Seed-based Functional Connectivity Analysis of Hippocampal Network of Patients Suffering from Major Depressive Disorder

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Table of Contents

Introduction

- Major Depression (MDD) is a mental disorder that severely disrupts normal brain function and affects the emotions and memory processing of the brain.
- Functional neuroimaging techniques determine the changes in the brain related to cognition and behavior.
- Hippocampus is one of the major brain areas affected by depression. For this reason, we have chosen hippocampus as our region of interest
- Resting state functional connectivity can be acknowledged through analysis of spontaneously generated BOLD signals during resting state.

Objectives

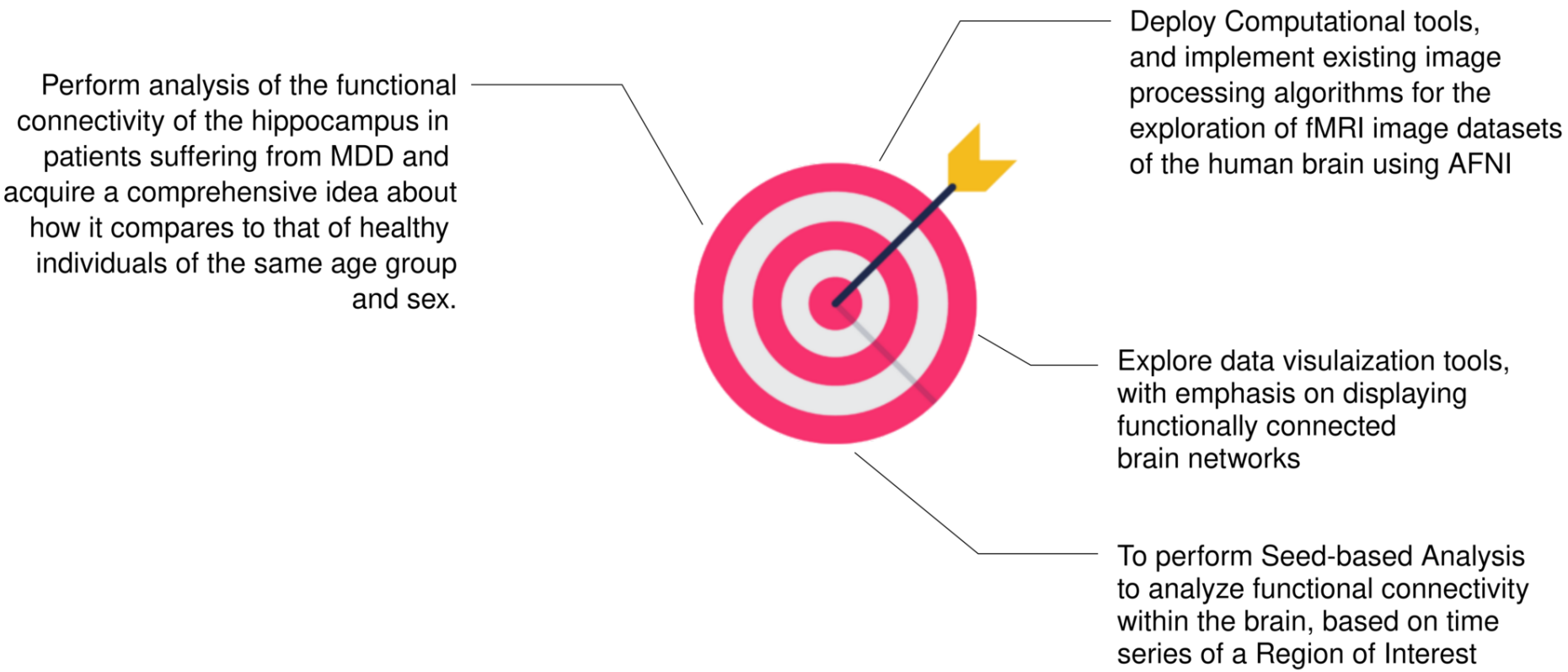

Figure: Chart representing Objectives

Methodology

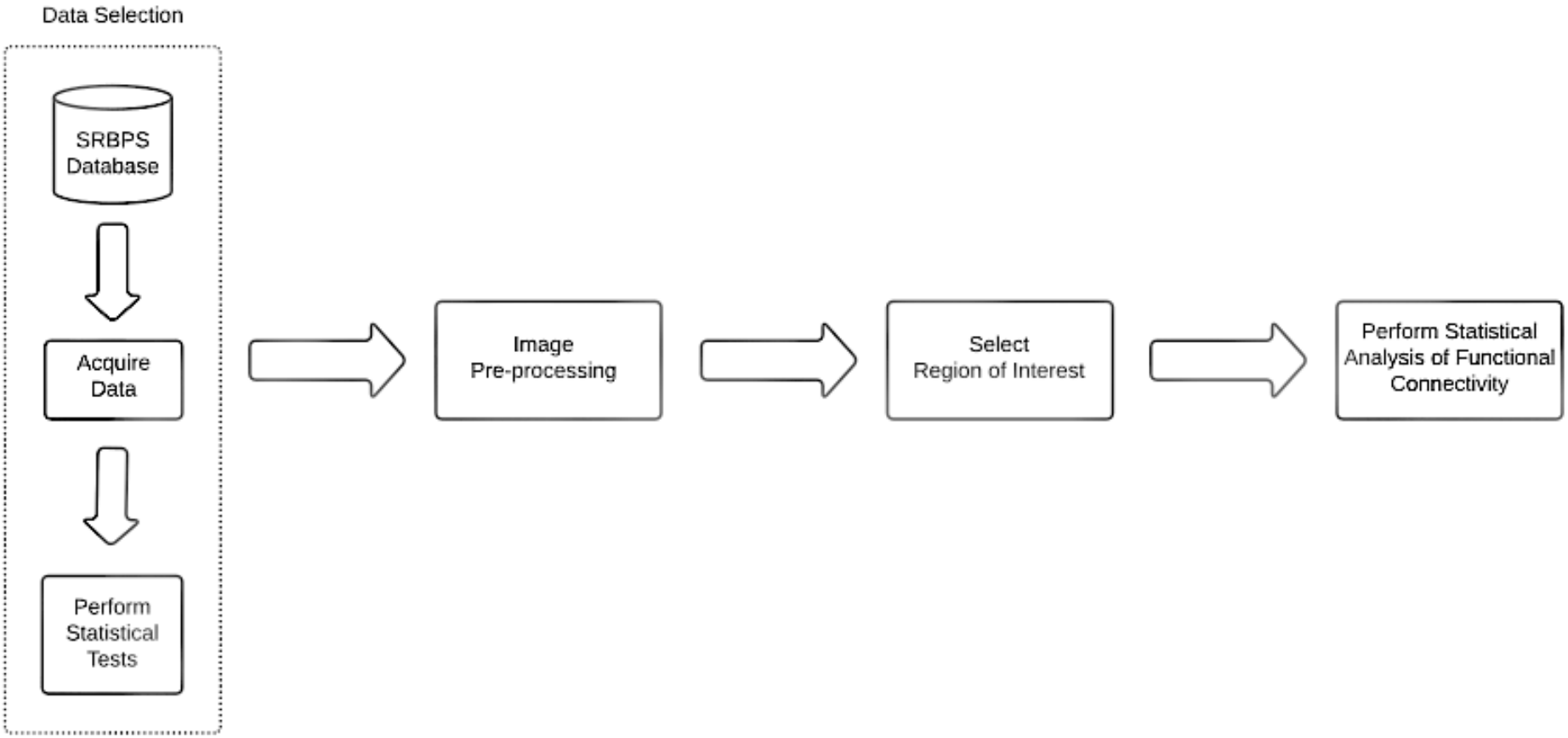

Figure: Flowchart representing Methodology

Data Acquisition & Selection

- Image data for HCs (healthy controls) and MDD patients were acquired from the SRPBS Multidisorder MRI Dataset.
- 15 HC subjects and 15 MDD patients were hand-picked and statistical tests were performed to verify the selected participants were well matched.
- Chi-square test to test the goodness of fit based on sex and t-test to test the goodness of fit based on age.

Test Results

Data Acquisition & Selection Continued...

Diagnosis	Diag 0	Diag 2
age	39	34
	48	41
	37	49
	32	44
	33	34
	38	31
	34	30
	36	37
	37	33
	32	43
	45	35
	34	42
	38	34
	39	39
total	40	45
T-test p-value		0.75172766

Table: T-Test results

Test Results

Data Acquisition & Selection Continued...

Count of Sex	Diagnosis		
Sex	0	2	Grand Total
1	7	6	13
2	8	9	17
Grand Total	15	15	30
Chi-test P-value		0.002937071596	

Table: Chi-square test results

Data Preparation

- The software tools that we chose, required the image data to be in a specific format.
- The original image data was converted from DICOM to NIfTI.
- A functional MR image is acquired in blocks, where each block represents the functional MR signal acquired at a given time.
- Multiple 3D fMRI volumes acquired at different times were converted into a 4D image where time is the 4^{th} dimension.

Extracting the Brain Tissue

- T1-weighted images contain non-brain tissues such as eyeballs, skull and skin, amongst the brain tissue.
- We are only concerned with analyzing brain functions, so we extract the brain tissue from its surroundings.

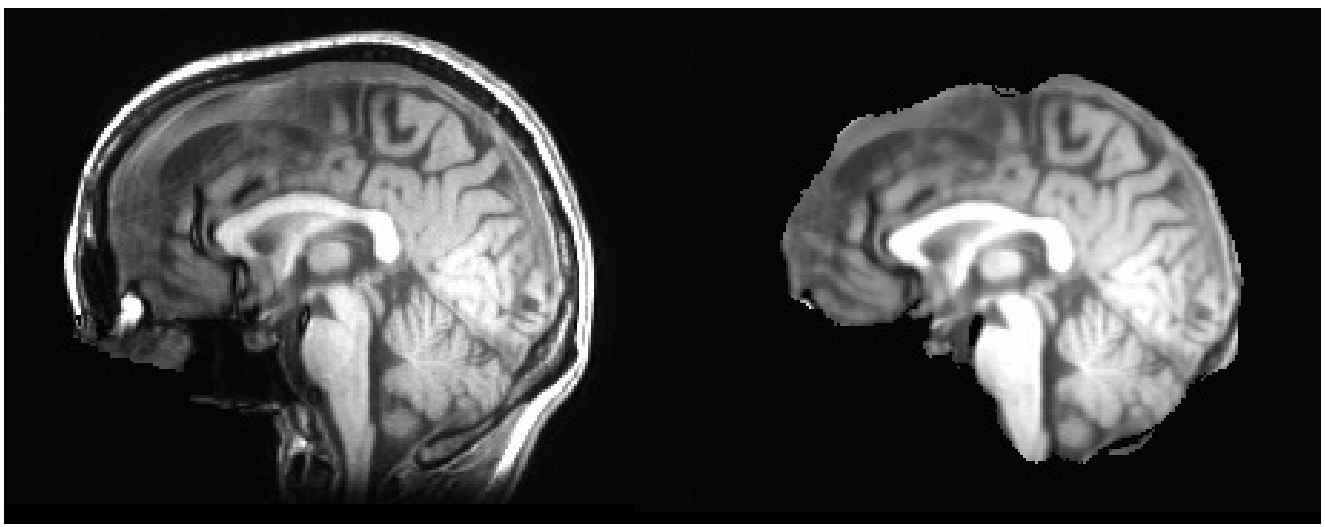

Figure: T1 image with and without skull

Image Segmentation

- Segmentation is a process of partitioning an image into multiple set of pixels, where each set represents a specific region in the image.
- In this step, the original T1 image was segmented into grey-matter, white-matter and CSF.
- This was performed in an image processing package called SPM (Statistical Parametric Mapping) in GNU Octave.
- SPM employs a region based segmentation algorithm to achieve this.

Image Segmentation Results

Image Segmentation Continued...

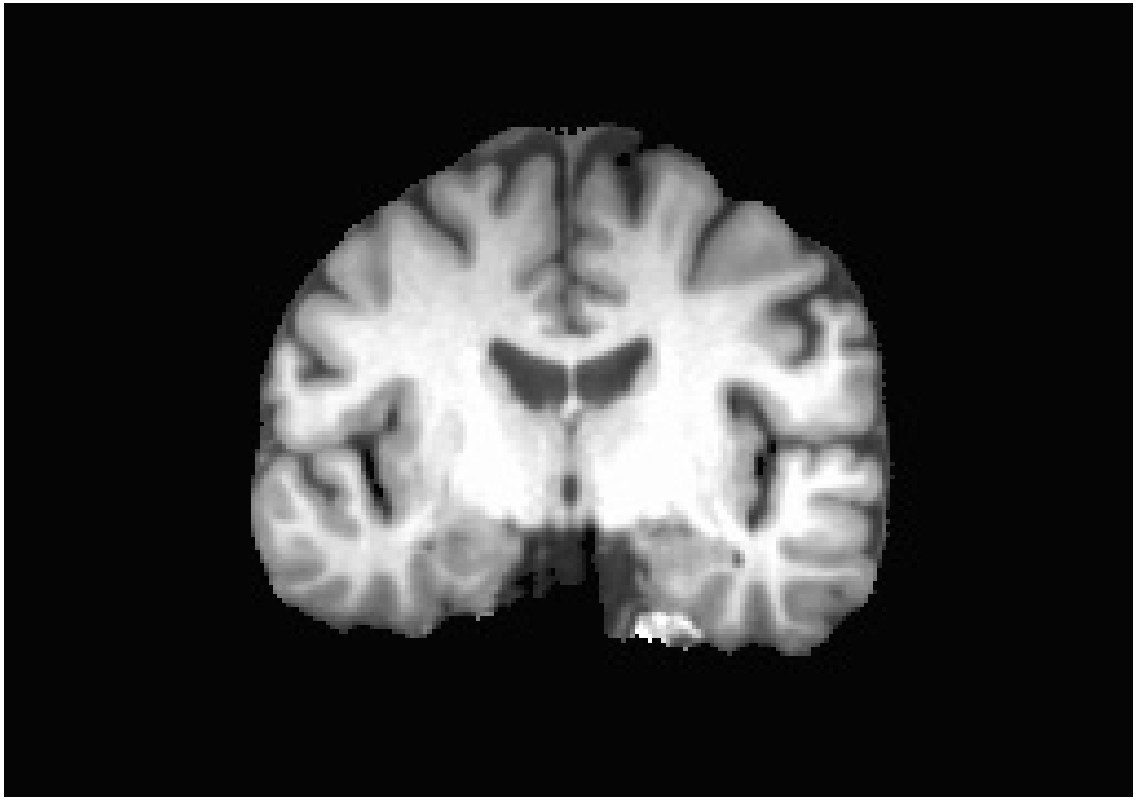

Figure: Original Image of the brain

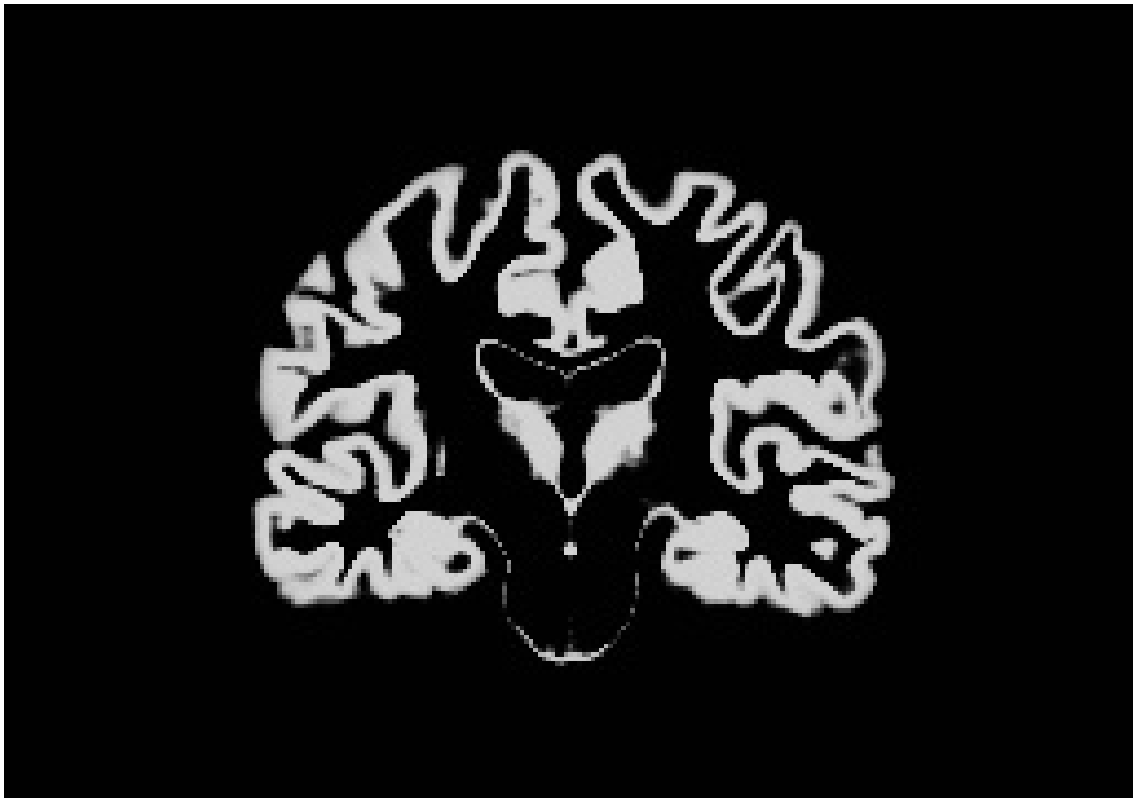

Figure: Segmented Gray Matter

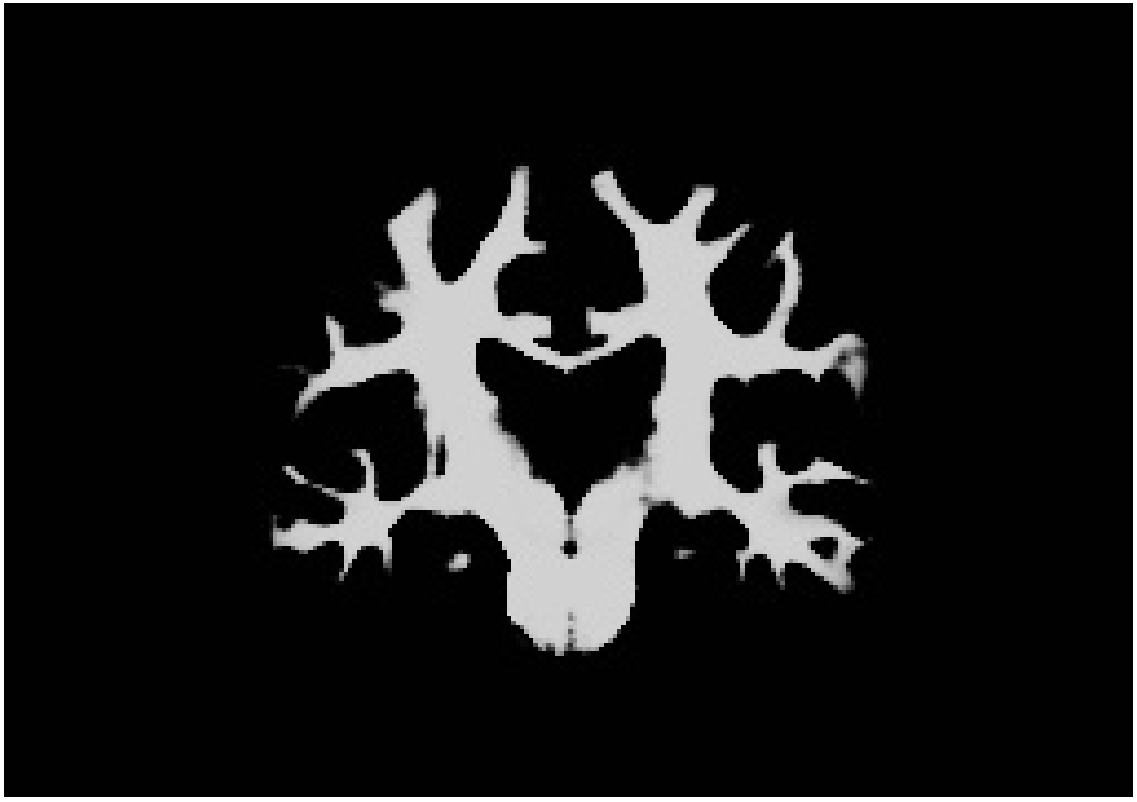

Figure: Segmented White Matter

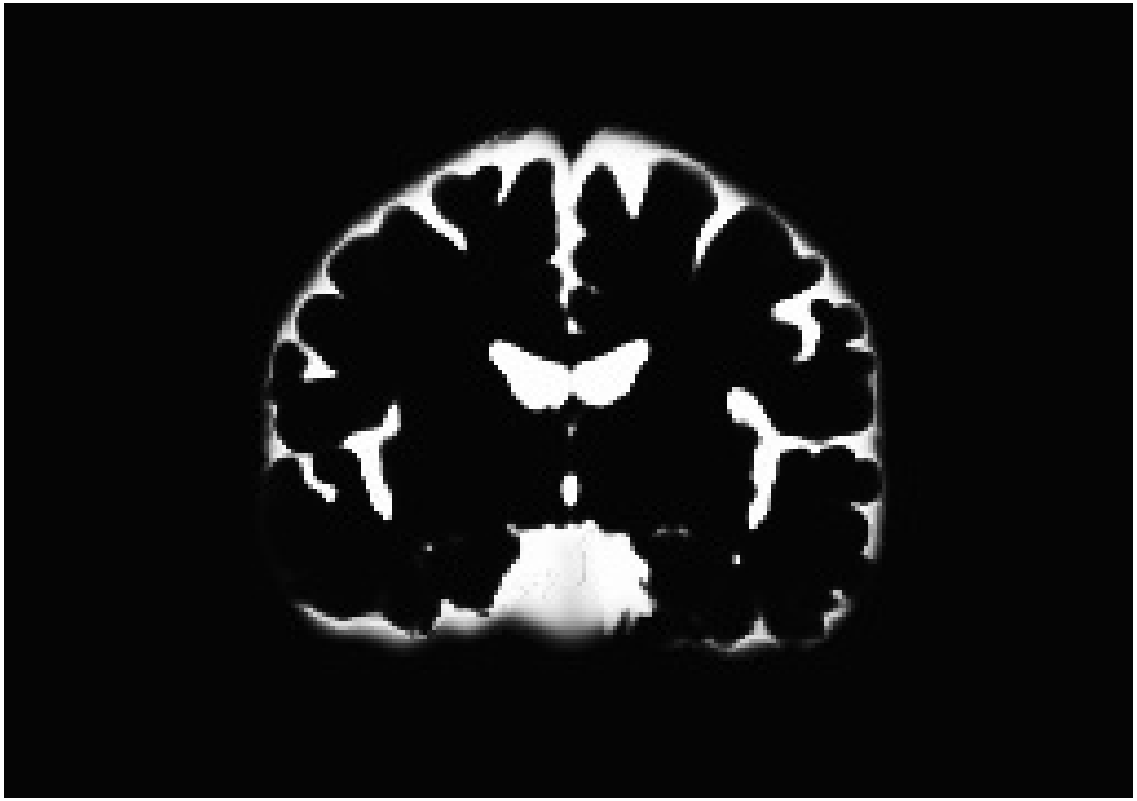

Figure: Segmented CSF

Creating GM Templates

Image Segmentation Continued...

- A common gray-matter template was created
- This was accomplished by using another image processing toolbox in SPM called DARTEL.

BOLD Data Preprocessing

- BOLD signals are produced due to changes in blood-oxygen levels, during neural activation of different regions of the brain.
- BOLD image data are inherently of lower quality and have a lower resolution.
- The primary software tool used for the preprocessing of BOLD fMRI data was AFNI.
- Numerous steps were undertaken for the preprocessing of the BOLD data:
  1. Exclusion of the first few TRs
  2. Despiking
  3. Slice Timing Corrections
  4. Head Motion Corrections

BOLD Data Preprocessing

- Spatial normalization is to normalize the imge pixels at specific co-ordinates in the 3D space.
- fMRI image provides information about the brain function.
- sMRI image provides information abouth the brain strucuture.
- Co-registration of fMRI image and sMRI image to map the brain functions to specific brain structures.
- Alignment of the BOLD fMRI image data to the anatomical image to accurately map the BOLD signals to brain structures.

Image Preprocessing Results

Image Preprocessing Continued..

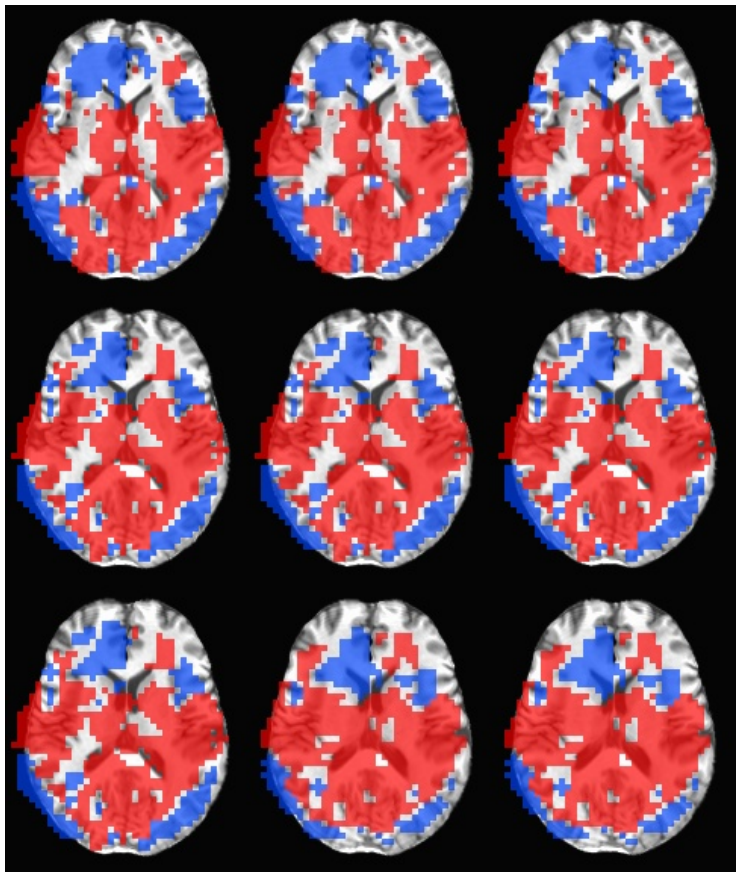

Figure: Alignment of BOLD EPI to T1-weighted Image (HC)

Image Preprocessing Results

Image Preprocessing Continued..

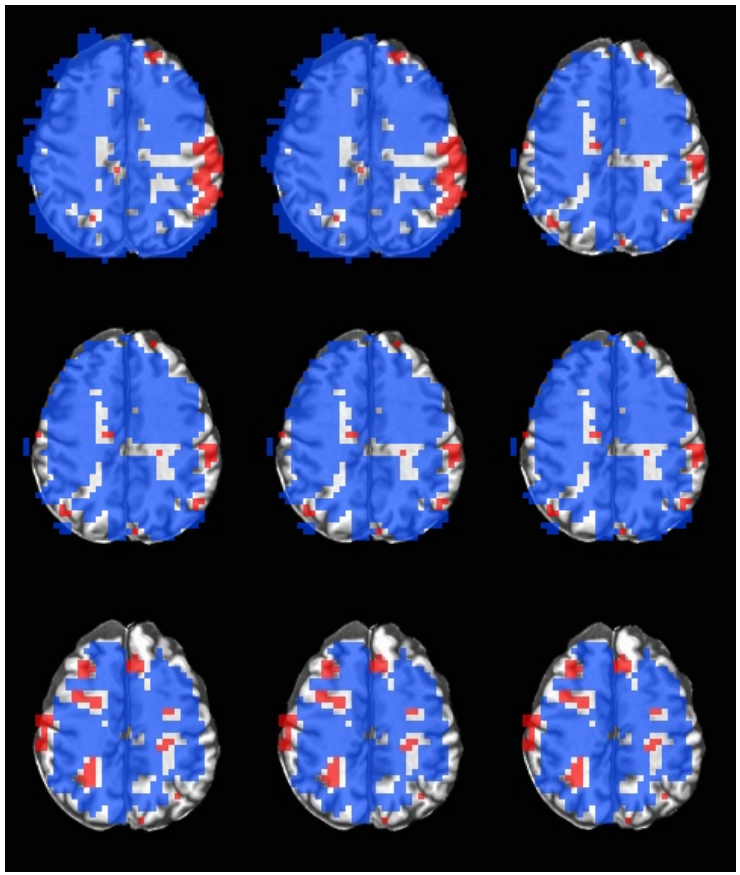

Figure: Alignment of BOLD EPI to T1-weighted Image (MDD)

Conclusion

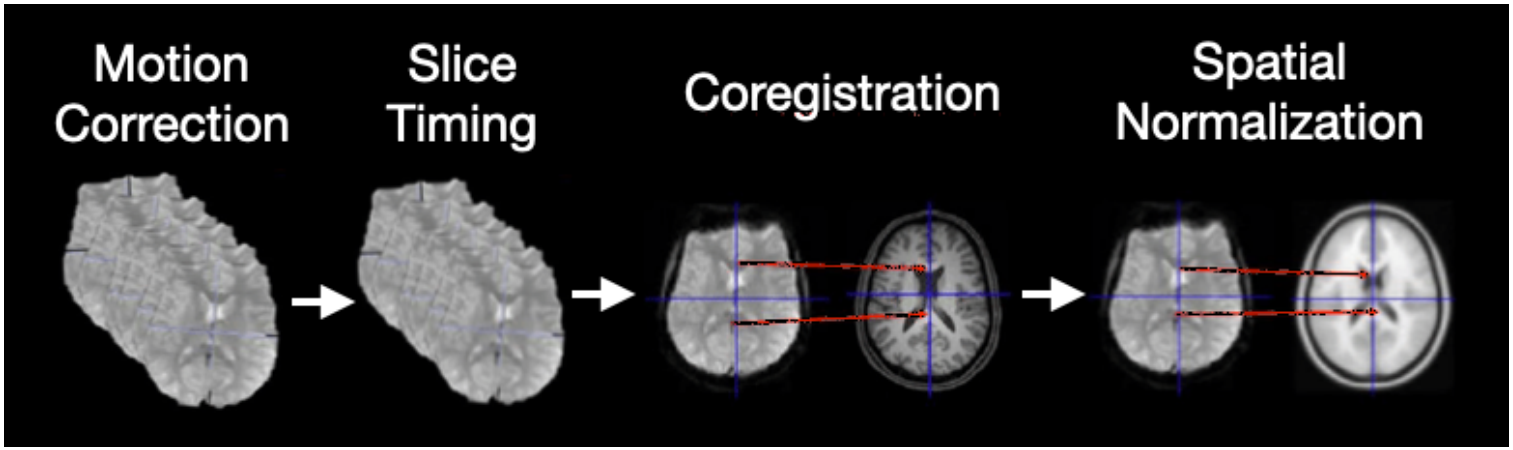

Figure: Steps in fMRI Image Preprocessing

Conclusion

- The results of the project might not be sufficient to provide a detailed understanding of the complex and changing functional connectivity of the brain for making the actual diagnosis of MDD through fMRI possible.
- It will only lay the foundations for further reasearch and devlopment.

Further Works

- Selection of a seed or a region of interest.
- Extraction of signal from the specified ROI.
- Statistical analysis to compare the functional connectivity of the seed region between HCs and MDD patients.

References

Thank You!