CSC320: Visual Computing
Term Test 1 February 27, 2004 9:10-11:00

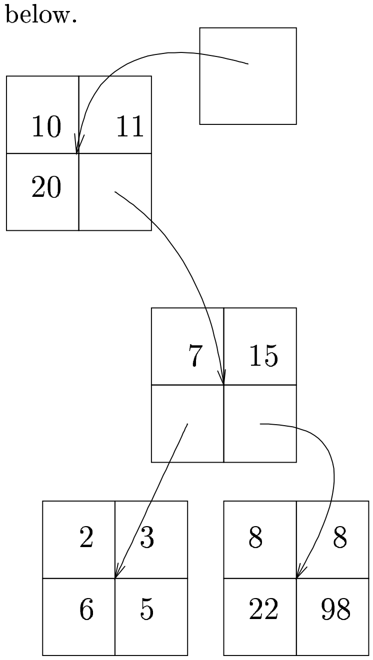
Student Number:____________________

Last Name:____________________ First Name:____________________

This exam consists of 8 questions on 3 double sided pages.

Aids allowed: A non-programmable calculator.

1. [**5 Marks: Easy**] Draw the image (all pixels and their values) represented by the sparse **quad tree** below.



2. [**10 Marks: Easy**]

(a) Define the image gradient ∇I.

(b) Define $|\nabla I|$. What does this have to do with edge detection?

(c) Define the gradient orientation. What does this have to do with edge detection?

(d) Define the Laplacian $\nabla^2 I$ and write down a mask which could be used to compute it.

(e) The Fourier Series for function $f : \mathbf{R} \rightarrow \mathbf{R}$ is the $\{a_i, b_j\}$ such that

$f(x) = \frac{a_0}{2} +$

3. [**3 Marks: Medium**] Using Big-Oh notation, write down the running time for rendering a line from (x_1, y_1) to (x_2, y_2) using Bresenhams algorithm.

4. [**3 Marks: Medium**] Pictured below is an image (on the left) and its partially completed Haar wavelet representation (on the right). Complete the wavelet representation. **Note:** We are using the storage scheme covered in the lecture notes (the recursive image).

Image

16	12	4	8
8	12	4	16
4	16	8	12
12	8	16	4

Haar Wavelet Rep

	1	0	-4
0		-2	2
2	-2	2	
0	0	-4	-4

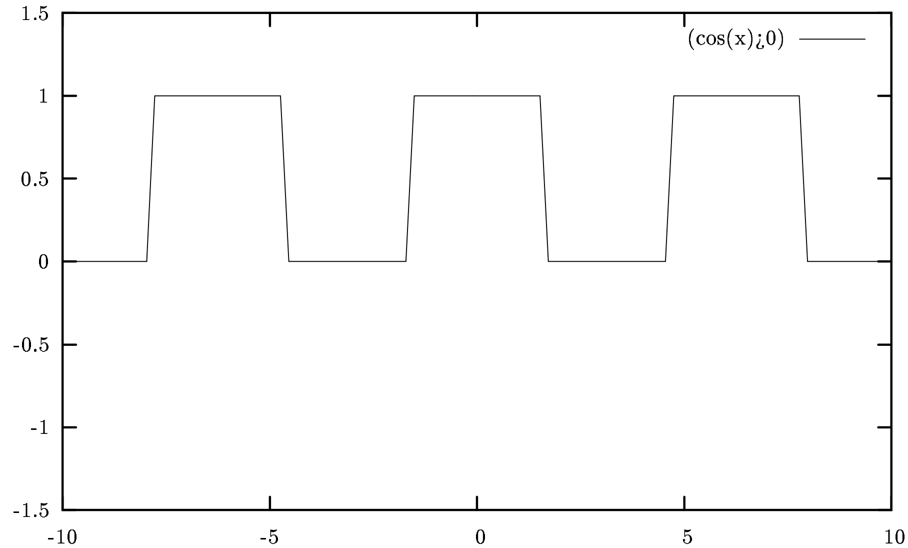
5. [**3 Marks: Medium**] **Greyscale Triangulation Matting:** A background B_1 of uniform intensity $b_1 = 50$ is placed behind a subject and an image is captured. Pixel p in this image has intensity $i_1 = 65$. B_1 is removed and background B_2 with uniform intensity $b_2 = 208$ is now placed behind the subject and another image captured. Pixel p in the second image has intensity $i_2 = 175$. Compute the foreground pixel intensity (i, α) for pixel p.

   $i =$

   $\alpha =$

6. [**5 Marks: Medium**] Derive a discrete approximation to $\frac{d^2 f(x)}{dx^2}$ for function $f : \mathbf{R} \to \mathbf{R}$.

7. [**7 Marks: Hard**] Fourier Series Compute the fourier series $(a_0, a_1, a_2, \ldots, b_1, b_2, \ldots)$ for the following square wave. **Note:** Vertical changes occur at $\{\frac{\pi}{2} + k * \pi : k \in \mathbf{N}\}$. **Hint:** $a_0 = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x) dx$



8. [**7 Marks: Hard**] Consider the following 1-dimensional image masks, each centered around the '2' term.

$$M_l = \boxed{\tfrac{2}{3}}\boxed{\tfrac{1}{3}} \quad M = \boxed{\tfrac{1}{4}}\boxed{\tfrac{2}{4}}\boxed{\tfrac{1}{4}} \quad M_r = \boxed{\tfrac{1}{3}}\boxed{\tfrac{2}{3}}$$

Using the above smoothing masks, we can extend the definition of $M * I$ as follows: The leftmost pixel of $M * I$ is obtained by applying M_l to the leftmost two entries in I. The rightmost pixel of $M * I$ is obtained by applying M_r to the rightmost two entries in I. All other (middle) entries are obtained as in question (1) above.

With this extension, $M * I$ has the same dimensions as I.

(a) Prove that it is impossible (in general) to unblur a blurred image, that is, given I' obtained from M, M_l, M_r via $I' = M * I$ it is impossible to determine I. You should assume that each image is represented by an array of integer values in the range 0 to 255.

(b) Explain in a few words what the **key issue** is that prevents one from unblurring an image.