EE101 Homework 1

Submission via Blackboard Due: Sept.25th

Your name: _____ Student ID: _____

Question 1:

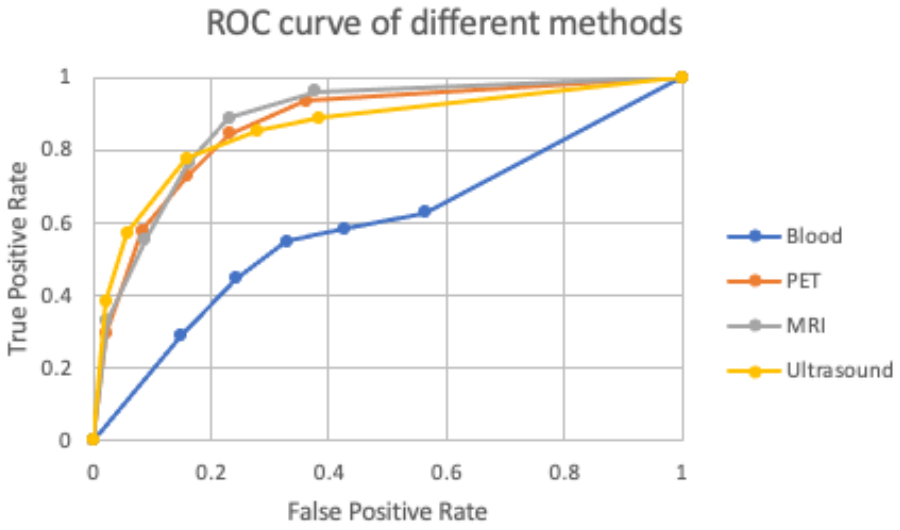
In a study for testing a new form of cancer among 5130 suspected patients, multiple medical methods had been considered for auxiliary diagnosis. For each method, the number of positive and negative people corresponding to the different threshold values was given in Table.1.

Table.1 Diagnosis Results

Biopsy							
Positive Negative				1026 4104			
Blood (Immune cell concentration 10^9/L)							
Threshold	3	7.5	8.5	9.5	10.5	11.5	15
Positive (>Thr)	5130	2958	2359	1910	1454	909	0
TP	1026	643	598	562	458	297	0
PET (length(cm))							
Threshold	0.5	3	3.5	4	4.5	5	10
Positive (>Thr)	5130	2438	1812	1401	938	393	0
TP	1026	958	865	747	594	301	0
MRI (length(cm))							
Threshold	0.5	3	3.5	4	4.5	5	10
Positive (>Thr)	5130	2538	1862	1453	934	442	0
TP	1026	985	911	786	570	341	0
Ultrasound (length(cm))							
Threshold	0.5	3	3.5	4	4.5	5	10
Positive (>Thr)	5130	2493	2022	1451	825	483	0
TP	1026	910	875	796	587	394	0

(1) Plot the ROC curve.
(2) Determine a standard Threshold for each method.
(3) Consider which method is best for auxiliary diagnosis and explain. (Provide necessary calculation to support your answer.)

(1) For reference. (10 pts)



(2) Blood: 9.5, PET: 3.5, MRI: 3.5, Ultrasound: 4. (10 pts)
To determine a standard Threshold, one could calculate the distance between the threshold point to the upper-left corner, and the threshold point with the minimum distance can be chosen as a standard threshold.

(3) MRI. To decide which method is the best in a diagnostic test, we could use the area under curve (AUC) to measure the performance of different methods. In this case, we have the following results.

AUC(Blood) = 0.5917, AUC(PET) = 0.8691,
AUC(MRI) = 0.8833, AUC(Ultrasound) = 0.8596.

So, we consider MRI as the best method. (Note that the usage of different methods of plotting and calculating AUC might result in different values. We accept minor deviations if your method is also valid.)
(10 pts. Only 5 pts w/o legit explanation and/or necessary calculation)

Note: Other methods are acceptable if you provide your calculation and comparison. Otherwise, 2 or 3 pts will be taken accordingly.

Question 2:

Here we provide 3 coronal spine images. Please compute the following image characteristics of three different images, and compare the quality of three images based on these characteristics.

1) Image brightness, which can be computed as the average intensity of the image;

2) Image contrast, which can be illustrated by the standard deviation of image intensity;

3) Signal-to-noise ratio (SNR). First, please manually select the region of interest (ROI) which covers the lamina range as shown in Fig. 1. (For this step, Matlab function “roipoly” could be helpful.)

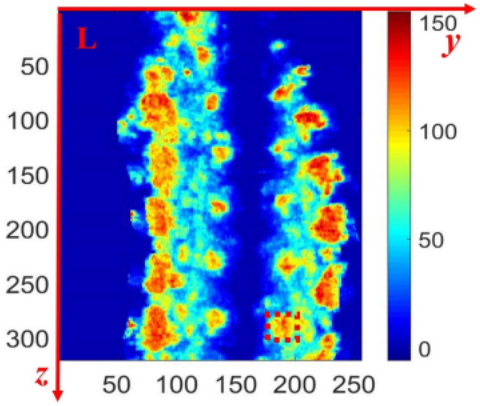


Fig. 1 The lamina range is shown in the red box (lower right corner).

Then, use the mean and standard deviation of this region to compute SNR

$$\mathrm{SNR} = 10\log_{10}\frac{\mathrm{Signal}^2}{\mathrm{Noise}^2}$$

Requirement: Please report the results of your computation and attach your code below. Also, please hand in your code in a separate file.

Results	1	2	3
Image brightness	58.38	66.81	69.55
Image contrast	56.44	69.80	71.87
SNR	23.09	24.13	25.05

So, for all three image characteristics (i.e., brightness, contrast and SNR),

image_1 has the lowest values and image_3 has the highest values.

(15 pts for Brightness, 10 pts for Contrast, 15 pts for SNR)

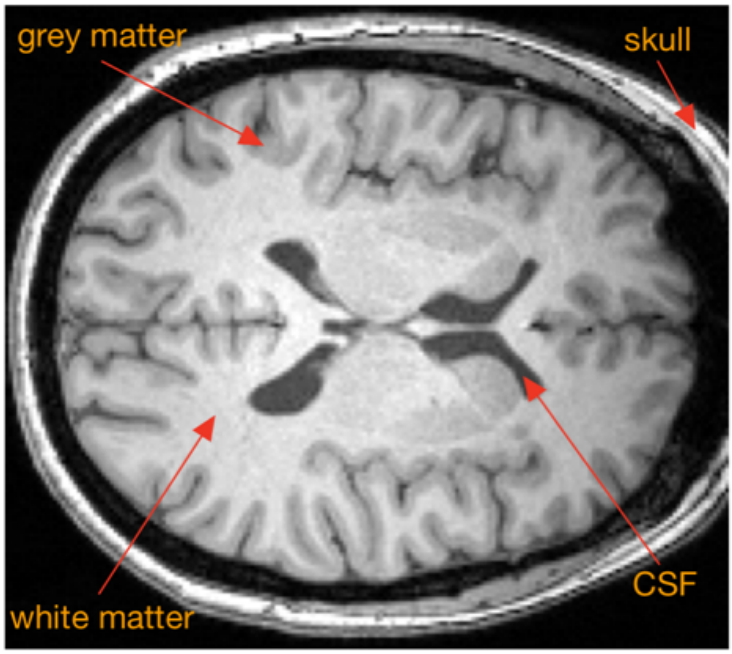
Note: Grading will focus on the correct implementation of the formulas provided. And you need to report the finding that image_3 is of the best quality. Minor deviation of specific values is acceptable, especially for the SNR, due to manual selection of ROIs.

In specific, for the selection of ROI, it is advisable to choose a very small area with relatively high intensity (regions shown in red in Fig.1). Otherwise, if the region you choose is rather big and contains pixels with very low values (potentially only noise), the mean value of this region would be lower than expected and the SD would be very high, resulting in a significantly lower SNR (maybe around 1.0) than the value I provide here.

And about the 15 pts for SNR, 5 pts for your selection of ROIs, 5 pts for the correct implementation of the formula, and another 5 pts for your comparison. If your results show that the second image has the highest SNR and you draw your conclusion based on that, no points will be taken.

Question 3: Brain MR Image Segmentation

A brain MR image is provided. First, please strip the skull around the brain. Then, please mark different structures of the brain (i.e., white matter, grey matter and CSF) with different colors using thresholding method.



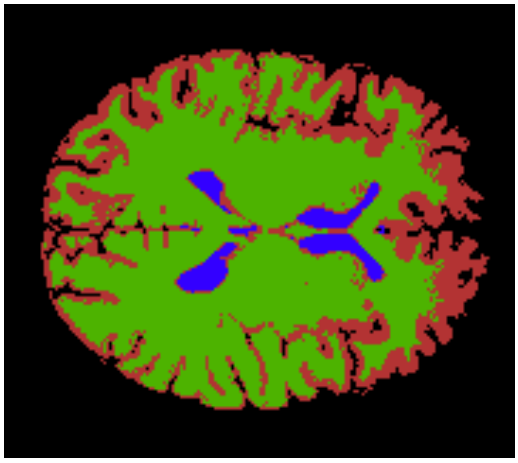
Hints: Histogram can be used to determine the threshold.

Edge detection is also commonly used in image segmentation tasks.

Matlab function “roipoly” can specify polygonal region of interest.

Requirement: Please attach the segmented image and your code below, and hand in your code in a separate file.

For reference. (10 pts for stripping the skull, 20 pts for marking different structures correctly. Only half score w/o submitting your code.)



Note: Grading will focus on the general effect of your segmentation, and differences in trivial details are allowed. Also, various ways of segmenting and marking are acceptable, as long as the result is satisfactory.