE 3.8 Illustration of histogram equalization. (a) Input image, and (b) its histogram. (c) Histogram-equalized image, and (d) its histogram. The improvement between (a) and (c) is quite visible. (Original image courtesy of Dr. Roger Heady, Research School of Biological Sciences, Australian National University, Canberra.)

Spatial filtering

* Linear spatial filtering
  - Multiply each pixel in the neighborhood by a corresponding coefficient and sum the results to obtain the response at each point
  - Matrix of coefficients is called filter, mask, filter mask, kernel, template or window
* Nonlinear spatial filtering
  - Performs nonlinear operations on neighborhood pixels

Linear spatial filtering – (1)

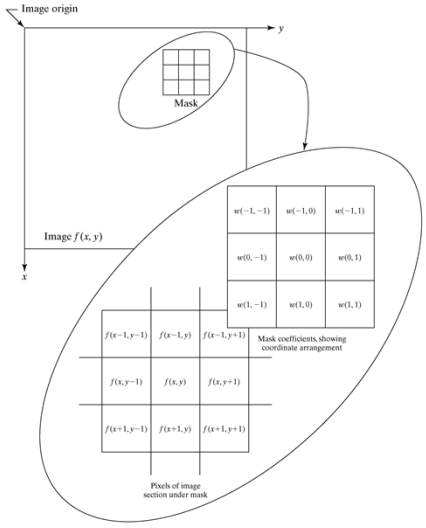


FIGURE 3.12 The mechanics of linear spatial filtering. The magnified drawing shows a 3×3 mask and the corresponding image neighborhood directly under it. The neighborhood is shown displaced out from under the mask for ease of readability.

Linear spatial filtering – (2)

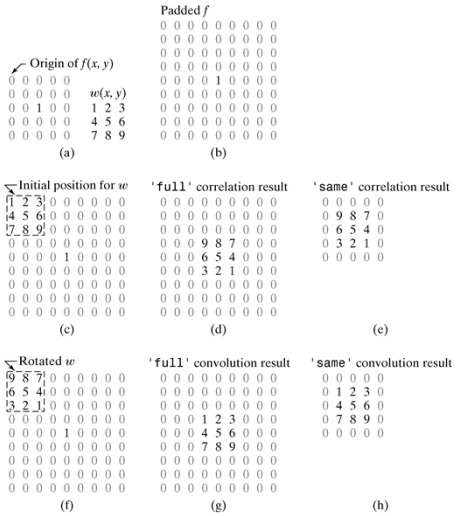


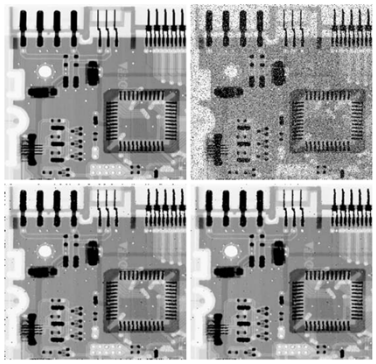
FIGURE 3.14 Illustration of two-dimensional correlation and convolution. The 0s are shown in gray to simplify viewing.

Linear spatial filtering – (3)

* **`imfilter`** – linear filtering with a user-defined mask
  - options – boundary (symmetric, replicate, circular), output size (same or full), correlation or convolution
* **`fspecial`** – create predefined 2D filters
  - types of filters – average, gaussian, laplacian, prewitt, sobel, etc.

Nonlinear spatial filtering

* **`ordfilt2`** – 2D order-statistic filter
  - `g=ordfilt2(f,1,ones(m,n))` – min filter
* **`medfilt2`** – 2D median filter



a b
c d

FIGURE 3.18 Median filtering. (a) X-ray image. (b) Image corrupted by salt-and-pepper noise. (c) Result of median filtering with `medfilt2` using the default settings. (d) Result of median filtering using the `'symmetric'` image extension option. Note the improvement in border behavior between (d) and (c). (Original image courtesy of Lixi, Inc.)

References

– Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, "Digital Image Processing Using Matlab", Pearson Education, 2004
  – Chapter 3