EE 569 Introduction to Digital Image Processing

Midterm Exam
Prof. Sunil Kumar
Summer 2001

Name:
SSN:
Location:
☐ USC Campus
☐ Remote

Notes:
1. Exam duration: 90 minutes

Time: 3:30 – 5:05 pm

2. Closed book and notes. No crib sheet. One single-line calculator is OK.

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Problem 1

Note: You are required to give a brief explanation of your answer wherever applicable. No credit will be given for no reason or for wrong reason.

(a) (4 points) What is the difference between orthographic and perspective transforms?

(b) (4 points) What is a free variable in perspective transform?

(c) (6 points) Write the steps involved in convolution, along with formula.

(d) (4 points) Compare gradient and Laplacian operators for edge detection.

(e) (4 points) Compare opening and closing operations in morphological processing.

(f) (4 points) Give one example of linear and median noise cleaning techniques.

(g) Yes/No questions (explain your choice)
   (1) (5 points) Consider the application of the skeletonizing operation to a binary image. It may not be possible to reconstruct the original image from the skeletonized image.
      _______ Yes _______ No

   (2) (5 points) After selecting 6 control points, we can warp a round image into a smaller round image.
      _______ Yes _______ No
Problem 2  Edge Detection

Consider an image of size 4*4 with the following grey levels.

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1. (10 points) Calculate the Sobel horizontal and vertical gradients.
2. (5 points) Design two Sobel gradient operators to calculate $45^\circ$ and $135^\circ$ gradients.

Note: If boundary extension is needed, please simply duplicate the boundary rows and columns.

Sobel horizontal gradient operator and vertical gradient operator:

\[
H = \frac{1}{4} \begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix} \quad \quad V = \frac{1}{4} \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}
\]
Problem 3 Image Enhancement

Suppose that the histogram function $h(x)$ of an image $F(i,j)$ can be expressed as:

$$h(x) = \begin{cases} 
128 - x & 64 \leq x \leq 192 \\
0 & \text{otherwise}
\end{cases}$$

1. (5 points) Can this image be a square image?
2. (3 points) Plot the histogram of the image.
3. (10 points) To enhance the image, we want to stretch the intensity of this image to the dynamic range of [0, 254]. Design a linear transform to achieve this objective and plot the histogram of the processed image.
Problem 4 Geometrical Modification

Describe an algorithm based on geometrical image modification to the left image below to achieve the effect demonstrated on the right one:

1. (10 points) Please state your algorithm with as much detail as possible.
2. (5 points) Is it possible to recover the original image perfectly (i.e. the recovered image is just the same as the original one)? If not, please explain the reason. Where does the error come from?

Note: these two images have the same size.
Problem 5 Morphological Processing

1. (4 points) Sketch the result of the dilation of a circle of radius $r$ by a circular structuring element of radius $\frac{r}{4}$.

2. (4 points) Use the above structuring element to dilate a square of size $r \times r$.

3. (8 points) Repeat Step 1-2 for erosion.
   Note: Use only one iteration.