5 Computer Vision (JGD)

(a) Consider the following 2D filter function $f(x, y)$ incorporating the Laplacian operator that is often used in computer vision:

$$f(x, y) = \left( \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} \right) e^{-(x^2+y^2)/\sigma^2}$$

(i) In 2D Fourier terms, what type of filter is this? Is it a lowpass, a highpass, or a bandpass filter? Justify your answer. [2 marks]

(ii) Are different orientations of image structure treated differently by this filter, and if so, how? Is it isotropic, or anisotropic? [2 marks]

(iii) Approximately what is the spatial frequency bandwidth of this filter, in octaves? [Hint: the answer is independent of $\sigma$.] [2 marks]

(iv) What is meant by image operations “at a certain scale of analysis?” Explain the scale parameter $\sigma$, and define a scale-space fingerprint. [2 marks]

(b) Write a block of pseudo-code for convolving an image with a feature-detecting kernel. (You may ignore out-of-bounds issues at the image array boundaries.) [3 marks]

(c) In pattern classification with two classes, explain how an ROC curve is derived from the underlying distributions. Define a threshold-independent performance metric based on the distributions’ moments. [4 marks]

(d) When visually inferring a 3D representation of a face, it is useful to extract separately both a shape model, and a texture model. Explain the purposes of these steps, their use in morphable models for pose-invariant face recognition, and how the shape and texture models are extracted and later re-combined. [5 marks]