

CSE166 – Image Processing – Final

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<http://www-cse.ucsd.edu/~sjb/classes/fa02/cse166>

3:00-6:00pm Wed. Dec. 11, 2002.

On this exam you are allowed to use a calculator and two 8.5” by 11” sheets of notes. The total number of points possible is 100. In order to get full credit you must **show all your work**. Good luck!

- (10 pts) Let $W = \text{dftmtx}(8)$.
 - Explain in words what each row of W represents.
 - Write down the result of the operation $(1/8) * W * W'$.
- (25 pts) Let X denote a continuous random variable representing pixel brightness in an image, and let $X \sim p_X(x)$. (This notation means “ X is distributed with probability density function $p_X(x)$.”)
 - Write down the transformation $T(\cdot)$ for which the random variable $Y = T(X)$ has a uniform distribution on $[0, 1]$.
 - Prove that $Y = T(X)$ has a uniform distribution.
 - Write down the version of $T(\cdot)$ used in the discrete case.
 - What is the name of this image processing operation?
 - Why is it used in practice?
- (10 pts) Suppose that before compressing an image (e.g. using Huffman coding) we filter it with the kernel $[-1 \ 1]$.
 - What quantitative measure of image compressibility is affected by this filtering operation?
 - Explain how one could benefit from such a strategy in terms of characteristics of the pixels in the input image.
- (10 pts) Consider the image shown in Figure 1(a).
 - Write down the 2×2 scatter matrix (up to a scale factor) for this shape.
 - Suppose we rotate the image 45° clockwise, as shown in Figure 1(b). Solve for the scatter matrix of the rotated shape.

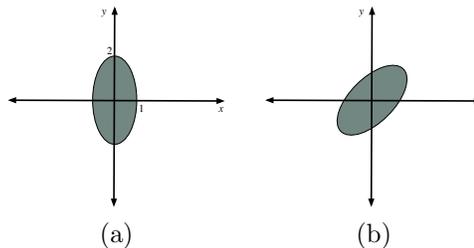


Figure 1: (a) original image, (b) rotated image.

- (15 pts) Consider the 7×7 binary image shown in Figure 2 in which black=1 and white=0. Assume the top left coordinate is $(0, 0)$.

- (a) Sketch the Hough Transform (HT) for this image using the normal line (ρ, θ) parameterization. On your drawing, let ρ range from 0 to 10 and let θ range from $-\pi/2$ to $\pi/2$.
- (b) Indicate the points of intersection on your HT sketch and explain what they represent in the input image.

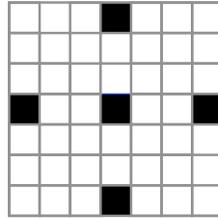


Figure 2: 7×7 binary image. The coordinates of the five nonzero pixels are: $(0, 3)$, $(3, 0)$, $(3, 3)$, $(6, 3)$, $(3, 6)$.

6. (15 pts) In this problem, which pertains to eigenfaces, please answer the following questions in words using one or two sentences each; use equations only if you feel it will help your explanation.
 - (a) What is an eigenface?
 - (b) Explain how eigenfaces can be used for compression.
 - (c) Explain how eigenfaces can be used for recognition.
7. (15 pts) Consider the function defined by

$$h(x) = 2^{-(N-1)} \binom{N-1}{x}, \quad x = 0, 1, \dots, N-1$$

- (a) Write down $h(x)$ for $N = 5$.
- (b) When used as a kernel, what is this function called?
- (c) What continuous function does $h(x)$ approximate?