National Exams

Final Examination

Exam Notes

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit the answer paper with a clear statement of any assumptions made.
2. This is an OPEN BOOK EXAM. Any paper notes or textbooks are permitted.
3. **No** calculator or computer or any sort is permitted.
4. This exam contains SIX (6) questions, however FIVE (5) questions constitute a complete exam paper. The first five questions as they appear in the answer book will be marked.
5. Each question is of equal value.
6. The clarity and organization of the answers are important.
7. The exam is three hours long.

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1. **Basic Definitions**

   For each of the following concepts, give a brief definition (2-3 sentences) and a description of where the concept is used or applied, in practice:

   (a) Lossless Compression

   (b) Watershed Segmentation

   (c) Wavelet Transform

   (d) RGB, HSV and YCrCb Color Spaces

   (e) Image Watermarking

   (f) Hough Transform

   (g) Image Morphology

2. **Image Filtering**

   An image $f(m, n)$ of size $M_1 \times N_1$ is to be convolved with a filter array or convolution kernel $h(m, n)$ of size $M_2 \times N_2$ to produce a new resulting image $g(m, n)$.

   (a) Depending on how the convolution is implemented, g could be one of three different sizes. Specify these sizes.

   (b) Write a short program (in pseudo-code, Matlab, or C) to explicitly show how to compute g from f and h.

   (c) Describe a method to compute g using Fourier transforms.

   (d) Determine the computational complexity of the methods in (b) and (c). Which approach is more efficient in the case that M_2 and N_2 are much smaller than M_1, N_1?

   (e) De-convolution is the process of recovering f from g. What are the conditions on h for deconvolution to be possible?

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3. **The Human Visual System**

(a) Describe the two types of photoreceptors on the retina. What are their relative quantities?

(b) How are the photoreceptors distributed on the retina? What is the rationale behind this distribution?

(c) Discuss some of the basic image processing steps that take place in the retina.

(d) Describe in some detail how algorithms for

i. Image Denoising, and

ii. Colour Image Compression

have taken advantage of certain traits of the human visual system.

4. **Color Image Processing**

(a) Give a summary of the main colorspaces and their relative strengths and weaknesses.

(b) What is the significance or role of the Bayer Pattern in color imaging?

(c) How does multispectral image processing, for example in remote sensing, differ from color image processing?

(d) What is the rationale for an algorithm converting a color image to YUV and then operating on only the U and V channels?

(e) Give a description of how each of the following methods is generalized from gray-scale to colour images:

i. Edge Detection

ii. Image Segmentation

iii. Image Denoising

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5. **Application**

Suppose that I give you an image that suffers from the following issues:

- Image details such as edges appear blurred and difficult to see.
- The image has very poor contrast.
- The image is dark.
- The image is corrupted by high-frequency multiplicative noise.

Your Task: Design a system that addresses all of the problems from which the image suffers. Be sure to describe the system carefully, with a clear diagram for each system component and a clear outline of the entire system process. Be sure to justify and explain why each system component was chosen and the rationale behind the ordering of the components.

6. **Application**

You have the job of designing an algorithm that will count the number of objects with holes and the number of objects without holes in a given image.

Assume that each measured image I is binary, where "1" corresponds to object, and "0" corresponds to background and holes.

The imaging system is of low quality and produces images that are corrupted with salt and pepper noise. The objects do not actually overlap or touch, but they may be arbitrarily close to each other in any direction. The objects may be of any shape or size and with any orientation.

The algorithm should not be confused by the salt and pepper noise, and should not count noise pixels as objects.

Your Task: Write a pseudo-code description of your algorithm. You may also include a block diagram, sketches, and other information to make your answer understandable to a programmer. State any assumptions you make.