5 Computer Vision (JGD)

(*a*) The following very useful operator is often applied to an image $I(x, y)$ in computer vision algorithms, to generate a related "image" $g(x, y)$ for analysis:

$$g(x,y) = \int_\alpha \int_\beta \nabla^2 e^{-\left((x-\alpha)^2+(y-\beta)^2\right)/\sigma^2} I(\alpha,\beta)\, d\alpha\, d\beta$$

where

$$\nabla^2 = \left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}\right)$$

(*i*) Give the general name for this type of mathematical operation, and the chief purpose that it serves in computer vision. [1 mark]

(*ii*) What structures are expected at places (x, y) in the image $I(x, y)$ where the operator output $g(x, y)$ undergoes zero-crossings? [1 mark]

(*iii*) What is the significance of the parameter σ? If you increased its value, would there be more or fewer points (x, y) where $g(x, y) = 0$? [2 marks]

(*iv*) Describe the effect of the above operator in terms of the two-dimensional Fourier domain. What is the Fourier terminology for this image-domain operator? What are its general effects as a function of frequency, and as a function of orientation? [2 marks]

(*v*) If the computation of $g(x, y)$ were to be implemented entirely by Fourier methods, would its complexity be greater or less than the image-domain operation, and why? What would be the trade-offs involved? [2 marks]

(*vi*) If the image $I(x, y)$ has 2D Fourier Transform $F(u, v)$, provide an expression for $G(u, v)$, the 2D Fourier Transform of the operator output $g(x, y)$ in terms of $F(u, v)$, the Fourier plane variables u, v, some constants, and the parameter σ. [2 marks]

(*b*) Briefly define each of the following concepts as it relates to vision:

(*i*) "signal-to-symbol converter" [2 marks]

(*ii*) "inverse graphics" [2 marks]

(*iii*) quadrature demodulator [2 marks]

(*iv*) volumetric coordinates [2 marks]

(*v*) correspondence problem [2 marks]