3 Computer Vision (JGD)

(a) In early stages of machine vision systems, the isotropic operator shown on the right is often applied to an image \( I(x, y) \) in the following way: 
\[
\nabla^2 G_\sigma(x, y) \ast I(x, y)
\]
What is the purpose of this operation? Which class of neurones in the retina does it mimic?

How would the results differ if instead this operation: 
\( G_\sigma(x, y) \ast \nabla^2 I(x, y) \) were performed; and alternatively if this operation: 
\( \nabla^2 [G_\sigma(x, y) \ast I(x, y)] \) were performed?

(b) Explain the method of Active Contours. What are they used for, and how do they work? What underlying trade-off governs the solutions they generate? How is that trade-off controlled? What mathematical methods are deployed in the computational implementation of deformable models?

(c) In relation to the image formation diagram shown on the right, explain: (i) the concept of a reflectance map; (ii) what is a specular surface; (iii) what is a Lambertian surface; and (iv) what is surface albedo. In explaining these concepts, give the defining relationships for the amount of light from a point source that is scattered in different directions by such illuminated surfaces, and describe the inferences that a vision system must make with them.

(d) It can be said that the central problem of pattern recognition is the relative extent of within-class variability and between-class variability. Explain this issue in the context of facial recognition, treating separately the three problems of (i) face detection (distinguishing faces from non-faces); (ii) face identification; and (iii) face interpretation (classifying the expression and pose of the face). How does variability along some of these dimensions influence each of the three problems? Is within-class variability ever helpful, and between-class variability harmful, to the performance of the task?