Gazi University

Department of Computer Engineering Introduction to Image Processing Midterm Exam Answer Sheet

Question 1

a) Define the terms 'spatial resolution' and 'intensity level resolution,' and what are the corresponding values for the given image. (15 points)

Spatial Resolution: Spatial resolution refers to the number of pixels used to represent an image, which is equal to numbers of rows x number of columns. For the given image, the resolution is not explicitly stated, but the total number of pixels is 360.

Intensity Level Resolution: Intensity level resolution refers to the range of intensity values (gray levels) that each pixel can represent. For the given image, this is 16 levels (0-15).

b) Draw the histogram of the original image and explain the problem of this image. (5 points)

Histogram:

Gray Level (i)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Pixel Count (ni)	15	0	0	0	0	70	110	45	70	35	0	0	0	0	0	15

Problem: The histogram indicates a concentration of pixel intensities around a few levels, leading to low contrast.

c) What are the problems that can be corrected using histogram-based image enhancement methods, and what are these methods? (10 points)

Problems:

1. Low contrast.
2. Uneven distribution of intensity values.
3. Loss of detail in certain areas.

4. Low dynamic range
5. Low brightness

Methods:

- Histogram Equalization.
- Contrast Stretching.
- Adaptive Histogram Equalization.
- Adding and substracting constant value
- Multiplying with a constant function

d) Apply histogram equalization method to the given image, explain the method step by step, and fill the table with the new intensity values. (25 points)

Steps:

1. Compute the Probability Density Function (PDF) for each gray level:
   - PDF = ni / Total Pixels
   - Total Pixels = 360
2. Calculate the Cumulative Distribution Function (CDF):
   - CDF(i) = Sum of all PDF values up to i.
3. Normalize the CDF by multiplying with the maximum intensity value (15 in this case).
4. Round the result to the nearest integer to determine the new intensity level.

Original Gray Level (i)	Pixel Count (ni)	PDF	CDF	New Intensity Level
0	15	0.0417	0.0417	(CDF*15)= 1
1	0	0.0000	0.0417	(CDF*15)= 1
2	0	0.0000	0.0417	(CDF*15)= 1
3	0	0.0000	0.0417	(CDF*15)= 1
4	0	0.0000	0.0417	(CDF*15)= 1
5	70	0.1944	0.2361	(CDF*15)= 4
6	110	0.3056	0.5417	(CDF*15)= 8
7	45	0.1250	0.6667	(CDF*15)= 10
8	70	0.1944	0.8611	(CDF*15)= 13
9	35	0.0972	0.9583	(CDF*15)= 14
10	0	0.0000	0.9583	(CDF*15)= 14
11	0	0.0000	0.9583	(CDF*15)= 14
12	0	0.0000	0.9583	(CDF*15)= 14
13	0	0.0000	0.9583	(CDF*15)= 14
14	0	0.0000	0.9583	(CDF*15)= 14

15 15 0.0417 1.0000 (CDF*15)= 15

e) Draw the histogram after histogram equalization. (5 points)

New Gray Level Pixel Count

1 15
4 70
8 110
10 45
13 70
14 35
15 15

Question 2

a) Explain how to convert an 8-bit gray level image to bit planes. Explain the importance and possible applications of the process. (20 points)

Explanation:

- An 8-bit gray level image contains 256 intensity levels (0-255).
- Each pixel's intensity is represented by 8 bits, which can be divided into 8 binary layers (bit planes):
  - The Most Significant Bit (MSB) contains the highest-order bit, representing the largest intensity changes.
  - The Least Significant Bit (LSB) contains the lowest-order bit, often associated with noise or fine details.

Steps:

1. Extract each bit from the binary representation of pixel intensities.
2. Construct binary images (bit planes) using each extracted bit.

Importance:

- MSB highlights major features of the image, useful for feature extraction.
- LSB retains fine details and is often used in watermarking and data embedding applications.

Applications:

- Image compression.
- Digital watermarking.
- Steganography.
- Noise analysis and removal.

b) Calculate and show MSB and LSB bits for the gray level value 158.

- Binary Representation: 10011110
- MSB (Most Significant Bit): 1
- LSB (Least Significant Bit): 0

Question 3

Calculate the file size of images with different spatial, spectral, and intensity level resolutions. (20 points)

1. 512x512 binary image:
    - File Size = (512 × 512 × 1 bit) / 8 = 32 KB
2. 1024x768, 5-bit gray level image:
    - File Size = (1024 × 768 × 5 bits) / 8 = 480 KB
3. 1024x1024, 10-bit, 5-band image:
    - File Size = (1024 × 1024 × 10 bits × 5 bands) / 8 = 6400 KB