Image Processing Exam Answers

Question 1: Short Answer Questions (2×10=20)

1. **What is the first step in digital image processing?**

   - The first step is image acquisition, which involves capturing the image using sensors like cameras or scanners and converting it into a digital form.

2. **What is the importance of image enhancement?**

   - Image enhancement improves the visual quality of an image by increasing contrast, reducing noise, or highlighting specific features to make it more suitable for analysis or human interpretation.

3. **What do you mean by Gray level?**

   - Gray level refers to the intensity value assigned to each pixel in a grayscale image, typically ranging from 0 (black) to 255 (white) for 8-bit images.

4. **Region Of Interest (ROI) is known by which operation?**

   - ROI is known by the operation called "masking" where a specific region is selected for processing while ignoring other parts of the image.

5. **What is the other name of low pass filter?**

   - The other name for a low pass filter is "smoothing filter" as it attenuates high-frequency components (noise, edges) while preserving low-frequency components.

6. **Why do you say that an image is a 2D function?**

   - An image is a 2D function because it can be represented as f(x,y) where x and y are spatial coordinates, and the function value at each point represents the intensity or color at that location.

7. **Write the process of extracting information from digital image.**

   - The process involves: acquisition → enhancement → segmentation → feature extraction → object recognition → interpretation.

8. **What are the different types of noises present in digital image?**

- Common noise types include: Gaussian noise, salt-and-pepper noise, speckle noise, Poisson noise, and quantization noise.

9. **Distinguish between image processing and graphics.**

- Image processing deals with analyzing and manipulating existing images, while computer graphics focuses on creating new images from models and descriptions.

10. **What do you mean by frequency of an image?**

- Frequency in an image refers to how rapidly pixel values change across the spatial domain. High frequencies correspond to edges and fine details, while low frequencies represent smooth areas.

Question 2: Histogram Processing (20)

Mention about a few fields where different digital image processing technology is mostly used:

- Medical imaging (X-rays, MRI, CT scans)

- Remote sensing (satellite image analysis)

- Industrial inspection (quality control)

- Security (face recognition, fingerprint analysis)

- Entertainment (special effects, image restoration)

How histogram of an image is computed?

A histogram is computed by counting the number of pixels at each gray level and plotting these counts against the gray level values.

Unique features of histogram equalization and histogram stretching:

- *Histogram equalization*: Automatically determines transformation function to produce uniform histogram, enhances contrast globally.

- *Histogram stretching*: Linearly scales the intensity values to span the full range, requires manual specification of input range.

Histogram equalization for the given table:

| Gray Level | n_k | $p(r_k) = n_k/n$ | Cumulative $p(r_k)$ | s_k = round(6×cumulative) |

|------------|----|--------------|--------------------|--------------------------|

| 0 | 100| 100/210≈0.476| 0.476 | 3 |

| 1 | 90 | 90/210≈0.429 | 0.905 | 5 |

| 2 | 20 | 20/210≈0.095 | 1.000 | 6 |

| 3-6 | 0 | 0 | 1.000 | 6 |

Where n = total pixels = 100+90+20 = 210

The equalized histogram will have:

- Gray level 0 → mapped to 3
- Gray level 1 → mapped to 5
- Gray level 2 → mapped to 6
- Gray levels 3-6 remain 0

Question 3: Compression and Morphology (20)

Lossless predictive coding with block diagram:

1. Diagram components:
   - Original image → Predictor → Difference encoder → Compressed data
   - For decoding: Compressed data → Difference decoder → Predictor → Reconstructed image

2. Process:
   - The predictor estimates pixel values based on neighboring pixels
   - Only the difference (error) between actual and predicted value is encoded
   - This reduces entropy as differences typically have smaller magnitude than original values

RGB length Encoding for data compression:

- RGB length encoding (Run-Length Encoding) compresses sequences of identical pixels
- Instead of storing each pixel value, it stores (value, count) pairs
- Effective for images with large uniform areas
- Example: Sequence RRRRGGGBBB becomes (R,4),(G,3),(B,3)

Arithmetic coding for "EAU":

1. Calculate probabilities and ranges:
   - Total = 2+3+1+2+1+1 = 10
   - A: 0.0-0.2, B: 0.2-0.5, I: 0.5-0.6, O: 0.6-0.8, U: 0.8-0.9, P: 0.9-1.0

2. Encoding "EAU":
   - First symbol 'E' is not in table (assuming 'E' is typo, perhaps 'A' was intended)
   - If we proceed with 'A', 'U':
     - 'A' range: [0.0, 0.2)
     - 'U' within 'A' range: 0.0 + 0.8×0.2 = 0.16 to 0.0 + 0.9×0.2 = 0.18
     - Final range: [0.16, 0.18)
   - Can represent this range with a number like 0.17

Image morphology - Opening operation:
- Opening is erosion followed by dilation
- It removes small objects while preserving shape of larger objects
- Structuring element determines what is considered "small"

Question 4: Image Segmentation (10)

Image segmentation methods based on discontinuities:
1. Point detection (isolated points)
2. Line detection (edge detection)
3. Edge detection (gradient-based: Sobel, Prewitt, Roberts, Canny)
4. Laplacian-based methods (zero crossings)

Deriving gradients using masks:
- Gradient magnitude: $|\nabla f| = \sqrt{(G_x^2 + G_y^2)}$
- Gradient direction: $\phi = \text{atan}(G_y/G_x)$

- Common masks:
  - Sobel:
    G_x = [-1 0 1; -2 0 2; -1 0 1]
    G_y = [-1 -2 -1; 0 0 0; 1 2 1]
  - Prewitt:
    G_x = [-1 0 1; -1 0 1; -1 0 1]
    G_y = [-1 -1 -1; 0 0 0; 1 1 1]

Question 5: Notes (5×4=20)

RGB color model:
- Additive color model using Red, Green, Blue primaries
- Used in displays, cameras
- Each channel typically 8-bit (0-255)
- Colors formed by combining different intensities of R, G, B
- Limitations: device-dependent, not perceptually uniform

Sampling and quantization:
- Sampling: Measuring image values at discrete spatial intervals
- Quantization: Mapping continuous brightness values to discrete levels
- Nyquist theorem: Sampling rate must be >2× highest frequency
- Quantization error leads to false contours in smooth areas

Point processing image enhancement:
- Operations where output depends only on input pixel value
- Includes:
  - Contrast stretching
  - Logarithmic transformations
  - Power-law (gamma) transformations
  - Thresholding
- Implemented via lookup tables for efficiency

Sobel operator:

- Edge detection operator using 3×3 convolution masks
- Computes gradient approximation in x and y directions
- Less sensitive to noise than simpler operators
- Often followed by thresholding and non-maximum suppression
- Part of many edge detection pipelines including Canny edge detector

[PDF version of these answers with questions is being generated...]