2011 Paper 9 Question 2

Computer Vision

(*a*) Name **four** Gestalt laws of perceptual organisation. What is the main theme of Gestalt Psychology, and in what way is it relevant to automated object recognition in images and video sequences? [4 marks]

(*b*) Many computer vision algorithms such as SIFT (scale-invariant feature transform) seek to detect and analyse features at multiple scales of analysis.

(*i*) What is "scale-space" and what is a "scale-space fingerprint"? [2 marks]

(*ii*) Briefly describe how SIFT achieves scale and rotation invariance. [3 marks]

(*iii*) Show that the difference-of-Gaussian operation DoG given by

$$DoG(x, y, \sigma) = (G(x, y, k\sigma) - G(x, y, \sigma)) * I(x, y)$$

$$G(x, y, \sigma) = \frac{1}{2\pi\sigma^2} e^{-(x^2+y^2)/2\sigma^2}$$

on image data I as used by SIFT is an approximation of the scale-normalised Laplacian of Gaussian given by $\sigma^2\nabla^2 G$. You may assume that

$$\frac{\partial G}{\partial \sigma} = \sigma\nabla^2 G$$

Comment on a good choice for the value of k for practical applications of SIFT. [6 marks]

(*c*) The curvature map of a closed image contour is a bandlimited signal and can be described by its zero-crossings. Explain how this property can be exploited for 2D shape description. What properties make such a representation suitable for classification and recognition of shapes? [5 marks]