Work report for the period 27th May to 3rd June 2009

Project Task	To segment cerebellum from brain datasets using Textural properties
Method Used	GLCM based texture features were computed for the cerebellum & brain using a mask of dimension 19*19 for 2 dimensional images. The features computed are: Energy, Entropy, Inertia, InverseDifferenceMoment, ClusterShade & ClusterProminence. Initially it was tried to use the Neighborhood iterator but couldn't make it to work. So finally used region iterator to move the mask.The code has been written in ITK & can be found at https://sbia-svn.uphs.upenn.edu/projects/TextureBasedSegmentation/GLCMTexture/GLCMTexture.cpp & it is Revision 18.
Results	These were the 2 promising features found out: InverseDifferenceMoment Value Range Brain: Between 0.5 & 0.6 Cerebellum : Between 0.35 & 0.5 Inertia Value Range Brain: Less than 30 Cerebellum : More than 70 (Particularly between 70 & 100)
Further Work	The code has to be tested on more slices to affirm the initial results obtained.

Work report for the period 4th June to 10th June 2009

Project Task	To segment cerebellum from brain datasets using Textural properties
Method Used	Gabor Filter based textural properties were computed using a bandwidth of 0.5,gaussian sigma of 4.37 & frequency of ¼ for angles at an interval of 7.5 degrees. The frequency of 4-5 was found to be optimum for highlighting the texture of the cerebellum. I am now working on reducing the no of feature vectors & take the most optimum ones to capture the cerebellum information. We also applied a demons based registration algorithm for cerebellum segmentation using a mask which we built from one of the datasets given by Deepthi. The registration process works good for a rough segmentation after which we can combine the texture information to segment out the cerebellum which is left over on edges in some slices. We would need this registration in some slices in which the cerebellum becomes a bit bigger & its texture starts disappearing.
Results	I can show you the results in the lab.

Work report for the period 24th June to 1st July 2009

Project Task	To segment cerebellum from brain datasets using Textural properties & Demons Registration
Method Used	My 3D Gabor Filter is as follows G = exp(-0.5*((xPrime/Sx)^2+(yPrime/Sy)^2+(zPrime/Sz)^2))* exp(2i*pi*(x*f*cos(phi)*cos(si)+y*f*cos(phi)*sin(si)+z*f*sin(phi))); Where si is the angle in the xy plane & phi is the angle of rotation about x axis i.e. angle measured from xy plane. I have tried to apply Yang Li's code for registration based on intensity as well as texture features. The code used to crash on my local computer & took much time but then I ran on the server & it runs pretty fast on that. I have got some results but the mask goes into brain in some slices probably because I used only a single frequency. I used 8 orientations in xy plane(at an angle of 22.5) & 3 about the x axis i.e 0,30,150 because these angles only captured information related to cerebellum. Also I am trying to do the convolution for Gabor Filter in frequency domain as the convolution in spatial domain is a bit slower.

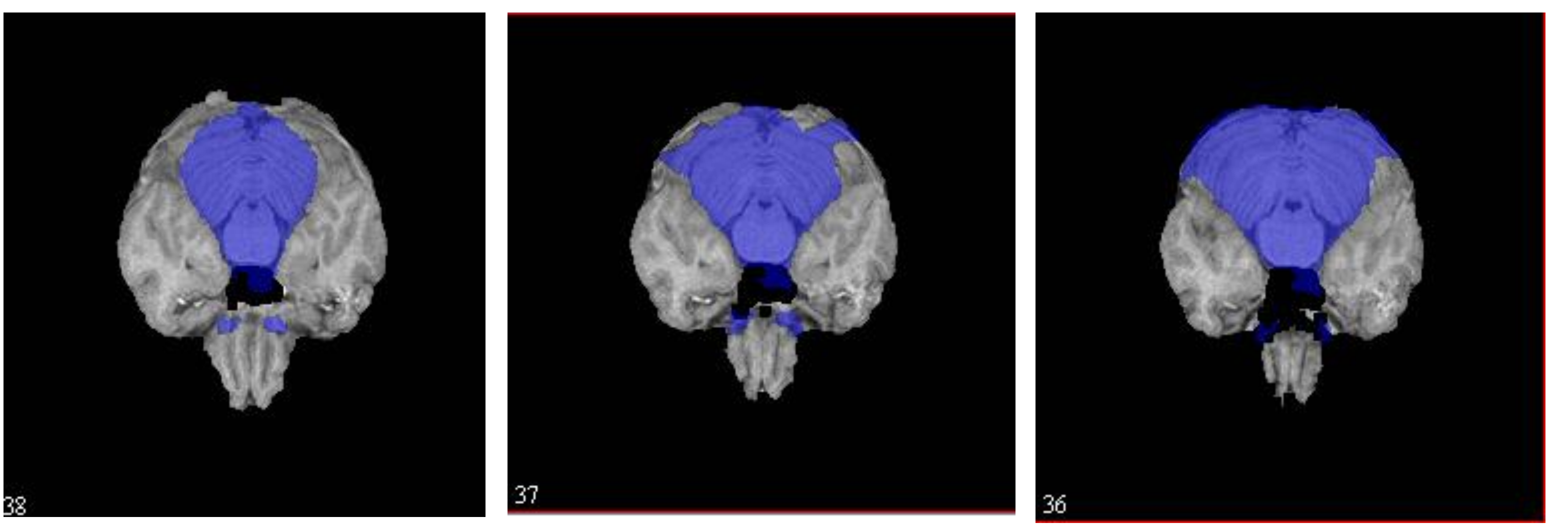
Work report for the period from 9th July to 23rd July 2009

Task 1	To segment cerebellum from brain datasets using Textural properties & Demons Registration
Method Used	I applied the Texture Detection method given in Prostrate Segmentation paper & cross-checked the Gabor feature images with those of YangMing so as to certify that my code is correct.I used 4 orientations & 3 scales as YangMing used with a frequency range of 0.1 to 0.4 . Then I used Yang Li's Multichannel Demons program for registering these feature images & the result obtained has left out cerebellum in some slices. I also applied the Fractal Dimension based Demons by calculating the Fractal dimension for each 3d image slice by slice as calculating the Fractal Dimension for a 3D subimage is computationally very expensive.The Fractal Dimension was based on Fractal Brownian Motion & was calculated taking subimages of size (7x7). The time consumed in applying the fractal dimension algorithm takes about 1 hr & the improvement is not much . I am attaching the results for both the algorithms within the report.
Task 2	Skull Stripping & Cerebellum Removal for datasets for same person.
Method Used	The method followed is as follows: 1. Apply n3bias correction on the original datasets for the same person taken at different times (FAST program is used). 2. Now the datasets for same person were shifted in z direction. Moreover Demons also requires a linear registration as as pre-processing step. So the dataset at time T1 was registered to datasets at time T2, T3, T4, T5 generating T2′, T3′, T4′, T5′ using FLIRT

method.
3. Now demons was applied between T2′ & T2 so as to remove any non linearity left out.
The true mask for dataset1 was subjected to the transformation matrix obtained from linear registration & then to deformation field obtained from Demons.The true mask covers the stuff to be removed i.e. skull & cerebellum.
We tested the algorithm for 3 persons with 5 datasets for each at different times. The jaccard ratios are as:

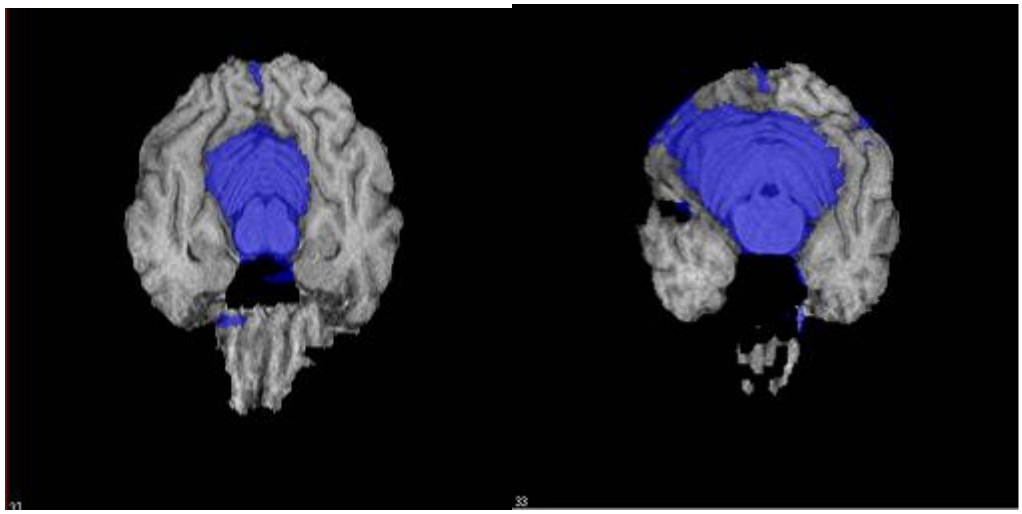
AI	AI02	AI03	AI04	AI05
	0.89	0.88	0.89	0.86
AG	AG02	AG03	AG04	AG05
	0.83	0.88	0.86	0.84
AK	AK02	AK03	AK04	AK05
	0.87	0.85	0.86	0.86

Here are some of the results for Texture based Demons(based on gabor filters implementation used in prostate paper)

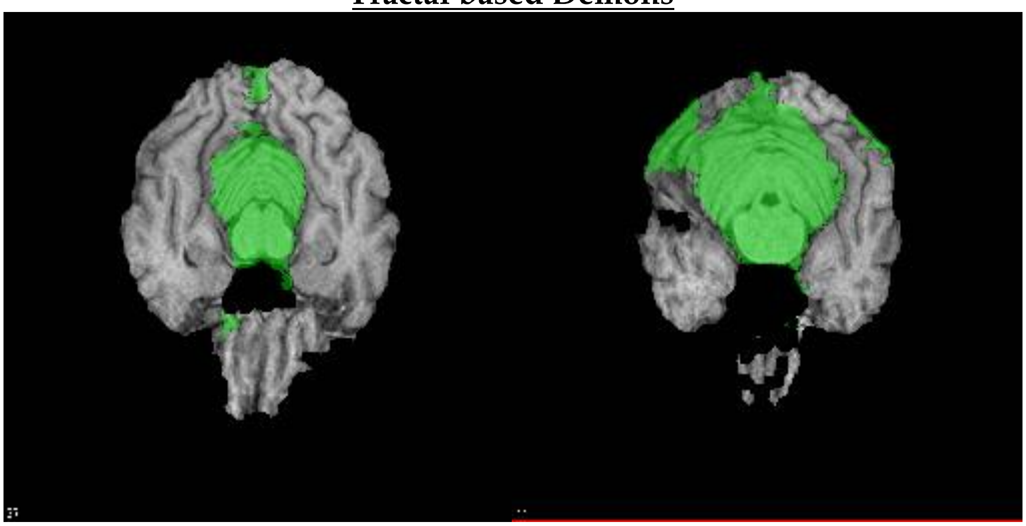


Comparision between intensity based Demons & Fractal based Demons

<u>Intensity based Demons</u>



<u>Fractal based Demons</u>



Skull Stripping using combination of flirt, demons & bet algorithms

1. The user inputs the subject image, template image, skull mask for the template image & a true skull mask for the subject image which will be used for comparison with the algorithm's output mask using jaccard ratio.

2. The user has the option whether to apply n3biascorrection on the subject image as well as the template image. If the user supplies 1 as the argument corresponding to n3biascorrection, n3biascorrection is done on the 2 images using FAST algorithm & the results are saved as '*< image name>_restore.img*'.

3. A linear registration is then performed between the subject & the template image using FLIRT algorithm (i.e. between the n3biascorrected images or the original images).This generates a 4x4 transformation matrix named as '<template image name>to<subject image name>mat' & a linearly registered image named as *'<subject image name>_flirt.img'*. This matrix is also applied to the skull mask for the template image generating the skull mask for the flirt registered image named as *'<subject image name>_flirt_mask.img'*.

4. A deformable registration using Diffeormorphic Demons algorithm is then performed between the flirt registered image & the subject image generating a deformation field named as *'<subject image name>_flirtto<subject image name>.img'*. This deformation field is then applied to the flirt generated skull mask to obtain a skull mask for the subject image named as *'aux_mask_<subject image name>.img'*.The skull mask is thresholded at intensity value 40 to give the demons skull mask named as *'aux_mask_<subject image name>_thresholded .img'*. The threshold 40 has been selected as it has been found to give the best jaccard ratio on comparison with the true skull masks in many cases.

5. Brain mask is now computed using the skull mask obtained from Demons. Now BET skull stripping algorithm is applied onto the subject image giving a BET brain mask. Since BET mask goes inside the brain in some slices & leaves out some grey matter on the brain boundary, it is used in combination with the brain mask obtained from Demons to obtain a perfect brain mask. The problem with Demons is that the skull mask tends to diffuse into brain in some places normally at the valleys on the brain surface & tends to eat up the brain. This problem is not encountered in BET because it is a level set based algorithm & doesn't tend to go deep into valleys. So the idea is to use these 2 algorithms to counteract each other's drawbacks.

6. The BET brain mask & Demons brain mask are compared & the uncommon regions are found out (let us call it as difference image).The difference image contains both parts of the brain & the background matter. Since the difference image mostly contains the region around the boundary of brain, if we can use a threshold which can differentiate the grey matter from the background, we can improve the demons mask (since at the boundary of the brain mostly gray matter is found).

7. Now the demons brain mask is used to extract brain from subject image & FAST algorithm is applied on this brain to segment out the grey matter. The mean & standard deviation of the grey matter is now computed & a threshold value of mean-2*standard deviation is then applied on the difference image thus segmenting out the grey matter & other brain region from the difference image (which is higher in intensity than grey matter). This image with thresholds is now combined with the intersection of bet & demons brain masks generating the final brain mask.

8. The versions of the programs used are as follows:

   FAST - version 4.1
   FLIRT - version 5.5
   BET – version 2.1
   MATLAB – version 6.5.1.199709 Release 13 (Service Pack 1)
   PYTHON – version 2.5.2