IMAGE PROCESSING (RRY025/ASM420)

One of the Exams in 2020/2021

1 Warming up: MISCELLANEA [12 points]

(a) [2p] What are the strong and the weak points of the discrete Fourier transform?

(b) [2p] And of the fast wavelet transform?

(c) [2p] And of the block discrete cosine transform?

(d) [2p] In which area(s) of image processing (enhancement, compression, restoration) can the discrete Fourier transform be successfully applied? And why?

(e) [2p] Same questions for the fast wavelet transform.

(f) [2p] Same questions for the block discrete cosine transform.

2 COMPRESSION, NOISE AND DENOISING [15 points]

(a) [3 points] You have an 8-bit image that you want to compress using lossless predictive coding, followed by entropy coding. [1p] Before applying entropy coding, how many bits/pixel will the transmitted error image have if the prediction is based on the previous pixel value? [1p] And in the case of gradient-based lossless predictive coding? [1p] Do your answers reveal a paradox, or can actually the error images be compressed more efficiently than the original image by applying entropy coding? Explain everything thoroughly!

(b) [9 points] Let us now solve a 'colourful' problem in this period of darkness. Imagine to be on holiday, surrounded just by the sea, the sky, and the sun :-) It is an amazing sunrise: the sun is pinkish, the sky is bluish without clouds, and the sea is also bluish with small waves! To remember such a beautiful moment, you take a photo with your camera, which has quite a sense of humour: it adds Gaussian blue noise to the sun, Gaussian pink noise to the sky, and no noise at all to the sea! Poissonian noise is instead negligible, since your camera is very sensitive to light. The photo is an image of 2048×2048 pixels. The bottom half of the image only shows the sea. The top half of the image shows both the sky and the sun, which is just all above the horizon, is horizontally centred, and has a diameter of 512 pixels. Demonstrate your expertise in image processing, and answer the following three questions: (1) [2p] What do (1D) cross sections of the sun and the sky look like? Sketch clearly the true colours and the noisy features of such cross sections, and explain everything thoroughly! (2) [2p] What do the Fourier power spectra of such cross sections look like? Sketch and explain! (3) [5p] How would you denoise the (2D) image in the best possible way? Just to be 100% clear: you want to suppress the noise in the sun and the sky, but not the small waves of the sea. Sketch and explain everything thoroughly, including the artifacts generated by your method of denoising! HELP: In questions (2) and (3), you can regard the photo as a greyscale image and still get full points :-)

(c) [3 points] Noise is sometimes anisotropic, which means that it has different properties along different directions. Consider additive Gaussian coloured (AGC) noise that contaminates an image only vertically. In other words, any vertical cross section of the image is noisy, whereas any horizontal cross section of the image is perfectly non-noisy. [1p] How can you generate such a type of noise in the image, if you know how to generate AGC noise in 1D? [2p] If the noise contaminating the sun and the sky in problem **2 (b)** was vertically directed in the sense specified above, then how would you modify your method of denoising?

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.