Chapter 3

Introduction to Digital Image Analysis

1

Introduction

- Image Analysis:
  - ✓Manipulation of image data to determine exactly what information is required to develop a computer imaging system
  - ✓Data reduction process
  - ✓Part of a larger process
  - ✓Iterative in nature
  - ✓Answers application specific questions

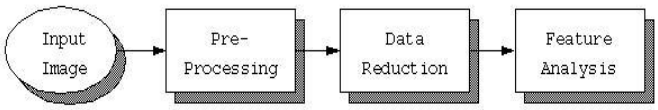
2

➢System Model:

✓Image analysis can be broken into three primary stages as:

- Preprocessing
- Data Reduction
- Feature Analysis

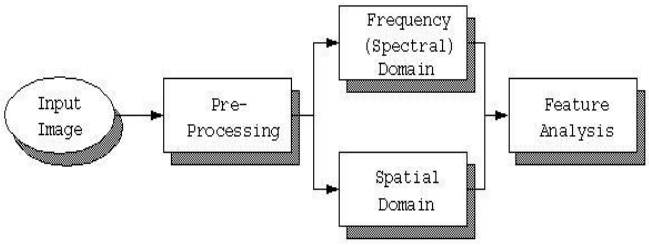
Figure 3.1-1: IMAGE ANALYSIS



3

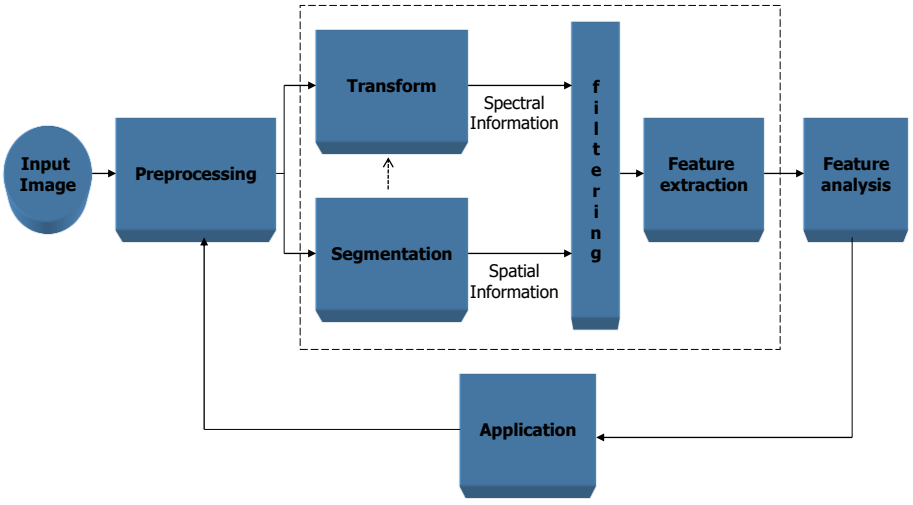
✓Data reduction involves reducing the data in the spatial domain or frequency domain

Figure 3.1-2: IMAGE ANALYSIS DOMAINS



4

Introduction - System Model



Preprocessing

✓To make data reduction and analysis task easier

✓Consist of following operations:

- Noise and artifact removal
- Extracting Region of Interest (ROI)
- Performing mathematical operations
- Enhancement of specific image features
- Data reduction in resolution and brightness

6

Image with border

Image with border removed

Shape information required

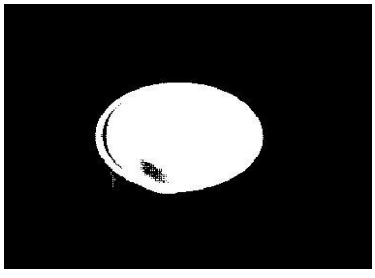


Image with object shape

7

➢**Region of Interest Image Geometry**

✓To investigate more closely a specific area of an image

✓Consists of following operations:

- Crop
- Zoom
  - Enlarge
- Shrink
- Translate
- Rotate

8

- *Crop*: Selecting a portion of an image, a sub-image, and cutting it away from the rest of the image , for example “border removal”

- *Zoom*:

❖Enlarging a section of an image, to improve visual analysis of detailed objects

❖Can be done by zero hold order (repeating previous pixel values) or first order hold (linear interpolation of adjacent pixels)

9

❖Zero order hold: Can also be performed by convolution in the following way:

a. Extend the image by adding rows and columns of zeroes between existing rows and columns

b. Perform convolution by using the following convolution mask

$$\begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$$

10

11

Preprocessing
Crop & Zooming Process

Original image. Area to be zoomed is outlined at the center

Image enlarged by zero-order hold.

Image enlarged by first-order hold.

❖First order hold:

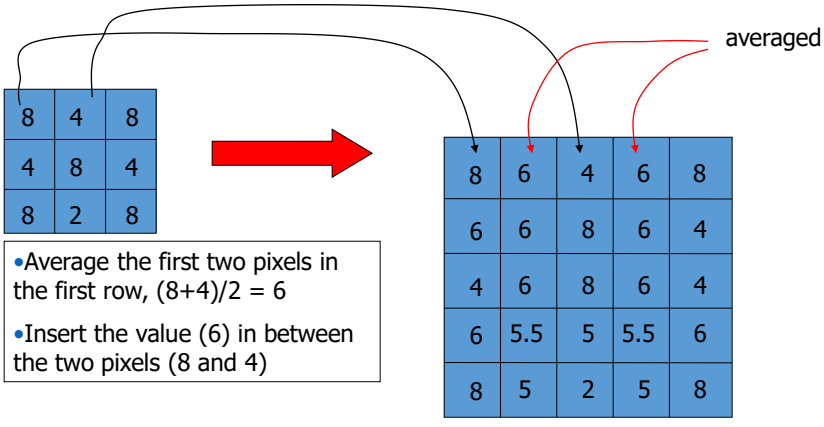
Can be performed in two ways:

1. Averaging
2. Convolution

1. Averaging: Allows to enlarge an N*N sized image to a size of (2N-1) * (2N-1), and can be repeated

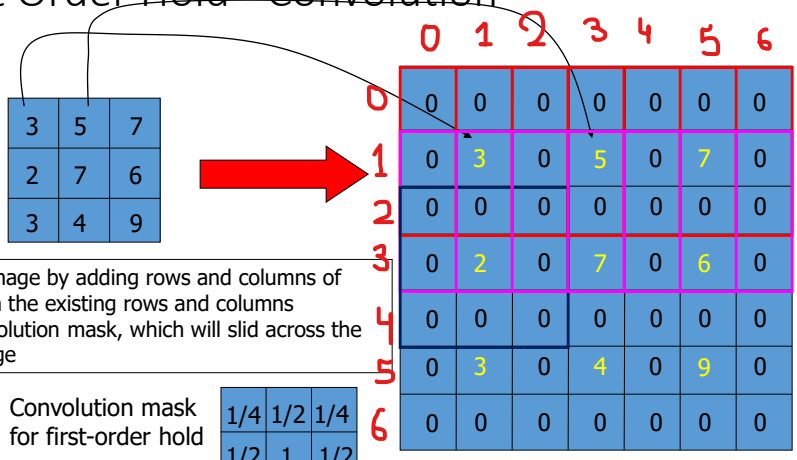
13

Preprocessing
First Order Hold - Averaging



- Average the first two pixels in the first row, (8+4)/2 = 6
- Insert the value (6) in between the two pixels (8 and 4)

Preprocessing
First Order Hold - Convolution

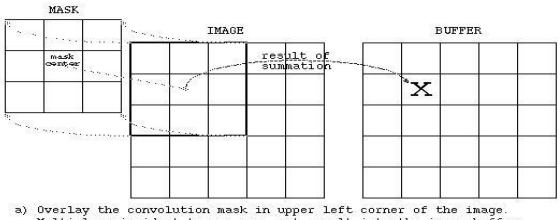


- Extend the image by adding rows and columns of zeros between the existing rows and columns
- Use the convolution mask, which will slid across the extended image

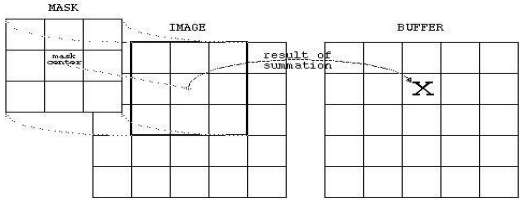
Convolution mask for first-order hold

1/4	1/2	1/4
1/2	1	1/2
1/4	1/2	1/4

Figure 3.2-3: THE CONVOLUTION PROCESS



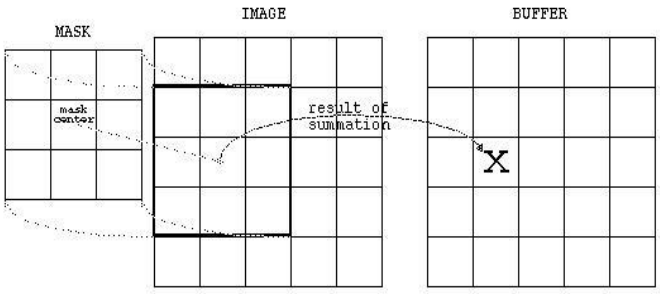
a) Overlay the convolution mask in upper left corner of the image. Multiply coincident terms, sum, put result into the image buffer at the location that corresponds to the mask's current center, which is (r,c) = (1,1).



b) Move the mask one pixel to the right, multiply coincident terms, sum, and place the new result into the buffer at the location that corresponds to the new center location of the convolution mask, now at (r,c) = (1,2). Continue to the end of the row.

16

Figure 3.2-3, continued



c) Move the mask down one row and repeat the process until the mask is convolved with the entire image. Note that we 'lose' the outer row(s) and column(s).

17

✓The convolution equation is given by

$$\sum_{x=-\infty}^{+\infty} \sum_{y=-\infty}^{+\infty} I(r-x,c-y)M(x,y)$$

where
M (x,y) is the mask
I (r,c) is the image

18

❖Why use the convolution method as opposed to the basic averaging of neighbors method?

✓Many imaging systems provide the convolution capability in hardware

✓In general, hardware is faster than software

19

❖**Linear interpolation method**

✓Enlarges an image other than a factor of (2N-1)

✓Finds a line that connects two values in brightness space, and hence sampling it faster to get more samples, thus increasing the resolution

20