بسم الله الرحمن الرحیم

University of Tehran
College of Engineering

Digital Image Processing

Instructor: Dr. Hamid Soltanian-Zadeh

Homework Assignment 9:

Representation and Description

Due date: 1404/03/12

Corresponding TA:
Zahra Nakhaei

zahranakhaei1999@yahoo.com

Spring 2025

Contents

1 Instructions

Please answer the following questions based on Chapter 11 (*Representation and Description*) of the textbook by Gonzalez and Woods. Submit your solutions by the due date. Read the following carefully and follow these instructions when submitting your answers:

Requirement	Description	Consideration
Standard Due Date	1404/03/12- 23:59	
Elearn HW Upload	**Only**	Only use ELearn to submit your homeworks.
Email Address	zahranakhaei1999@yahoo.com	Feel free to say hello!
Submit format	Read Note 4	Extremely important
Late Submit	Penalty	$5 - 10\%$ penalty per day

Note 1: *This request is not intended to impose any hardship on you, but to help with better management of the class. Your cooperation is greatly appreciated in making the process more efficient. Thank you!*

Note 2: *We will also have a Telegram group for Q&A. The link (clickable) is provided here:* [open the link]

Note 3: *Use camera scanners if you wish to submit your handwritten answers. While readability is always important, it is especially critical in the DIP course, which focuses on quality enhancement.*

Note 4: *You must send a zip or rar file named* `DIP-HWx-std.no` *where x is the number of the homework (e.g.* `DIP-HW9-810199034`*). Inside the zipped file will be a folder for each question containing its code and output images. There should also be a single pdf file in the root folder as your main report.*

Academic Integrity: *Plagiarism, cheating, or using unauthorized external resources (including AI tools, solution manuals, or copying from peers) is strictly prohibited. All assignments will be checked for originality, and any violations will result in academic penalties. Please submit only your own work.* It's easy to detect whether your answers are generated by AI or are truly your own work, so be sure to submit original solutions.

2 Border Following and Chain Codes

Background

This exercise focuses on extracting and representing object boundaries using contour following, chain codes, and Fourier descriptors for efficient and compact shape analysis.

(a) Develop a program that applies the boundary following algorithm as described in Section11.1.1 of the textbook to the "leaf.tif" image.

(b) Now implement a program that retrieves the chain code of the boundary. To acquire the chain code using the program, it is necessary to first subsample the boundary.

(c) Carry out the Fourier descriptor approach explained in Section 11.2.3 and utilize it to process the boundary from part a. Minimize the number of descriptors needed to maintain the recognizability of the leaf image.

Note:

You are not allowed to use built-in functions for finding boundaries and obtaining chain code.

3 Statistical Moments and Approaches

Background

This exercise introduces statistical texture analysis using image moments. We compute global and local statistical measures to characterize texture patterns and compare them across selected image regions.

Load the images "img1", "img2", and "img3":

(a) Implement the statistical texture measures in Eqs.(11.3-4)-(11.3-9) and apply them on the images.

(b) Extract a 100×100 segment from the lower, right quadrant of each image and compute the statistical measures of the sub-images using the measures described in Table 11.2. Present your results in the same format. Discuss your results.

4 Skeletons

Background

This exercise focuses on shape representation and analysis using skeletonization. By reducing objects to their skeletal forms, we aim to extract structural features and identify shapes based on their geometric signatures.

(a) Please implement the skeletonization algorithm that is explained in Section 11.1.7 of the textbook.

(b) Open the image "fingerprint.png" and apply your algorithm from part a to skeletonize the image.

5 Polygonal Approximations

Automatically detect the objects in "shape.png" and then specify its polygonal type based on its signature.

Note:

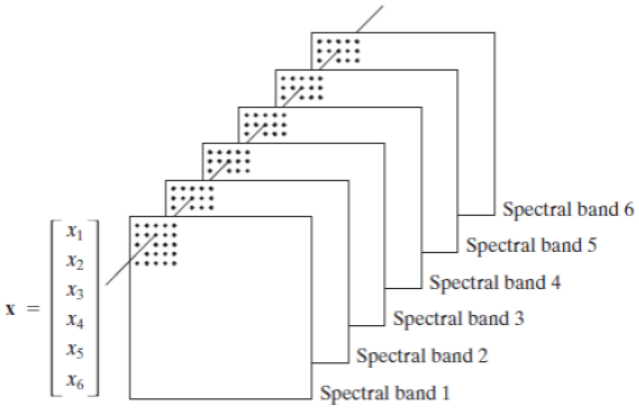
You are allowed to use built-in functions, but you should specify the polygonal type just by plotting its signature (refer to figure 11.10 for more details).

6 Use of Principal Components for Description

Background

In this exercise, we aim to gain familiarity with using Principal Component Analysis (PCA) to describe images.

You are given six images named "slice1.tif",...,"slice6.tif", which depict six multispectral satellite images representing different spectral bands. Arrange these images to create a six element vector for each pixel.



(a) Compute the average of these six images.

(b) Compute the covariance matrix as discussed in Section 11.4.

(c) Compute eigenvalues and eigenvectors of the covariance matrix.

(d) Reconstruct the images using the eigenvectors corresponding to the largest eigenvalue, the two largest eigenvalues, and the three largest eigenvalues.

(e) Compare your results with the original images.

Note:

You are allowed to use built-in functions.

7 Boundary Descriptors

Background

This exercise explores how reducing Fourier descriptors affects shape reconstruction, aiming to identify the minimum number needed to preserve key features of a chromosome boundary.

The image "chromosome.tif" displays a boundary of a human chromosome that is composed of 2868 points. The purpose of this problem is to investigate the impact of reducing the number of Fourier descriptors on reconstructing the boundary.

(a) Reconstruct the boundary using 50%, 10%, 5%, 2.5%, 0.63%, and 0.28% of 2868 points, respectively.

(b) How many descriptors are enough to retain the principal shape features of the original boundary (four long protrusions and two deep bays)?

Note:

You are allowed to use built-in functions.

Textbook Questions

Please provide the solutions to the questions presented in the 11th chapter of the Image Processing textbook (Edition 3): 2, 10, 12, 18, 22