Midterm Test

March 2nd, 2016

CSC320H1S : Introduction to Visual Computing

Duration: 50 minutes

No aids allowed

There are 5 pages total (including this page)

Given name(s): ________________________________

Family name: ________________________________

Student number: ________________________________

Question	Marks
1	__________/25
2	__________/25
Total	_________/50

1 Estimation by 2D Polynomial Fitting (25 marks total)

(a) **[5 Marks]** Give the expression for the first-order Taylor series approximation of image $I(x, y)$ in the neighborhood of pixel (a, b).

$I(x, y) \ =$

(b) **[10 Marks]** Consider the image I below. We want to use polynomial fitting to estimate the Laplacian of the image at the center of the highlighted 15×15-pixel patch. To do this, we will use least squares to fit a *single* polynomial in both x and y to the patch intensities.

Using matrix notation, show the linear system that must be solved to compute the fit. Be sure to indicate the contents and dimensions of each matrix, to explain why these dimensions were chosen, and to specify the meaning of all variables you introduce.

(c) **[5 Marks]** Now suppose we slide the 15×15-pixel window over the entire image I, solving the system in (b) for every possible center (x, y). In addition to estimating the Laplacian at (x, y), this will also give us an estimate, $\hat{I}(x, y)$, of the intensity at (x, y). What differences do you expect to see between images $\hat{I}$ and I? Explain in one or two sentences.

(d) **[5 Marks]** Finally, suppose we use RANSAC-based fitting to do (c) rather than standard least squares. What differences do you expect to see now between $\hat{I}$ and I? Explain briefly.

2 Image Matting (25 marks total)

(a) **[5 Marks]** Give the expression for the Matting Equation and define all terms.

(b) **[5 Marks]** Suppose you go to a museum and take a photo of a semi-transparent vase that is inside a cube-shaped protective glass enclosure. The enclosure is rather dirty because of fingerprints, dust, *etc*. Since you took the photo from the front, it can be thought of as a composite C of four distinct images: the enclosure's semi-transparent front face F; the semi-transparent object O; the enclosure's semi-transparent back face B; and an opaque "background" image K of everything lying behind the enclosure.

Modify the matting equation in (a) to express C in terms of these four images. Explain briefly, and be sure to define all terms.

(c) **[5 Marks]** You are now told to use the triangulation matting technique to compute the individual images F, O and B. You have with you two opaque poster boards of known color (K_{r1}, K_{g1}, K_{b1}) and (K_{r2}, K_{g2}, K_{b2}), respectively, that you can place behind the enclosure. The enclosure, however, is sealed so you cannot put anything inside it. Give a mathematical proof that computation of F, O and B by triangulation matting is impossible under these conditions.

(d) **[10 Marks]** Give a mathematical proof that computation of F, O and B by triangulation matting is impossible even if you had n poster boards of known color rather than just two.

END OF EXAM