CSC320: Visual Computing

Term Test 1 March 7th, 2008 9:10-10:00

Student Number:_____

Last Name:_____ First Name:_____

This exam consists of 3 questions on 6 single-sided pages (including cover page).
Aids allowed: None.

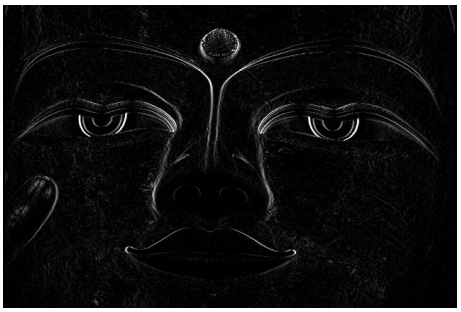
Total Marks: 50
Minutes: 50

Question	Marks
1a	_____/5
1b	_____/5
1c	_____/5
2a	_____/5
2b	_____/10
2c	_____/5
2d	_____/5
3	_____/10
Total	_____/50

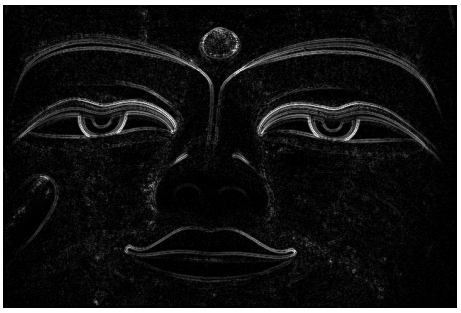
1. **Edge & Corner Enhancement [15 Marks]**

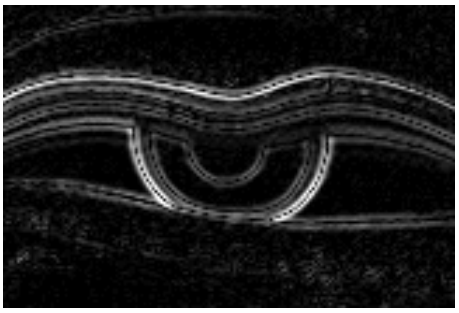
   Consider the image I shown on the left, along with the zoomed-in portion shown on the right.


   (a) [5 Marks] Give your best guess as to what the "enhanced" image below, and its corresponding zoomed-in portion, represent, using standard calculus notation. Explain why in 1-2 sentences.

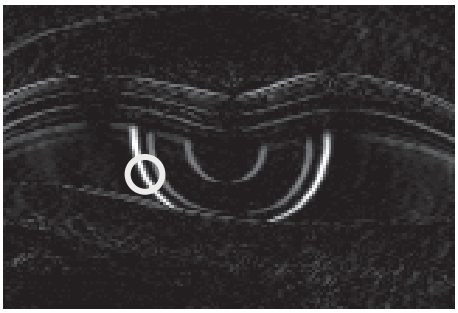



(b) [5 Marks] Do the same for the following "enhanced" image:





(c) [5 Marks] Finally, on the "enhanced" image below, draw the principal directions of its Hessian at the center of the circle. What are the signs of the Hessian's first and second eigenvalue at the center? $(+, -,$ or $0)$.



2. **Estimation by 2D Polynomial Fitting [25 Marks]**

(a) [5 Marks] Give the 2nd-order Taylor series expansion of the image $I(x, y)$ in the neighborhood of pixel $(0, 0)$:

$I(x, y) \quad =$

(b) [10 Marks] Consider the image below. We want to use polynomial fitting to estimate the intensity, I, and its first and second partial derivatives at the center of the highlighted 21×21-pixel patch.

To do this, we will use least squares to fit a *single* second-degree polynomial in x *and* y to the patch intensities.

Using matrix notation, show the linear system that must be solved to compute the fit for the patch center. Be sure to indicate the dimensions and contents of each matrix.

[Use the space at top of next page]

(c) [5 Marks] Now suppose that we slide the 21×21-pixel window over the entire image, solving the system in (b) for every possible window center (x, y) in order to estimate $I(x, y)$. Ignoring the pixels near the image border, what differences do you expect to see between the estimated image I and the original photo?

(d) [5 Marks] Finally, suppose that we use RANSAC fitting, rather than standard least squares, to estimate $I(x, y)$. Ignoring the pixels near the image border, what differences do you expect to see between the estimated image I and the original photo in this case?

3. **2D Curves [10 Marks]**

Prove that if s is the arc-length parameter of a curve $\gamma(s)$ and $\mathbf{T}(s)$ is the curve's unit tangent vector, then

$$\mathbf{T}(s) \cdot \frac{d\mathbf{T}}{ds}(s) \;=\; 0 \quad .$$