HST.583 - Lab 6: Cortical and Subcortical Parcellation with MRI

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1. Goals of Lab 6

This Lab examines ways in which different brain anatomical structures can be classified based on the signal intensity of high spatial resolution anatomical MR images acquired with different contrast weightings.

2. Organization of the lab

Here is an outline (details are below):

- You will run a MATLAB® program that loads some images (T1 and proton density maps).
- You will be asked questions about these images.
- To answer these questions you will have to process the images using simple MATLAB® functions that you will have to write for this purpose.

5. Excercises

EXCERCISE 1a:
Write a MATLAB® script that will use the T1 and PD maps to synthesize a new image volume using a flip angle of a = 30 degrees (remember to use radians for MATLAB® sin and cos) and a TR of 20 msec (assume that TE is short relative to T2 and can therefore be neglected). Call this new volume synthesized_vol.

The equation you need is:

$E1 = \exp(-TR/T1)$

$E2 = \exp(-TE/T2)$

$S(TR, TE, a, T1, T2, PD) = PD * \sin a * ((1-E1) / (1 - (\cos a) * E1)) * E2$

What is the primary 'weighting' of this image? That is, what tissue parameter is primarily responsible for the contrast in the image? Why?

EXCERCISE 1b:
Compute the contrast to noise ratio of each of the following pairs of structures using the synthesized volume obtained in the previous point.

- amygdala and hippocampus
- pallidum and putamen
- cortical_gray_matter and cerebral_white_matter

You may find the MATLAB® function 'find' useful in this context. For example:

- amygdala_indices = find(LABELvol == amygdala) ;
- amygdala_mean = mean(synthesized_vol(amygdala_indices));
- amygdala_var = var(synthesized_vol(amygdala_indices)) ;

would compute the mean intensity (amygdala_mean) and the variance (amygdala_var) of all voxels labeled amygdala in the volume you have synthesized.

Generate a table with these contrast to noise values and turn it in.

EXCERCISE 1c:
Turn in a plot of the empirical distribution of the signal intensity of voxel in each structure using the synthesized image. (hint: take advantage of MATLAB®'s histogramming function (which may or may not be called "hist" --E'beth).) Remember to normalize the empirical distributions so they sum to 1. Please use the following colors:

- amygdala 'c'
- hippocampus 'y'
- cortical_gray_matter 'g'
- cerebral_white_matter 'k'
- putamen 'm'
- pallidum 'b'

Comment on your results with regard to building an automated segmentation procedure based on this type of intensity image.

EXCERCISE 1d:
Compute the optimal discriminant between gray matter and white matter assuming that the classes have a normal distribution with equal variances. Plot the empirical distributions of each on the same plot, together with a line representing the decision boundary. Compute the percentage of voxels of each

class that would be misclassified using this decision rule. How well placed is the discriminant based on the Gaussian models?

EXCERCISE 1e:
Now compute the contrast-to-noise ratio for a subset of cortical gray matter and white matter. Use a single horizontal slice near the center of the 30 degree flip angle volume (use slice 90, meaning vol(:,90,:)). Compare it to the gray/white contrast-to-noise ratio for the entire volume. Speculate on the cause of the disparity between the two (hint: you may want to take a look at this data at different horizontal slice planes). Recalculate the discriminant as in 1d and percent voxels misclassified using just this slice. How well placed is the discriminant based on the Gaussian models?

EXCERCISE 2a:
Change the flip angle to 5 degrees and synthesize a new volume. Use this volume to recalculate the contrast-to- noise ratio of the same pairs of structures (neglecting T2 effects again). What is the primary 'weighting' of this image? Why is it different from the 30 degree image of exercise 1a?

EXCERCISE 2b:
Compute the contrast to noise ratio of the same structures as 1b using this synthesized volume. Compare them to your results in 1b. Which type of volume would you choose for segmentation purposes for each structure pair?

EXCERCISE 2c:
Plot the empirical distribution of each structure using this volume with the same colors as done in 1c.

EXCERCISE 2d:
Compute the optimal discriminant between gray matter and white matter assuming that the classes have a normal distribution with equal variances. Plot the empirical distributions of each on the same plot, together with a line representing the decision boundary. How well placed is the discriminant based on the Gaussian models? Compute the percentage of voxels of each class that would be misclassified using this decision rule. Compare this to your results in 1d. Which volume is more useful for gray/white classification?

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