Multimodal Neuroimaging

Analyzing MRI images using SPM

Soumyabrata DEV
http://www3.ntu.edu.sg/home2012/soumyabr001/

Nanyang Technological University Singapore

May 2017

Objectives

Our objectives are to analyze MRI images from patients with Mild Cognitive Impairment (MCI) and Alzheimer's Disease (AD).

Specifically

- Comparison of global- grey matter and white matter.
- Regional differences for cortical and subcortical regions for grey matter volumes.
- Voxel-wise differences between MCI and AD.

Pre-processing

We pre-process the 20 MRI images and extract the corresponding grey matter (referred as c1) and white matter (referred as c2). We use *Segment* module in SPM toolbox, with 'East Asian brains' settings etc. , as shown below:

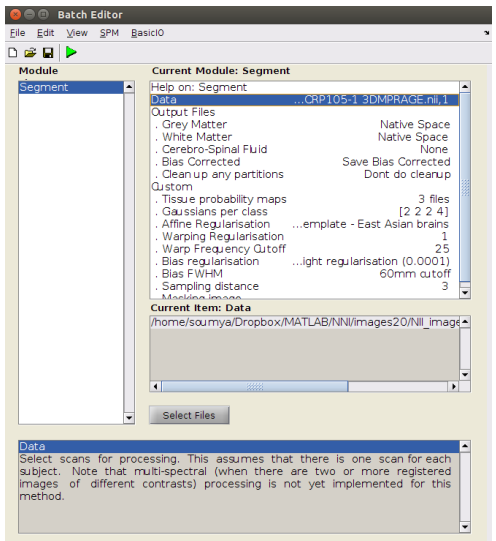


Figure: Segment module in SPM toolbox.

This process generates the corresponding 'c1' and 'c2' files for all MRI images.

MRI image

We illustrate a sample MRI image below, using *Check Reg* button in SPM toolbox.

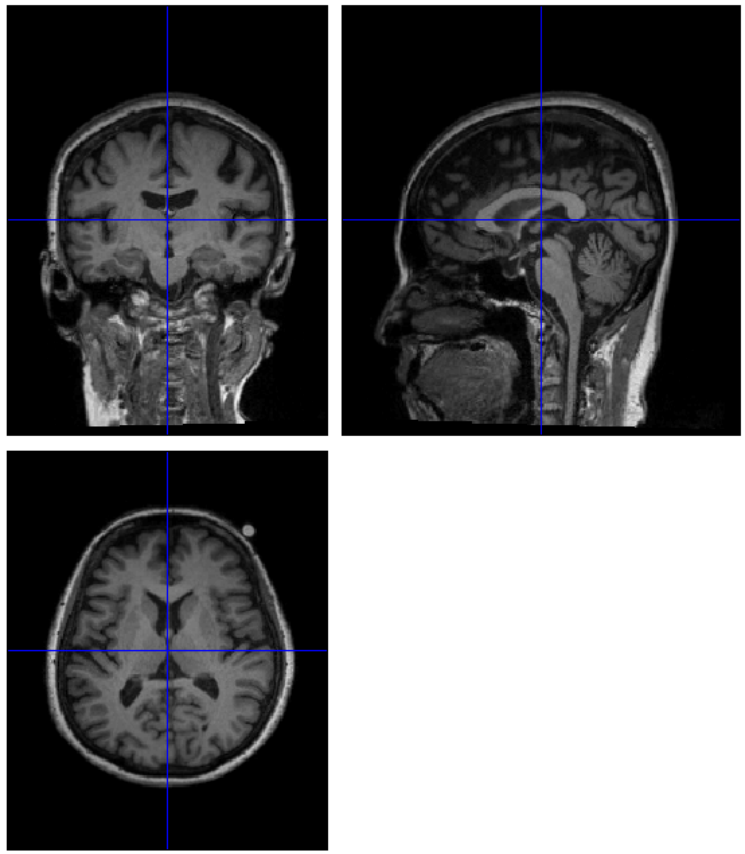


Figure: Sample MRI image.

Grey matter (c1) image

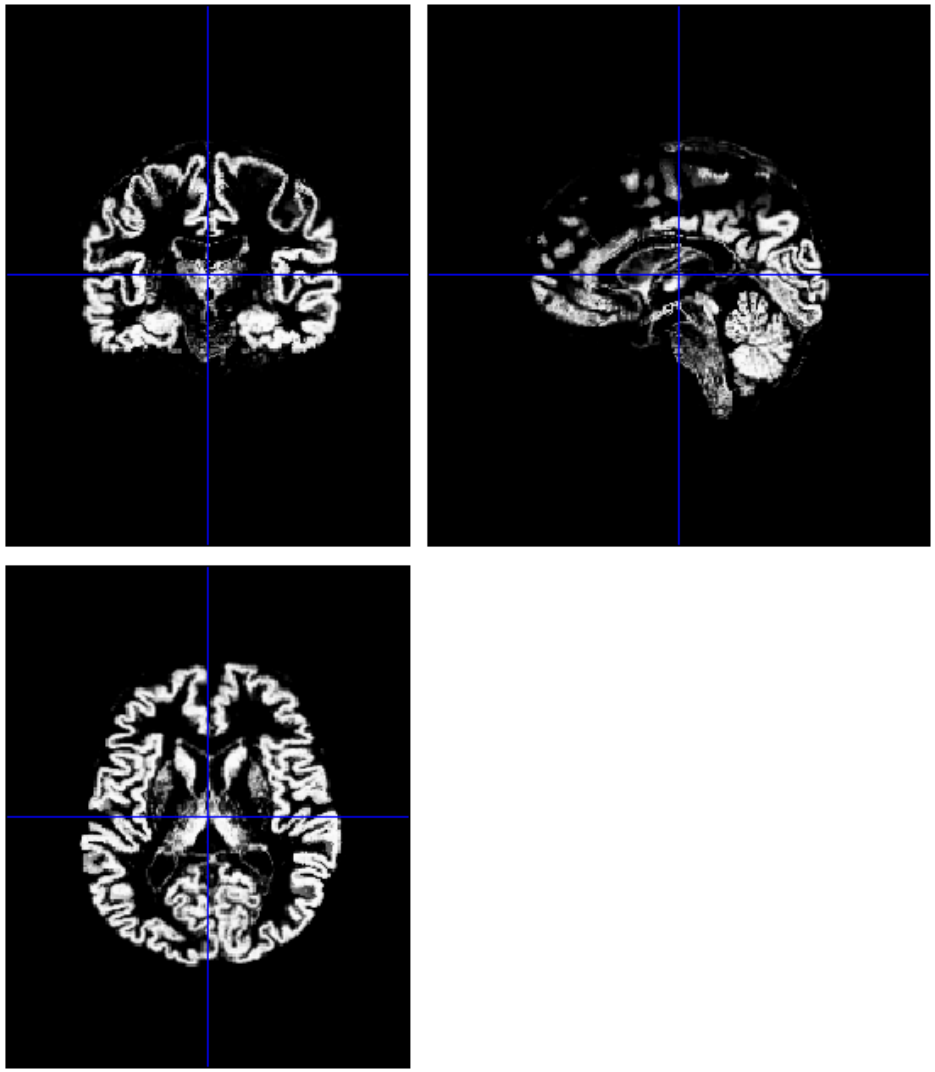


Figure: Corresponding Grey matter (c1) image.

White matter (c2) image

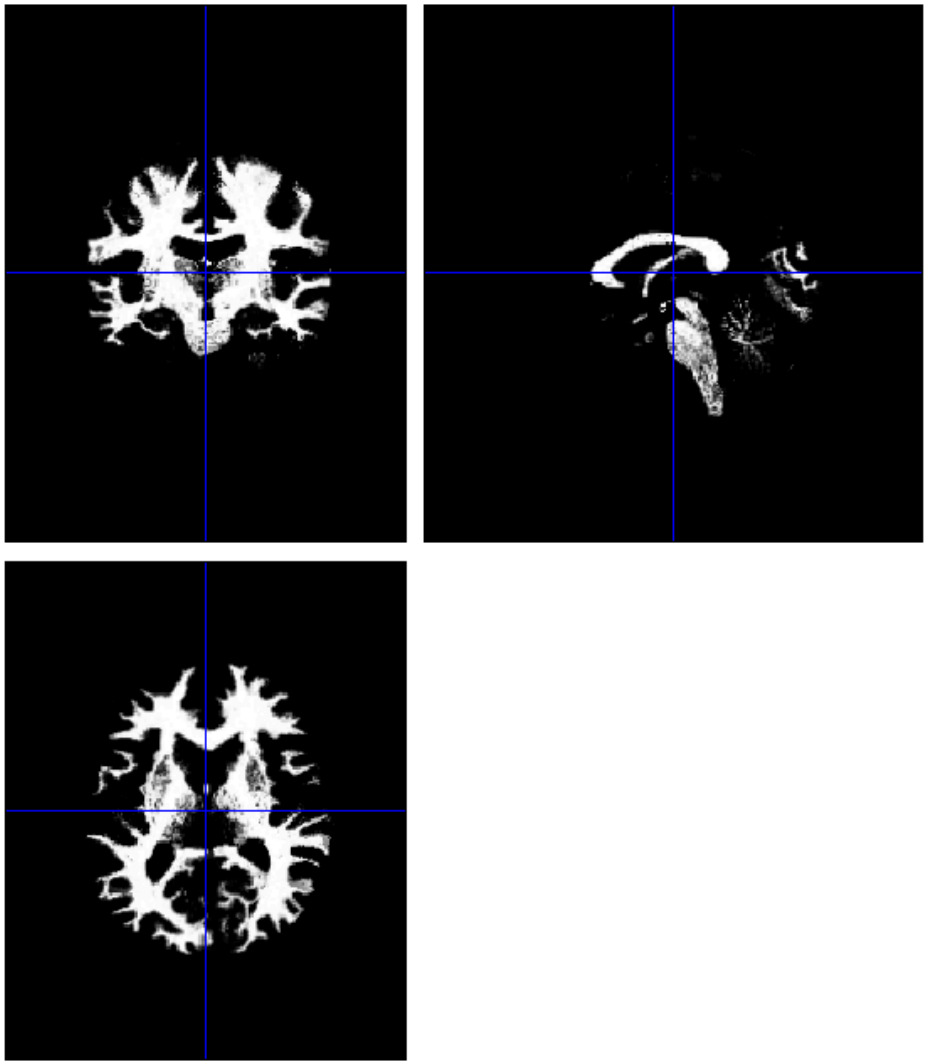


Figure: Corresponding White matter (c2) image.

Comparison of Global Grey Matter

File Name	Status	Global Grey Matter [in ml]
TCRP105-1 3DMPRAGE.nii	AD	521.94
TCRP109-1 3DMPRAGE.nii	AD	541.58
TCRP136-1 3DMPRAGE.nii	AD	559.69
TCRP224-1 3DMPRAGE.nii	AD	678.05
TCRP234-1 3DMPRAGE.nii	AD	581.73
TCRP262-1 3DMPRAGE.nii	AD	575.40
TCRP270-1 3DMPRAGE.nii	AD	628.06
TCRP274-1 3DMPRAGE.nii	AD	571.78
TCRP281-1 3DMPRAGE.nii	AD	459.48
TCRP285-1 3DMPRAGE.nii	AD	582.68

Table: (Part 1/2) Table containing Grey matter values.

Comparison of Global Grey Matter

File Name	Status	Global Grey Matter [in ml]
TCRP299-1 3DMPRAGE.nii	MCI	555.28
TCRP304-1 3DMPRAGE.nii	MCI	600.99
TCRP306-1 3DMPRAGE.nii	MCI	485.43
TCRP307-1 3DMPRAGE.nii	MCI	838.67
TCRP309-1 3DMPRAGE.nii	MCI	541.61
TCRP311-1 3DMPRAGE.nii	MCI	–
TCRP312-1 3DMPRAGE.nii	MCI	440.72
TCRP314-1 3DMPRAGE.nii	MCI	564.93
TCRP315-1 3DMPRAGE.nii	MCI	645.24
TCRP317-1 3DMPRAGE.nii	MCI	724.18

Table: (Part 2/2) Table containing Grey matter values.

Comparison of Global White Matter Volume

File Name	Status	Global White Matter [in ml]
TCRP105-1 3DMPRAGE.nii	AD	389.86
TCRP109-1 3DMPRAGE.nii	AD	431.68
TCRP136-1 3DMPRAGE.nii	AD	417.60
TCRP224-1 3DMPRAGE.nii	AD	419.78
TCRP234-1 3DMPRAGE.nii	AD	362.23
TCRP262-1 3DMPRAGE.nii	AD	396.38
TCRP270-1 3DMPRAGE.nii	AD	482.29
TCRP274-1 3DMPRAGE.nii	AD	470.98
TCRP281-1 3DMPRAGE.nii	AD	359.78
TCRP285-1 3DMPRAGE.nii	AD	442.03

Table: (Part 1/2) Table containing white matter values.

Comparison of Global White Matter Volume

File Name	Status	Global White Matter [in ml]
TCRP299-1 3DMPRAGE.nii	MCI	413.97
TCRP304-1 3DMPRAGE.nii	MCI	465.40
TCRP306-1 3DMPRAGE.nii	MCI	422.23
TCRP307-1 3DMPRAGE.nii	MCI	474.84
TCRP309-1 3DMPRAGE.nii	MCI	396.83
TCRP311-1 3DMPRAGE.nii	MCI	–
TCRP312-1 3DMPRAGE.nii	MCI	436.91
TCRP314-1 3DMPRAGE.nii	MCI	393.51
TCRP315-1 3DMPRAGE.nii	MCI	417.76
TCRP317-1 3DMPRAGE.nii	MCI	496.56

Table: (Part 2/2) Table containing white matter values.

Cortical and Sub-cortical regions

Several literature have studied grey matter volumes in cortical and sub-cortical regions.

- Study of various factors in differences of grey matter volume and cortical thickness [1].
- Understanding the growth of Cortical and Subcortical Grey Matter from birth till young age [2].

[1] Comparison of grey matter volume and thickness for analysing cortical changes in chronic schizophrenia: a matter of surface area, grey/white matter intensity contrast, and curvature [Kong et al. Psychiatry Res. 2015].

[2] Longitudinal Development of Cortical and Subcortical Grey Matter from Birth to 2 Years [Gilmore et al. Cereb Cortex. 2012]

Generation of Cortical and Sub-cortical masks

We can compute a binary mask for Cortical and Sub-cortical regions of the brain, based on the following figure [3]:

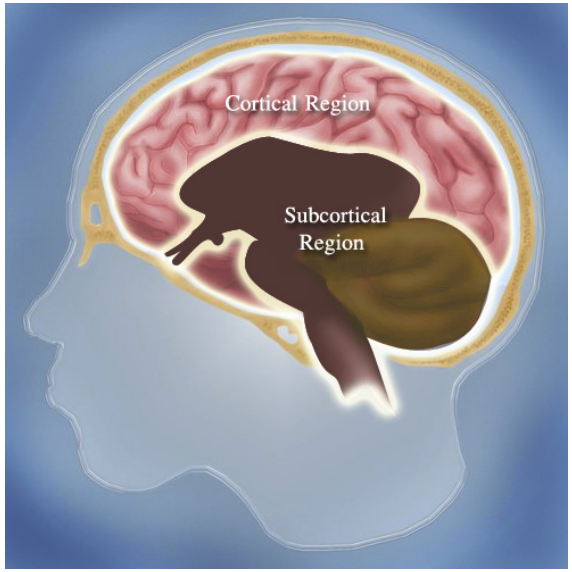
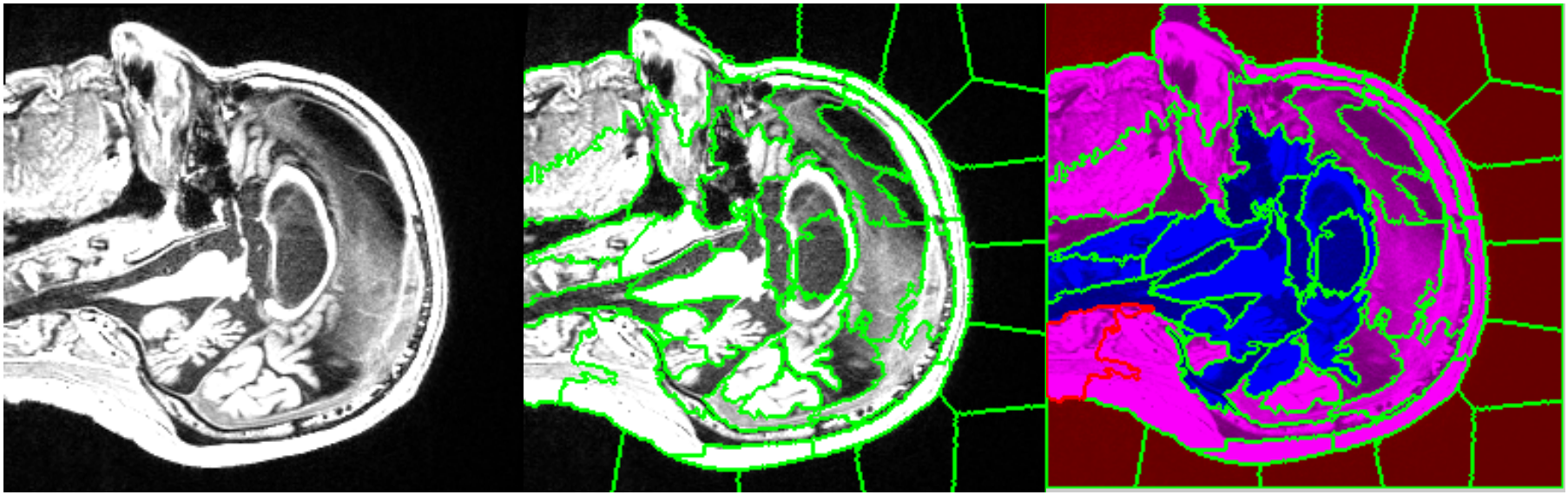


Figure: Illustration depicting the Cortical and Sub-cortical regions of the brain.

[3] Referenced from ://web.stanford.edu/group/hopes/cgi-bin/hopes_test/dementia-in-huntingtons-disease/

Generation of Cortical and Sub-cortical masks

We generate a over-segmented image for the image `TCRP306-1 3DMPRAGE.nii`.

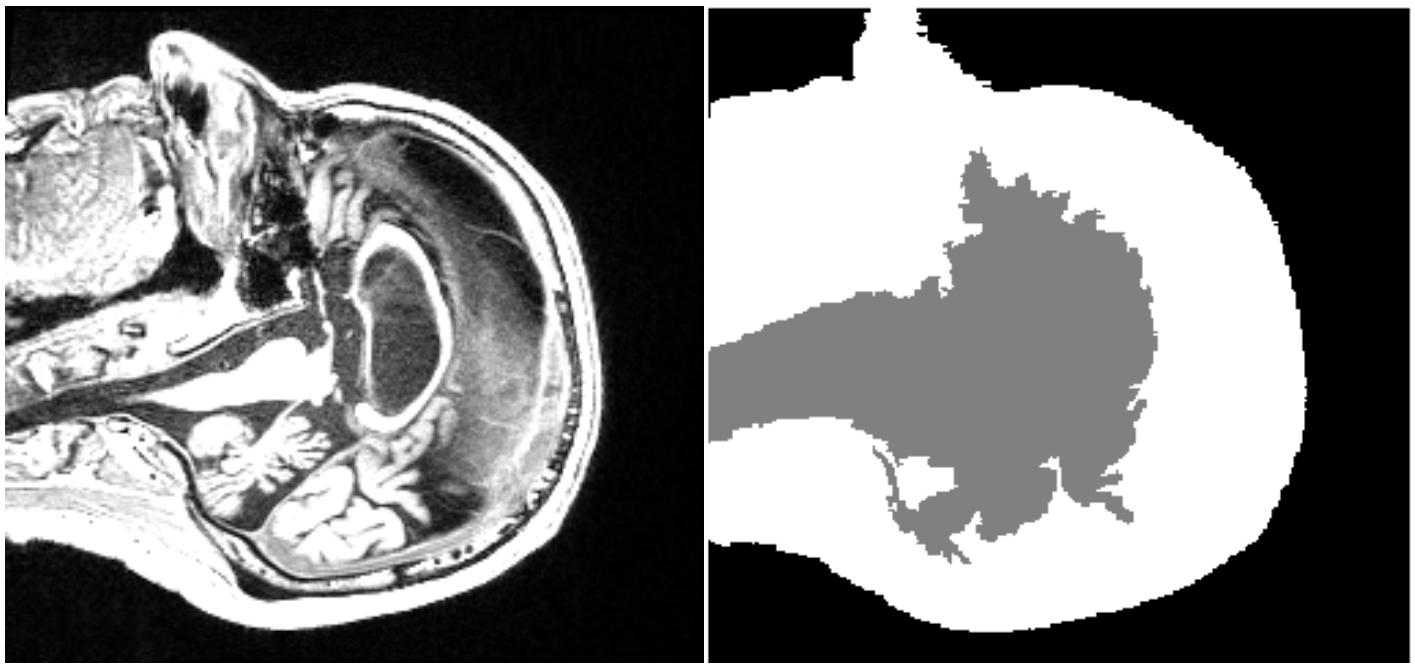


(a) Slice 96 of .nii image (b) Oversegmentation of sliced image. (c) Manual labeling of the segmented image to generate corresponding masks.

Figure: Generation of corresponding masks.

Generation of Cortical and Sub-cortical masks

We use the following generated masks in calculating the grey matter volumes.



(a) Slice 96 of .nii image (b) Generated mask.

Figure: In the manually generated mask, *white* indicates cortical region, *gray* indicates sub-cortical region and *black* indicates invalid region.

Cortical and Sub-cortical regions

We compute the grey matter volumes in cortical and sub-cortical regions based on the *pre-defined mask*.

Region	Status	Grey Matter Volumes [in ml]
Cortical	All subjects	674497.92
Sub-cortical	All subjects	510908.80

Table: Table representing the regional differences (cortical and subcortical) in grey matter volumes.

Cortical and Sub-cortical regions

We also compute the mean grey matter volumes in cortical and sub-cortical regions, categorized according to the status of patients.

Region	Status	Grey Matter Volumes [in ml]
Cortical	MCI	707902.54
Cortical	MCI	527714.26
Sub-cortical	AD	644433.77
Sub-cortical	AD	495783.88

Table: Table representing the regional differences (cortical and subcortical) in grey matter volumes, based on the status of the patients.

Voxel-wise differences

Literature discusses voxel-wise grey matter difference for MRI images, and establishes 12-step user guide [4].
Unfortunately, I could not establish the step-by-step procedures for the given .nii images.

[4] A 12-step user guide for analyzing voxel-wise grey matter asymmetries in statistical parametric mapping (SPM) [Kurth et al. Nature Protocols 2015]

Software codes

The software codes used in this presentation are available online at `https://github.com/Soumyabrata/neuroimaging`.

Multimodal Neuroimaging: Analyzing MRI images using SPM

This repository contains the codes used in the analysis of MRI images, obtained from National Neuroscience Institute, Singapore.

Software

- Please install MATLAB.
- Download and install SPM8. More details in this link.

Presentation

The details are provided in the PDF `multimodal-neuroimaging.pdf`.

Usage

Please run `calculate_matter.m` to calculate global gray matter and global white matter for patients.

Please run `reg_diff.m` to determine the regional differences (cortical and subcortical) in grey matter volumes

Thank You!