

2006 Paper 9 Question 6

Computer Vision

- (a) Extraction of visual features from images often involves convolution with filters that are themselves constructed from combinations of differential operators. One example is the Laplacian $\nabla^2 \equiv \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}$ of a Gaussian $G_\sigma(x, y)$ having scale parameter σ , generating the filter $\nabla^2 G_\sigma(x, y)$ for convolution with the image $I(x, y)$. Explain in detail each of the following three operator sequences, where $*$ signifies two-dimensional convolution.

(i) $\nabla^2 [G_\sigma(x, y) * I(x, y)]$ [2 marks]

(ii) $G_\sigma(x, y) * \nabla^2 I(x, y)$ [2 marks]

(iii) $[\nabla^2 G_\sigma(x, y)] * I(x, y)$ [2 marks]

(iv) What are the differences amongst their effects on the image? [2 marks]

- (b) In human vision, the photoreceptors responsible for colour (cones) are numerous only near the fovea, mainly in the central ± 10 degrees. Likewise high spatial resolution is only found there. So then why does the visual world appear to us uniformly coloured? Why does it also seem to have uniform spatial resolution? What implications and design principles for computer vision might be drawn from these observations? [4 marks]

- (c) Outline a scheme for accomplishing transcription of handwriting (not cursive, that is, with letters already separated). Explain the core modules in your system, from low-level feature extraction to high-level classification of letters. At the highest level of the classifier, explain how the system could use Bayesian methods to incorporate expert knowledge such as a lexicon of actual words and knowledge about relative letter frequencies. [4 marks]

- (d) How can dynamic information about facial appearance and pose in video sequences (as opposed to mere still-frame image information), be used in a face recognition system? Which core difficult aspects of face recognition with still frames become more tractable with dynamic sequences? Are some aspects made more difficult? [4 marks]