The University of Western Ontario
Computer Science CS630a
Final Examination - December 11th, 2006

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This exam consists of 5 questions (8 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%) Consider the morphological operators of opening, set $A$ opened by structuring element $B$, defined as $A \circ B = (A \ominus B) \oplus B$ and closing, set $A$ closed by structuring element $B$, defined as $A \bullet B = (A \oplus B) \ominus B$. $B$ is a $3 \times 3$ structuring element with its center as the center of the array holding its values of all 1’s (black). Consider the binary image shown in Figure 1 below.

Figure 1: A binary image $A$ and a $3 \times 3$ structuring element $B$. The origin of $B$ is the pixel in the center.
(1a) (10%) Show the dilation and erosion of image $A$ by $B$ below. Show your shaded results in pencil if possible. This will allow you to make corrections.

[Hint: remember in the calculation of dilation or erosion, that the origin of the structuring must be placed at each pixel in order to determine that’s pixels effect from the dilation or erosion.]
(1b) (10%) Show the opening and closing of image $A$ by structuring element $B$ below.

\[(A \ominus B) \oplus B \quad (A \oplus B) \ominus B\]
(2) (20%) Consider a convex shape, whose shape we want to represent. The shape is currently represented as 64 points connected by straight line segments, i.e. a polyline. Consider using a 64 point Fourier Transform or a 64 point Cosine transform. Answer these 2 questions:

1. Required space for the representation is crucial. We want the smallest amount of data to best represent the data. Which method is best and why to represent this shape at the same quality?

2. Only a $8 \times 8$ 2D cosine transform is available. How would you use this transform on the above data? Nothing about the shape other than the number of points in the polyline representing it is known.
(3) (20%) Which spatial method is best for noise suppression and why: histogram equalization or median filtering?
(4) (20%) Consider a camera that yields systematic noise along the horizontal axis in the frequency space. How might you go about eliminating (or, at least, significantly attenuating) this noise?
(5) (20%) Consider a $2 \times 2$ image where each of its pixels results from a sampling factor of 2. Assume the image has has been translated to the origin (as in the notes and on the assignments) before its Fourier transform was computed. Its Fourier transform yields the following results:

\[
\begin{array}{cc}
2+2i & 10 \\
-6i & 2+2i \\
\end{array}
\]

In the following tables below give the corresponding amplitudes, phases and frequencies in the tables provided.

(5a) (6%) **Amplitudes:**

(5b) (6%) **Phases:**

(5c) (6%) **Frequencies:**

(5d) (2%) What is the average of the pixels in the image?