IMAGE PROCESSING (RRY025/ASM420)

One of the Exams in 2019/2020

1 Warming up: MISCELLANEA [15 points]

(a) [9p] (1) What are the two most important assumptions that must be satisfied for Wiener filtering a noisy image?

- `Assumption 1`: the noise is additive
- `Assumption 2`: the noise is Gaussian
- `Assumption 3`: the noise is uncorrelated with the signal
- `Assumption 4`: the noise is white

Suppose that the image is noisy but *without* distortions. (2) What are the point spread function and the optical transfer function? (3) Write down the formula for computing the Wiener filter, and explain what each symbol in that formula represents. (4) Show then how to Wiener filter the noisy image using its Fourier power spectrum. (5) Where do the two assumptions mentioned above enter the filtering? (6) For which type of coloured noise (red, pink, white, blue, violet) does Wiener filtering work best/worst? (7) Why? (8) If the noise is white, does Wiener filtering work better or worse than Gaussian low-pass filtering? (9) Why?

(b) [6p] The root-mean-square error (RMSE) is a quantity commonly used for measuring how lossy compression methods degrade an original image, supposed to be non-noisy and of sufficiently good quality. (1) Write down the formula for computing RMSE, and explain what each symbol in that formula represents. (2) Why is RMSE so commonly used? (3) Is RMSE always a reliable measure of the error perceived by our brain/eyes? (4) If not, give *your own* example of a case where RMSE fails drastically. The (root-)mean-square error is also used in other areas of image processing. (5) In which case has it played an especially important role, promoting advances in that area? (6) Illustrate the basic idea behind such an application! Perhaps, I am helping you too much :-)

2 MISCELLANEA [12 points]

(a) [10p] Consider an image I of class double and size 1024×1024, which is almost perfectly regular as a function of the two coordinates: $I(x, y)$ is continuous together with its first seven derivatives, except at a certain point (x_0, y_0), where the 3rd derivative has a discontinuity. In spite of its regularity, I is not a simple function of x, y for $x \neq x_0, y \neq y_0$. (1) How would you detect the 'breakdown' point (x_0, y_0)? (2) What would be the uncertainty $(\Delta x_0, \Delta y_0)$ of your detection? Are you really sure?? Explain in detail and with illustrations!!

(b) [2p] Suppose that you have an image of 400×800 pixels, and that you want to Fast Fourier transform it. (1) What should you do first, and why? Suppose now that you have the same image, and that you want to filter it in Fourier domain. (2) What should you do first, and why?

3 Cooling down: MISCELLANEA [3 points]

(a) [3p] In your opinion, what is the most interesting topic of the course? Explain how important this topic is in the context of image processing, and how important it is for your studies/job.