

IMAGE PROCESSING (RRY025)

One of the Exams in 2008/2009

1 IMAGE ENHANCEMENT

Two students of this course, X and Y, want to test their understanding of image enhancement.

- (a) X asks Y to enhance a 4-bit image of size 4×4 by histogram equalization. X sends the image by horizontal raster scanning:

15, 1, 2, 12, 4, 10, 9, 7, 8, 6, 5, 11, 3, 13, 14, 0.

Y receives this image and breaks into a laugh! Can you explain why? [2 points]

- (b) X then sends a 2-bit image of the same size:

1, 1, 2, 2, 2, 1, 3, 1, 1, 1, 0, 1, 1, 2, 2, 1.

How does Y equalize the histogram of this image? What is the output image? Any comment on the output histogram? [3 points]

- (c) Now Y asks X to equalize the histogram of an image in which the gray level is equal everywhere. How do the output and input images differ in this case? [2 points]

- (d) Finally, X and Y want to do some experiments involving exponential noise, for which the probability distribution function is $p(x) = a e^{-ax}$ if $x \geq 0$, and $p(x) = 0$ otherwise. The problem is that their toolbox has a command to generate only uniform noise, for which the probability distribution function is $q(y) = 1$ if $0 \leq y \leq 1$, and $q(y) = 0$ otherwise. How can they generate exponential noise? [3 points]

2 WAVELETS

Explain the following points, AND sketch simple diagrams to illustrate them:

- (a) the fundamental property of wavelets; [2 points]
(b) the fast wavelet transform; [2 points]
(c) the idea behind data compression using wavelets; [3 points]
(d) the idea behind data de-noising using wavelets; [3 points]

3 IMAGE COMPRESSION

A gang of criminals threaten to paralyse the World Wide Web by transmitting huge images. They will do so unless someone finds a smart way to compress their images efficiently and without loss. You accept the challenge. Warm up your brain [(a) and (b)], and save the world [(c) and (d)]!

- (a) Consider the same image as in **1(a)** (image enhancement). What is the theoretical maximum compression without loss, if each pixel is coded separately? Note now that this image is a magic square: the sum of the elements in each row, or in each column, or in each diagonal is the same. Using such information, how much can you surely compress this image without loss? And why can you compress more than the theoretical maximum evaluated above? [2 points]
- (b) Consider the same image as in **1(b)** (image enhancement). How much can you compress this image by Huffman coding each pixel separately? [2 points]
- (c) In order to give you a chance to understand, the criminals send a 6-bit miniature image of size 4×4 by horizontal raster scanning:
18, 21, 24, 27, 30, 33, 36, 39, 42, 45, 48, 51, 54, 57, 60, 63.
You deduce that the criminals like mathematics and are predictable. So find a smart way to compress this image efficiently and without loss! If the image had a larger size and obeyed the same mathematical rule, would your compression scheme be more efficient or not? Explain! [3 points]
- (d) Finally, the criminals send a 7-bit miniature image of size 4×4 :
0, 1, 3, 6, 10, 15, 21, 28, 36, 45, 55, 66, 78, 91, 105, 120.
Same questions as in (c). [3 points]