

Preprocessing

- Converting a source image into a new image as a preliminary operation
- ❶ Spatial Domain methods
- ❷ Frequency Domain methods

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Spatial Domain Methods

- Directly on pixels
- $g(x,y) = T[f(x,y)]$
- $f(x,y)$ is the input image
- $g(x,y)$ is the resulting image
- T an operator on f , defined over some neighbourhood of (x,y)

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Neighbourhood of (x,y)

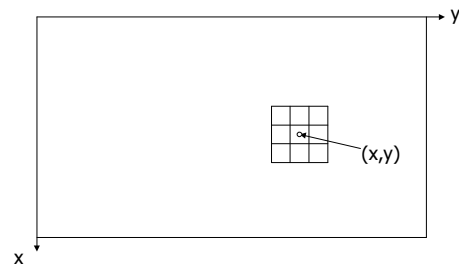
- A square or other shape subimage area centred at (x,y)
- Square is easiest and most common
- Circle, rectangle, used sometimes

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A (3,3) neighbourhood of (x,y)



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The operation

- The centre of the subimage is moved from pixel to pixel,
- starting from, say, at the top corner,
- applying the operator at each location (x,y) to yield $g(x,y)$

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❶ Spatial Domain methods

- ❶ a) Transformations
- ❶ b) Histogram Processing
- ❶ c) Arithmetic/Logic Operations
- ❶ d) Spatial Filtering

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1 a) Transformations

- When the neighbourhood is (1,1)
- Intensity mapping
- $s=T(r)$
- s and r are the intensities of $f(x,y)$ and $g(x,y)$ at any point (x,y)
- [Gonzalez Fig. 3.2](#)

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Contrast stretching

- Low Contrast images
 - poor illumination
 - lack of dynamic range in sensor
 - wrong aperture setting
- [Gonzalez Fig. 3.10](#)

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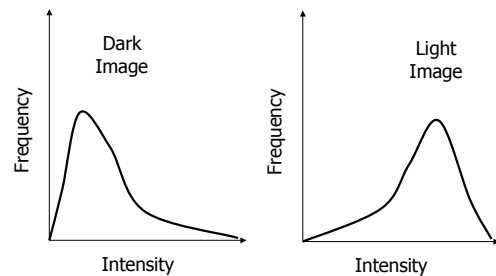
1 b) Histogram Processing

- What is a histogram?
- The frequency of each intensity gives an image histogram
- Histogram provides information on the general appearance of the image

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Intensity Transformation

- [Gonzalez DIP ch 03 Slide 16](#)

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Enhancement

- To adapt for changes in illumination
- Compensate for shadows and hot-spots, etc
- ◆ Histogram Equalization
- ◆ Histogram Specification
- ◆ Local Enhancement

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Histogram Equalization

- A transformation such that the resulting intensities are uniformly distributed
- A transformation of shape equal to the cumulative distribution function of the original intensity will give a uniform distribution

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Example

- [Gonzalez Fig 3.10\(b\)](#)
- Suitable for automatic enhancement, but only a uniform distribution results

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Histogram Specification

- Intensity histogram of image after transformation is specified
- Finding the required transformation is not simple

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Local Enhancement

- Equalization and Specification methods were global, but results may not be satisfactory
- Solution: Local enhancement
- Eg: [Gonzalez DIP ch 03 Slide 23](#)

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❶ c) Arithmetic/Logic Operations

- Performed on a pixel by pixel basis between two or more images
- AND, OR and NOT Operators
- Image Subtraction

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❶ d) Spatial Filtering

- Also Templates, Windows, Masks
- A small (eg 3X3) two dimensional array whose coefficients determine the nature of the process
- Multiply each coefficient with the corresponding pixel intensities and add
- Divide by a constant to avoid intensities going out of range

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Example

7	3	6	4
5	4	15	6
3	15	16	7
5	4	4	6

Image

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-1	-1	-1
-1	8	-1
-1	-1	-1

3X3
Sharpening
filter

Solution:

7*-1	3*-1	6*-1	4
5*-1	4*8	15*-1	6
3*-1	15*-1	16*-1	17
5	4	4	6

Image

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$$-7-3-6-5+32-15-3-15-16=-38$$

What about border?

- Limit excursions of the centre of the mask to be at a distance of no less than $(n-1)/2$ pixels from the border
 - Image size reduced
- Pad the image by rows or columns and strip off the padding after filtering
 - Edge effects may not match

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Contd..

7	3*-1	6*-1	4*-1
5	4*-1	15*8	6*-1
3	15*-1	16*-1	7*-1
5	4	4	6

Image

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$$-3-16-4-4+120-6-15-16-7=49$$

Contd..

7	3	6	4
5*-1	4*-1	15*-1	6
3*-1	15*8	16*-1	7
5*-1	4*-1	4*-1	6

Image

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$$-5-4-15-3+120-16-5-4-4=64$$

Contd..

7	3	6	4
-1	4*-1	15*-1	6*-1
3	15*-1	16*8	7*-1
-1	4*-1	4*-1	6*-1

Image

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$$-4-15-5-15+128-7-4-4-6=68$$

Final Result

-38	49
64	68

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Smoothing

- 1 Neighbourhood averaging
- 2 Median filtering
- 3 Image Averaging
- 4 Smoothing Binary Images

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Neighbourhood averaging

- Generate a smoothed image $g(x,y)$ whose intensity at every point (x,y) is obtained by averaging the intensity values of the pixels in a predefined neighbourhood of (x,y)

$$g(x, y) = \frac{1}{P} \sum_{(n,m) \in S} f(n, m)$$

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Example

- Gonzalez Fig 3.34 to 3.36

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Median Filtering

- The intensity of each pixel is replaced by the median of intensities in the neighbourhood of the pixel
- What is the median?
- Forces points with distinct intensities to be more like their neighbours, thus eliminating isolated spikes
- Gonzalez Fig 3.37

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Image Averaging

- Capture several images of the same scene in same position
- Each will be corrupted by noise
- Take the average of the pixel values corresponding to each x,y location

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Smoothing Binary Images

- Binary Images are two valued images that result from using backlighting, or from thresholding processes, etc
- Assign to each pixel a 1 or 0, depending on the spatial arrangement and binary values of its neighbours

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Some binary smoothing operations

- Fill in small one pixel holes in otherwise dark areas
- Fill in small notches in straightedge segments
- Eliminate isolated 1s
- Eliminate small bumps along straightedge segments
- Replace missing corner points

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Example

- Eg: [Gonzalez DIP ch 03 slide 37](#)
- Image: [Gonzalez DIP Fig3.37\(a\)](#)

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② Frequency Domain methods

- Compute the Fourier transform of the image
- Multiply the result by a filter transfer function
- Take the inverse transform

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Two dimensional discrete Fourier transform

$$F(u, v) = \frac{1}{MN} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x, y) e^{-i2\pi \left(\frac{ux}{M} + \frac{vy}{N} \right)}$$

for $u=0,1,2,\dots,M-1$, $v=0,1,2,\dots,N-1$

$$f(x, y) = \sum_{u=0}^{M-1} \sum_{v=0}^{N-1} F(u, v) e^{i2\pi \left(\frac{ux}{M} + \frac{vy}{N} \right)}$$

for $x=0,1,2,\dots,M-1$, $y=0,1,2,\dots,N-1$

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Examples

- [Gonzalez DIP ch 4 Fig 4.1](#)

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Fourier transform applications

- Descriptors of boundary shape
- Detecting object motion
- Image reconstruction, enhancement, restoration

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Segmentation

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