Midterm Test

March 6th, 2013

CSC320H1S : Introduction to Visual Computing

Duration: 50 minutes

No aids allowed

There are 6 pages total (including this page)

Given name(s): ________________________________

Family name: ________________________________

Student number: ________________________________

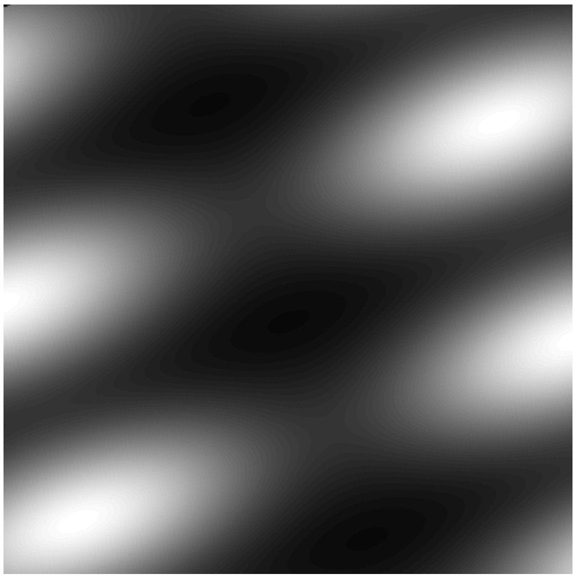
Question	Marks
1	__________/15
2	__________/20
3	__________/15
Total	__________/50

1 Hessians and Principal Curvatures (15 marks total)

(a) **[4 Marks]** Define the Hessian of an image I at point (x, y) using standard calculus notation.

(b) **[5 Marks]** Give the mathematical definition of the principal curvatures and principal directions of an image I at a point (x, y) for which $\|\nabla I(x, y)\| = 0$.

(c) **[6 Marks]** Consider the following image:



(c1) **[2 Marks]** Mark with an **A** on the image above a *hyperbolic point* for which $\|\nabla I(x,y)\| = 0$, and draw its principal directions. Be as precise as possible. You may include an explanation if you wish (but this is not necessary).

(c2) **[2 Marks]** Now mark with a **B** an *elliptical point* for which $\|\nabla I(x,y)\| = 0$, and draw its principal directions. You may include an explanation if you wish (but this is not necessary).

(c3) **[2 Marks]** Finally, mark with a **C** a point that is a *zero-crossing of the image Laplacian*. Explain in 1-2 sentences; no marks will be awarded without an explanation.

2 Isophotes (20 marks total)

Consider the image

$$I_1(x,y) \;=\; \sqrt{(x-c)^2 \;+\; (y-r)^2}$$

where r, c are positive constants. Recall that the isophote at (x, y) is the curve whose points all have intensity equal to $I_1(x, y)$.

(a) **[9 Marks]** Give the expression for the arc-length parameterization of the isophote through point (x, y). If you wish, you may define auxiliary variable(s) to simplify your calculations.

(b) **[6 Marks]** Give the expression for the isophote's unit normal at (x, y).

(c) **[5 Marks]** Now consider the image

$$I_2(x, y) \;=\; \sqrt{10(x-c)^2 \;+\; 5(y-r)^2} \;\;.$$

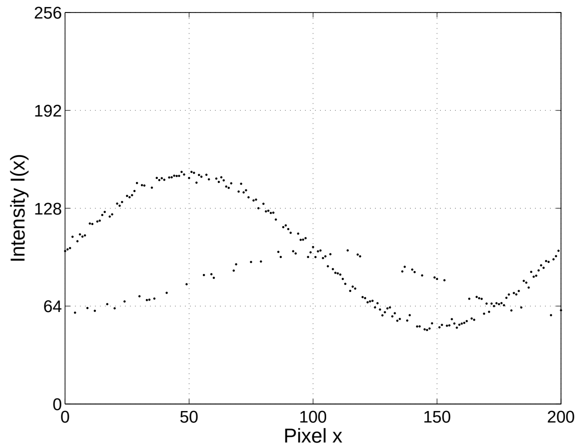
What is the shape of the isophote through point (x, y)?

3 Robust Estimation (15 marks total)

Suppose you are given a 1D image I containing n pixels that is generated by randomly "interleaving" two other n-pixel images, I_1 and I_2:

$$I(x) = \begin{cases} I_1(x), & \text{or} \\ I_2(x) \; . \end{cases}$$

An example is shown below (in this example, I_1 is shaped like a sinusoid):



The images I_1 and I_2 are *not* known and neither is the way by which they were interleaved. Moreover, since the interleaving was random, there is no fixed interleaving pattern. You are told, however, that in any window of size $w > 10$, approximately 70% of the pixels come from image I_1 and the rest come from I_2.

Show how to estimate the derivative of I in a way that is completely unaffected by the pixels coming from image I_2. That is, your derivative estimate should be (almost) identical to the estimate that you would have computed if $I(x)$ were equal to $I_1(x)$ for *every* pixel x. If your method requires any additional assumptions, be sure to state them.

END OF EXAM