The University of Western Ontario
Computer Science CS9630a
Final Examination - December 9th, 2014

Surname

Given Name

Student Number

This exam consists of 5 questions (7 pages, including this page) worth a total of 100%. It is an open book exam. All answers are to be written in this booklet. Scrap work may be done on the back of each page; this will not be marked. The exam is 2 hours long and comprises 30% of your final mark. Assignments 1 and 2 are each worth 35% respectively, for a total of 70%.

(1) 20%
(2) 20%
(3) 20%
(4) 20%
(5) 20%
Total

Professor: John Barron

Answer the following questions briefly and concisely and show all relevant work. Where possible, use point-form. Generally, correct answers will be short.
(1) (20%) Suppose you have a 60 × 60 binary image with background of 0’s and a square object at coordinates 25:35, 25:35 of 1’s.

Consider the following image operations on this image:

1. What happens to the image after 1 application of 3 × 3 median filtering?

2. What happens to the image after 5 applications of 3 × 3 median filtering?
3. What happens to the image after 1 application of \texttt{imerode} with the $3 \times 3$

structuring element $X = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$?

4. What happens to the image after 5 applications of \texttt{imerode} with the $3 \times 3$

structuring element $X = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$?
(2) (20%) Consider the series:

\[ S = \sum_{k=1}^{n} \frac{1}{k^3} \]

\( S \) evaluates to 1.202057 when \( n \) is large enough. Write a MatLab function to compute this series given \( n \):

1. Use a loop to compute \( S \) for a known \( n \) and

2. Vectorize this code
(3) (20%) Consider colour edge detection using:

1. Thresholding the magnitude of the 1\textsuperscript{st} order spatial intensity gradient of each colour plane separately by a value $T$ and labelling a pixel an edgel if the threshold constraint $\sqrt{(I_x^2 + I_y^2)} \geq T$ is satisfied for all 3 colour planes.

2. Computing the zero-crossings of $\nabla^2 I$ of each colour plane and labelling a pixel an edgel if any colour plane yields a zero-crossing at that pixel.

The image may or may not be smoothed by a Gaussian before the 1\textsuperscript{st} and 2\textsuperscript{nd} order gradients are computed but this should have no bearing on your answer to the following question: Which approach to edge detection do you think is the best and why?
(4) (20%) Give examples of functions (pictures will do, formulas not necessary) satisfying the following:

1. The FT of a discrete signal is a continuous signal:

2. The FT of a continuous signal is a discrete signal:

3. The FT of a discrete signal is a discrete signal:

4. The FT of a continuous signal is a continuous signal:
(5) (20%) Consider a 1D signal (image), $f(x), x \in [1, 256]$. We are given its **centered** Fourier transform as 256 $F(u)$ values, indexed by 1 to 256. Suppose the spatial signal, $f(x)$, is subsampled by 8 and $F(128)$ is 5. For your convenience it is known that $\tan^{-1}(-1.0)$ is -0.7854, $\tan^{-1}(0.0)$ is 0.0 and $\tan^{-1}(1.0)$ is 0.7864. Show any needed calculations when answering these questions:

1. What is the minimum frequency represented in $F(u)$?

2. What is the maximum frequency represented in $F(u)$?

3. What is the frequency at $F(128)$?

4. What is the amplitude at $F(128)$?

5. What is the phase in radians at $F(128)$?