IMAGE PROCESSING (RRY025)

One of the Exams in 2015/2016

1 Warming up: MISCELLANEA [12 points]

(a) [3p] Describe histogram equalization as a tool for image enhancement. Can this tool be used for other important applications? Explain!

(b) [3p] Same questions as in **(a)**, but for histogram specification (matching).

(c) [6p] What are the strong and the weak points of the fast wavelet transform, the block discrete cosine transform and the discrete Fourier transform?

2 NOISE / NOISE REMOVAL [15 points]

(a) [3p] A common form of noise is the so-called power-law noise. Its Fourier power spectrum varies on average as $1/f^{\beta}$, where f is the frequency and β determines the 'colour' of the noise. For example, $\beta = 0$ corresponds to the well-known white noise, while $\beta = 2, 1, -1, -2$ corresponds to red, pink, blue, violet noise. Now suppose that you have an image polluted by additive white noise, and that you want to detect the vertical edges of the image by correlating it with the filter [-1 0 1]. Does this change the colour of noise in the horizontal direction? If so, how? HELP: reduce this problem to a simpler 1D exercise, and argue in terms of continuous (rather than discrete) variables!

(b) [3p] Suppose again that you have an image polluted by additive white noise, but now you want to transmit the image row by row using the simplest lossless predictive coding (the one based on the nearest pixel value). What is the colour of noise in the horizontal direction of the transmitted (error) image? And why? Same HELP as in **(a)**.

(c) [3p] Which mathematical operation transforms white noise into red noise? And why?

(d) [3p] A friend of yours is interested in physics, and especially in Brownian motion. This is the *random* motion of particles suspended in a liquid or gas, and is caused by the collisions between such particles and the atoms or the molecules of that fluid. Today your friend is analysing the results of an important experiment, which can be summarized in terms of the following formula: $x(t) = B(t) + n(t)$, where $x(t)$ is the x-coordinate of a given particle at time t, $B(t)$ is its Brownian motion, and $n(t)$ is the 'noise' generated by the experimental device. Unfortunately, your friend is not able to separate the 'signal' $B(t)$ from the 'noise' $n(t)$ and asks for your help! She gives you the following information:

- $B(t)$ has a Gaussian probability distribution, and its Fourier power spectrum varies on average as $1/f^2$.
- $n(t) = a\,\cos(2\pi f_0 t) + c\,\cos(6\pi f_0 t)$, where $f_0 = 1000$ Hertz, a and c are large but their precise value is not known.

How would you remove the 'noise'? Would your noise removal affect the 'signal'? If so, how? HELP: look this problem in the eyes, and you will see that it is simpler than it seems!

(e) [3p] Finally, consider the more general case in which the functional form of $n(t)$ is not known, but you know that $n(t)$ is regular and has more power at high frequencies. Same questions and HELP as in **(d)**.

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.