Term Test

February 28, 2018

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	________/22
2	________/28
Total	________/50

1 Cameras (22 marks total)

(a) **[5 Marks]** Give the equation for the *thin-lens law* and draw a diagram to indicate the equation's relevant quantities.

(b) Images captured with a camera always contain some amount of noise. Specifically, if I is the captured image and p is a pixel, then

$$I(p) \; = \; \hat{I}(p) + n(p)$$

where $I(p)$ is the intensity at pixel p, $n(p)$ is the noise at p, and $\hat{I}(p)$ is the intensity that would have been measured at that pixel if there was no noise at all.

(b1) **[5 Marks]** Give the mathematical definition for the *signal-to-noise ratio (SNR)* at pixel p.

$$SNR(I(p)) \; =$$

(b2) **[5 Marks]** Suppose that the image I was from a camera with a linear response function. We now double the radius of the camera's aperture and capture a second image, I_2, of the same scene while keeping all other camera parameters fixed and without moving the camera or anything else in the scene. The intensity at pixel p will now be

$$I_2(p) \;=\; \hat{I}_2(p) + n_2(p)$$

where $\hat{I}_2(p)$ is the intensity that would have been measured at p if there was no noise and $n_2(p)$ is the new noise at pixel p. What is the relation between $\hat{I}_2(p)$ and $\hat{I}(p)$? Explain briefly.

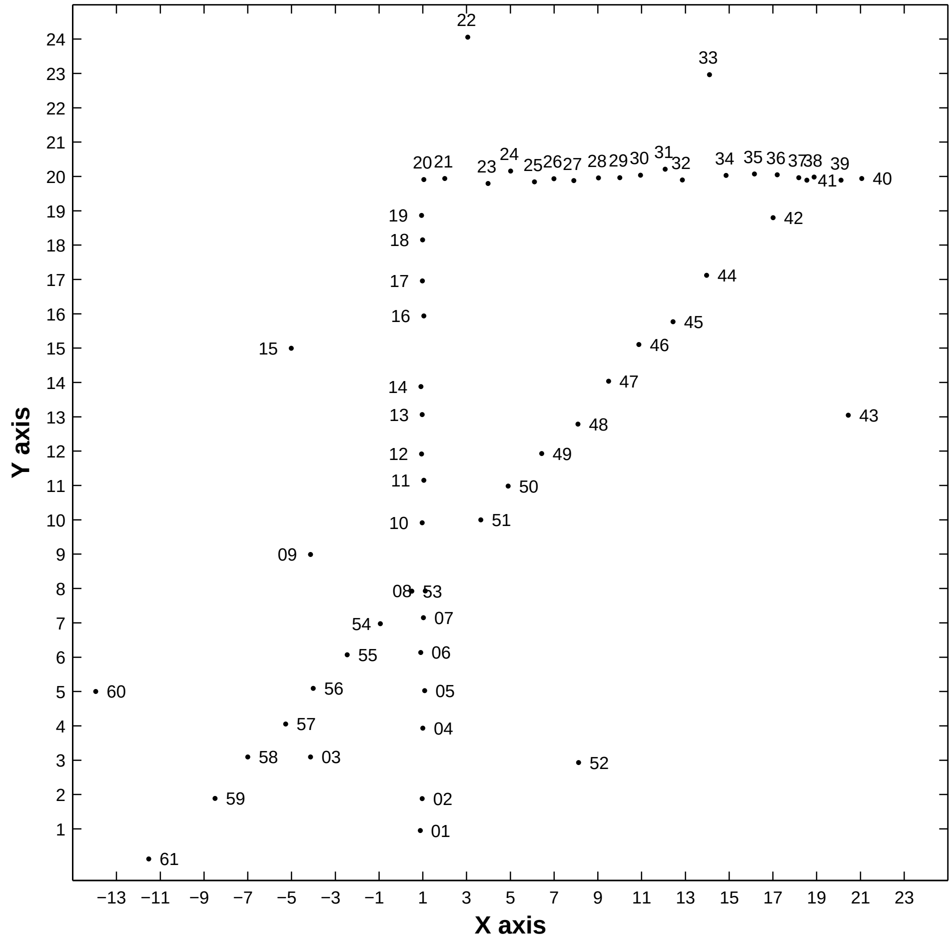
(b3) **[7 Marks]** Now consider the ratio

$$\frac{SNR(I_2(p))}{SNR(I(p))} \;\; .$$

Would this ratio be larger if the camera's noise was entirely due to *photon noise* or if it was due to *readout noise*? Show the calculations you used to arrive at your answer—no marks will be awarded without them.

2 Curve Tangent Estimation (28 marks total)

Suppose we are given 61 points, $\gamma(1), \gamma(2), \ldots, \gamma(61)$ along a 2D curve $\gamma(t)$, shown below as dots with the value of the curve parameter next to them. We want to estimate the 2D point $\gamma(t)$ and its unit tangent vector, $\mathbf{T}(t)$, for any *continuous* value of t in the interval $[5, 55]$.



(a) **[10 Marks]** List the main steps of a RANSAC-based algorithm for doing this. Be sure to specify the algorithm's input parameters as well as the actual numerical values you would choose for them. You do not, however, need to specify the number of RANSAC iterations.

(b) **[5 Marks]** On the plot of the previous page, give your best guess of what the algorithm's estimates will be for $\gamma(t)$ and $\mathbf{T}(t)$ at $t = 27.5, 39, 43, 53$ and 57.5. That is, for each of these five values of t draw a vector that starts from $\gamma(t)$ and is in the direction of $\mathbf{T}(t)$.

(c) **[8 Marks]** Now suppose you are given a function *PCA(*$\mathbf{M}$*)* that takes as input a matrix $\mathbf{M}$ with two rows and at least 3 columns and returns the top principal component. Give an algorithm that uses this function, <u>instead</u> of RANSAC or least-squares fitting, to estimate $\mathbf{T}(t)$ for any *integer* t in $[5, 55]$.

(d) **[5 Marks]** Would you expect your algorithm in (a) to perform better or worse than your algorithm in (c)? Explain with a sentence or two.

END OF TEST