Term Test

March 1st, 2017

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	_____/18
2	_____/22
3	_____/10
Total	_____/50

1 2D Curves (18 marks total)

Give the coordinate functions of the 2D curve corresponding to an ellipse centered at point (a, b) and aligned with the x and y axes (**5 marks**) and derive its tangent (**5 marks**), normal (**3 marks**), and arc length (**5 marks**).

You should show all calculations, including intermediate steps, but you do not need to compute any integrals.

2 Camera Response Functions (22 marks total)

Suppose your camera outputs 10-bit grayscale images and you are given fifteen samples of its response function $r(x)$, *i.e.,* the values $r(x_1), \ldots, r(x_{15})$ for incident photon counts $x_1, \ldots, x_{15}$, respectively. You may assume that the samples are noise-free, that $0 \leq x_i \leq E_{\text{max}}$, and that E_{max} is the maximum number of photons that can be collected at a pixel without saturating it.

(a) **[10 Marks]** Suggest an algorithm to estimate the value of $r(x)$ for all x in the continuous interval $[0, E_{\text{max}}]$ from these fifteen known samples. Be as concrete as possible, provide the relevant equations, and justify your choices. The marks you receive on this question will depend on how thorough your answer is.

(b) **[7 Marks]** Suppose you are given the freedom to choose the fifteen x_i's from the interval $[0, E_{\max}]$. Which ones would you choose and why? No marks will be given without an explanation.

(c) **[5 Marks]** Now suppose that two of the fifteen samples got somehow mixed up with samples from a different camera, but you don't know which ones they are. How would your answer to (a) change? Explain briefly. Your answer does not need to be as detailed as in (a), two or three sentences are sufficient.

3 Gradients & Video (10 marks total)

A video sequence is nothing more than a sequence of images indexed by time t. In the continuous domain, the video can be expressed as a 3D function $I(x, y, t)$ where x and y are continuous image coordinates and t is time. Just like with 2D images, one can define the *gradient* ∇I of the 3D function I.

Now consider a specific time instant t_0 and let $I'(x, y) = I(x, y, t_0)$ be the 2D image at time t_0. Suppose there is a pixel (x_0, y_0) for which the following two conditions hold:

$$\begin{aligned} \|\nabla I'(x_0, y_0)\| &> 0 \quad \text{and} \\ \|\nabla I'(x_0, y_0)\| &= \|\nabla I(x_0, y_0, t_0)\| \end{aligned}$$

What does this tell you about the intensity at pixel (x_0, y_0) of the video during the infinitesimal time interval $[t_0 - \epsilon, t_0 + \epsilon]$? Explain your reasoning.

END OF EXAM