The University of Western Ontario
Computer Science CS630a
Final Examination - December 5th, 1999

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This exam consists of 4 questions (5 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 1 hour long and comprises 10% of your final mark. Assignments 1 and 2 are each worth 45% respectively, for a total of 90%.

(1) 25%
(2) 25%
(3) 25%
(4) 25%
Total

Professor: John Barron
Answer the following questions briefly and concisely and show all relevant work. Where possible, use point-form.

(1) (25%) Consider applying a Butterworth lowpass filter to a $256 \times 256$ image of a centered spike. $D_0$ is 0.25. Describe the effects of setting $n$ to 1 and 10.

$n = 1$:

$n = 10$: 
(2) (25%) Consider the following statement: The FT of a discrete signal is continuous and the FT of a continuous signal is discrete. Is this statement true? If it is, use a few examples of signals and their FT’s to show this. If it is not, give a counterexample.
(3) (25%) Consider edge detection using:

1. Values of $||\nabla I||_2$ (the magnitude of the 1\textsuperscript{st} order spatial intensity gradient) or

2. Values of $\nabla^2 I$ (the 2\textsuperscript{nd} order spatial intensity gradient).

The image may or may not be smoothed by a Gaussian before the 1\textsuperscript{st} and 2\textsuperscript{nd} order gradients are computed (this is irrelevant to the question). How would edge detection be done in (1) and (2) and what are the advantages and disadvantages of each approach?

Using $||\nabla I||_2$:

Using $\nabla^2 I$:
(4) (25%) Consider the motion constraint equation:

\[ I_x v_x + I_y v_y + I_t = 0. \]

Suppose we can accurately compute, not only the 1\textsuperscript{st} order intensity derivatives \( I_x, I_y \) and \( I_t \), but also the 2\textsuperscript{nd} order intensity derivatives, \( I_{xx}, I_{xy}, I_{yy}, I_{xt} \) and \( I_{xy} \), at each pixel in the image. Show the equations we can use to compute \( v_x \) and \( v_y \) at each pixel.