

4 Computer Vision (JGD)

- (a) Explain how each of the following equations or expressions can be used for detecting and estimating visual motion in a spatio-temporal image sequence  $I(x, y, t)$ . Include in your answer the name used to describe each of these general classes of motion extraction models:

$$(i) \quad -\frac{\partial I(x, y, t)}{\partial t} = \vec{v} \cdot \vec{\nabla} I(x, y, t) \quad [2 \text{ marks}]$$

$$(ii) \quad -\frac{\partial}{\partial t} [\nabla^2 G_\sigma(x, y) * I(x, y, t)] \quad [2 \text{ marks}]$$

$$(iii) \quad \operatorname{argmax}_{(v_x, v_y)} \int_x \int_y \int_t I(x, y, t) \cdot I(x - v_x \tau, y - v_y \tau, t - \tau) dx dy dt \quad [2 \text{ marks}]$$

$$(iv) \quad F(\omega_x, \omega_y, \omega_t) = e^{-i(\omega_x v_x \tau + \omega_y v_y \tau + \omega_t \tau)} F(\omega_x, \omega_y, \omega_t)$$

where  $F(\omega_x, \omega_y, \omega_t) = \int_x \int_y \int_t I(x, y, t) e^{-i(\omega_x x + \omega_y y + \omega_t t)} dx dy dt$  [2 marks]

- (b) Colour perception is not about measuring wavelengths, because they vary with illumination. Explain why it is difficult to assign intrinsic spectral reflectance properties of surfaces. Explain all steps in the Retinex Algorithm intended to solve this, relating these steps where possible to neurobiology. [7 marks]
- (c) Sketch out an algorithm for shape classification and the construction of shape grammars, involving active contours, codon strings, and indexing. Explain how codon constraints enable a shape grammar to define broad equivalence classes such as “cashew shaped” objects, with invariance to irrelevant transformations such as planar rotations or dilations. [5 marks]