Final for SBU Medical Imaging: Please show all work. Final is due in by 12 noon, May 5. Please send me results (and code) via email. Please put your name and Stony brook id number on any files sent to me. Please make one easily readable pdf file with all your results in addition to the original code.

1. Testing the functionality of image segmentation techniques and comparing their accuracy requires us to work with images for which the correct segmentation is known. Develop some test images by:

(a) Create an image SEG1 containing artificial objects on a background of constant gray-level. Generate simple geometric objects such as squares, rectangles, diamonds, stars, circles, etc., each having a constant gray-level different from that of the background, some of them darker and some brighter than the background. Determine the area of each object and store it in an appropriate form.
(b) Superimpose additive Gaussian noise with a given standard deviation, thus creating an image SEG2.
(c) Superimpose random impulse noise of a given severity over the image SEG2, thus creating an image SEG3.

By varying the shapes of the objects, standard deviation of the Gaussian additive noise, and severity of the impulse noise, sets of controlled properties can be generated. To create a simple set of images for segmentation experiments, make a single image SEG1, apply three levels of Gaussian additive noise, and three levels of impulse noise. You will obtain a set of ten images that will be used in the segmentation problems below. (20 points)

2. To assess the correctness of a segmentation, a set of measures must be developed to allow quantitative comparison among methods. Develop a program for calculating the following two segmentation accuracy indices:

(a) "Relative signed area error" is expressed in percent and computed as:

$$A_{error} = \frac{\sum_{i=1}^{N} T_i - \sum_{j=1}^{M} A_j}{\sum_{i=1}^{N} T_i} \times 100$$

where T_i **is the true area of the i-th object and** A_j **is the measured area of the j-th object, N is the number of objects in the image, M is the number of objects after segmentation. Areas may be expressed in pixels.**

(b) "Labelling error" (denoted as L_{error} **) is defined as the ratio of the number of incorrectly labeled pixels (object pixels labeled as background as vice versa) and the number of pixels of true objects** $\sum_{i=1}^{N} T_i$ **according to prior knowledge, and is expressed as percent. (20 points)**

3. Implement the following methods for segmentation and apply to the test images created in Problem 1. For each method and each image, quantitatively assess the segmentation accuracy using the indices developed in Problem 2. Compare the segmentation accuracy for individual methods.

(a) Basic thresholding.
(b) Chan-Vese.

(20 points)

4. Take the image heart.jpg and rotate it 15 degrees. Call the new image heart.15.jpg. Align (register the images) using a rigid registration method. Explicitly explain your method. You may any package that you like, just give all the details. (20 points)

5. Take the image heart.jpg and apply the linear heat equation to smooth it. Specifically, write a program which will do the following:

(a) Load the image. Call this $I_0(x,y)$.

(b) Discretize the heat equation

$$\frac{\partial I}{\partial t} = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2}$$
$$I(x,y,0) = I_0(x,y).$$

You can use centered differences for the spatial derivatives.

Take $\Delta x = \Delta y = 1, \quad \Delta t = 0.1.$

Please submit all your formulas and your code.

(c) Output the smoothed image with the following number of iterations: n=10, n=100, n=1000.

(20 points)