COMPUTER SCIENCE TRIPOS Part II – 2013 – Paper 8

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:

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

(*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 σ.] [2 marks]

(*iv*) What is meant by image operations "at a certain scale of analysis?" Explain the scale parameter σ, 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]