

2009 Paper 9 Question 5

Computer Vision

(a) Consider the following two contrasting kinds of filter kernels, A and B:

0	-1	-1	-1	-1	0	A	B	1	1	1	1	1	1
-1	-2	-3	-3	-2	-1			-1	-2	-3	-3	-2	-1
-1	-3	12	12	-3	-1			-1	-3	-4	-4	-3	-1
-1	-3	12	12	-3	-1			1	3	4	4	3	1
-1	-2	-3	-3	-2	-1			1	2	3	3	2	1
0	-1	-1	-1	-1	0			-1	-1	-1	-1	-1	-1

- (i) Given that the sum of all taps in each kernel is zero, how will each filter respond to an image region having only uniform brightness? [1 mark]
- (ii) Which filter has much broader bandwidth in spatial frequency? [1 mark]
- (iii) Categorise each filter as being either essentially isotropic or anisotropic, and explain the significance of these terms. [2 marks]
- (iv) Which filter is better described as an oriented edge detector? What orientation of edges is it best able to detect? [2 marks]
- (v) Apply the terms “ $\nabla^2 G_\sigma(x, y)$ ” or “Imaginary part of a 2D Gabor wavelet” as you think most appropriate to each filter. [2 marks]
- (b) What is accomplished by the lateral signal flows within both plexiform layers of the mammalian retina, in terms of image processing and coding? [4 marks]
- (c) Consider the task of “anti-spoofing” in the automated visual recognition of iris patterns: how to confirm that an image is acquired from a living iris instead of from a spoofing artefact like a photograph or a fake printed contact lens. How would you implement strategies (i)–(ii), and detect properties (iii)–(iv)?
- (i) 3D shape description using inferences from stereo, shading information, or structured light and the fact that a real iris is planar whereas a printed contact lens on the cornea floats on a spherical surface. [2 marks]
- (ii) Motion detection tuned for radial changes in pupil size with iris pattern stretching and light-driven deformations. [2 marks]
- (iii) Lambertian properties and dynamic specular reflections. [2 marks]
- (iv) Photonic properties of living tissue compared with artificial objects, including reflectance maps and wavelength-dependent absorption spectra. [2 marks]