International Institute of Information Technology, Hyderabad

(Deemed to be University)

Digital Image Processing – Monsoon 2023

End Semester Examination

Max. Marks: 120

Max. Time: 3 Hrs

This paper has 10 questions, each carrying 12 marks. Answer each in one to two pages. Be precise in your answers and avoid verbosity.

Q1. What do the following terms mean in the context of image acquisition with a camera? How do these factors affect the final color (value) of a pixel?

a. Aperture, b. Shutter Speed, c. ISO, d. Color filter

Q2. When do we call a system to be Linear Shift Invariant? With the help of an example (in 1D), show that convolution operation is linear shift invariant.

Q3. What are Magnitude, Phase and Power Spectra in Fourier Transform? How will these change if the values of the input are all scaled by a constant value? Why? Explain the relative importance of Magnitude and Phase spectra while reconstructing an image from its Fourier Transform.

Q4. Define the operations of Opening and Closing using the basic operations of Dilation and Erosion. What does idempotence mean in the context of morphological operations? Are opening and closing idempotent operations? Why or why not?

Q5. You are tasked with the job of restoring images that were captured by the Mars rover. The image is corrupted by gaussian noise, motion blur and has shadows of a rock covering half the image. Describe what operations you will attempt to restore the image? What order will you use them in? Give justifications to each step and the order. Does your answer change of the shadow was cast be the moving rover itself?

Q6. With the help of a diagram, explain how foreground-background segmentation is posed as an optimization problem on a graph using MRF. What is the weight assigned to each edge? What is the function being optimized? What is the final solution and how does it connect the two together?

Q7. Huffman vs Arithmetic coding

a. Give two common features and one difference between the two coding schemes.

b. Huffman coding encodes an input sequence of symbols directly into a bitstream. The decoder is able to reconstruct the symbols without the need for any special information on how to split the bitstream for each symbol. Why? Show this with an example with at least 4 types of symbols and a sequence of 5 symbols.

c. Now, show the process to encode the same sequence above using arithmetic coding.

Q8. Image / video compression

a. Discuss the different kinds of redundancy in a video.

b. How much space would it take to store a documentary of 1 hour, without any encoding? Assume a colour video with resolution of 2000 x 1000 pixels and a 30 frames per second sampling rate. State any other assumptions if necessary.

c. What are the three main blocks used in the JPEG compression pipeline? What are their functions? Which part leads to compression?

d. Can JPEG compression be used in lossless mode? How?

e. What are better alternatives to compress JPEG images, especially for fingerprints? Why are they better?

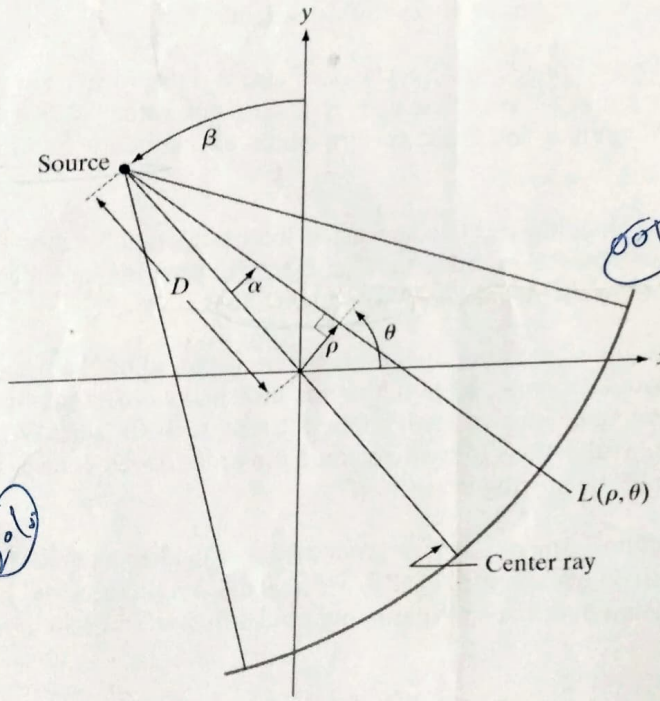
Q9. Explain how the value of the smallest eigen value of the of the H matrix corresponds to corners in Harris corner detector.

Q10. Using line detection as example, show how Hough Transform performs in two different parameter spaces. What are the advantages and disadvantages in each?

Q11

a. State and derive the central slice (Fourier slice) theorem. Using the notations $f(x, y)$ for a function in the image domain, $p_\theta(t)$ for a function in the projection or Radon domain, and $F(u, v)$ along with $P_\theta(w)$ for functions in the frequency or Fourier domain, briefly explain the relationships between these functions. What do the variables x, y, θ, t, u, v, *and* w stand for, and what are their units?

b. Determine the angular range $[0, x]$ for β to satisfy the sufficient condition for image reconstruction with fan-beam projection data, ensuring the acquisition of all projection lines. In other words, what is the value of x?



c. Is the Radon Transform of a periodic function also periodic? Explain the rationale behind your answer.