Neuroimaging Analysis in R: Image Preprocessing

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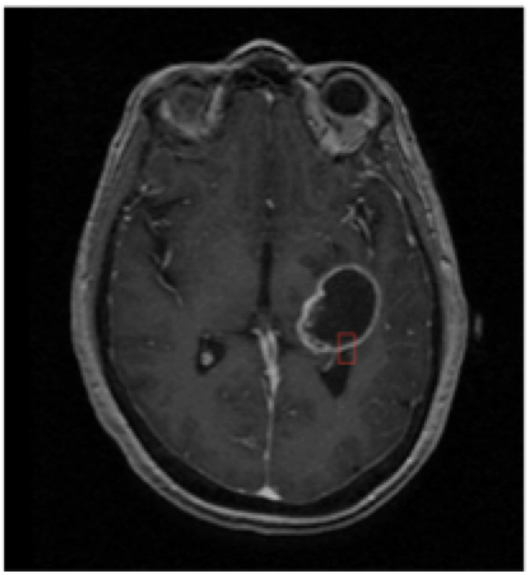
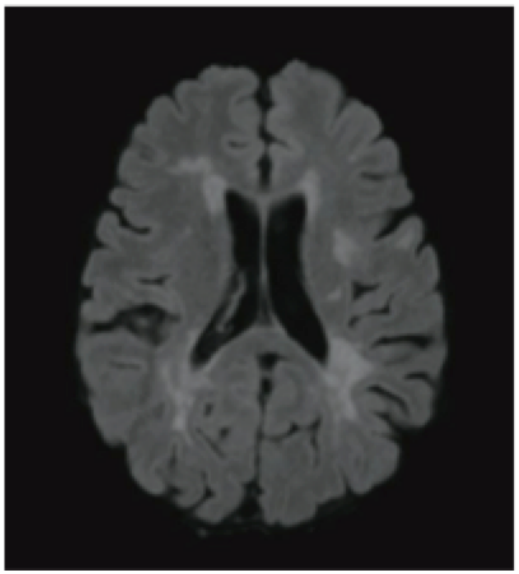
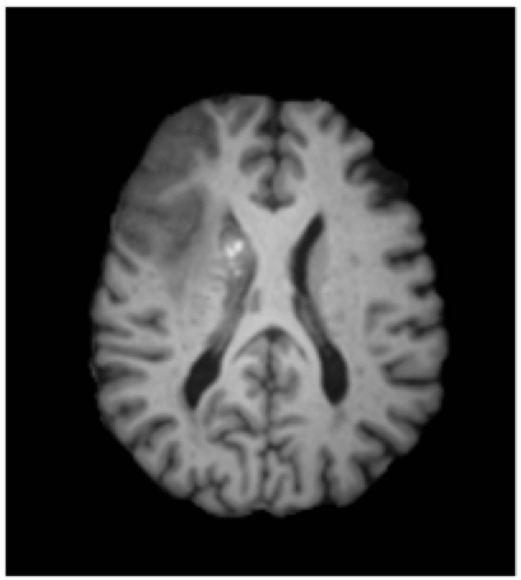
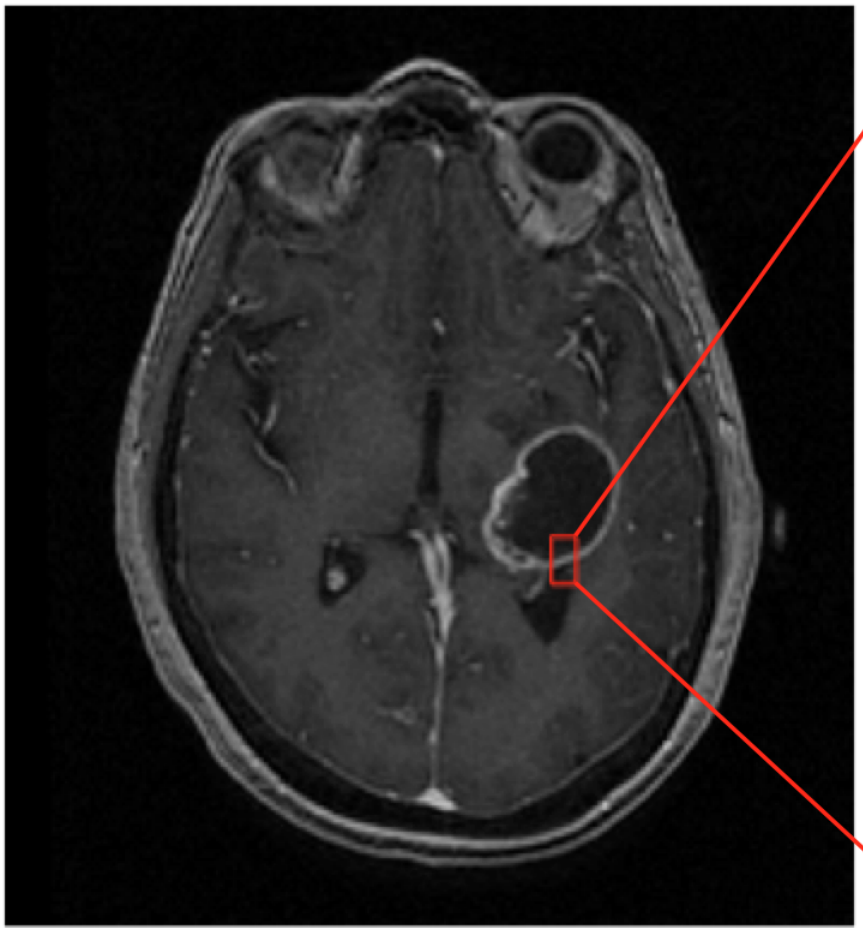
Houston R Users Group
September 5, 2016

Structural MRI

Structural MRI is used in clinical practice to diagnose disease and monitor disease progression.

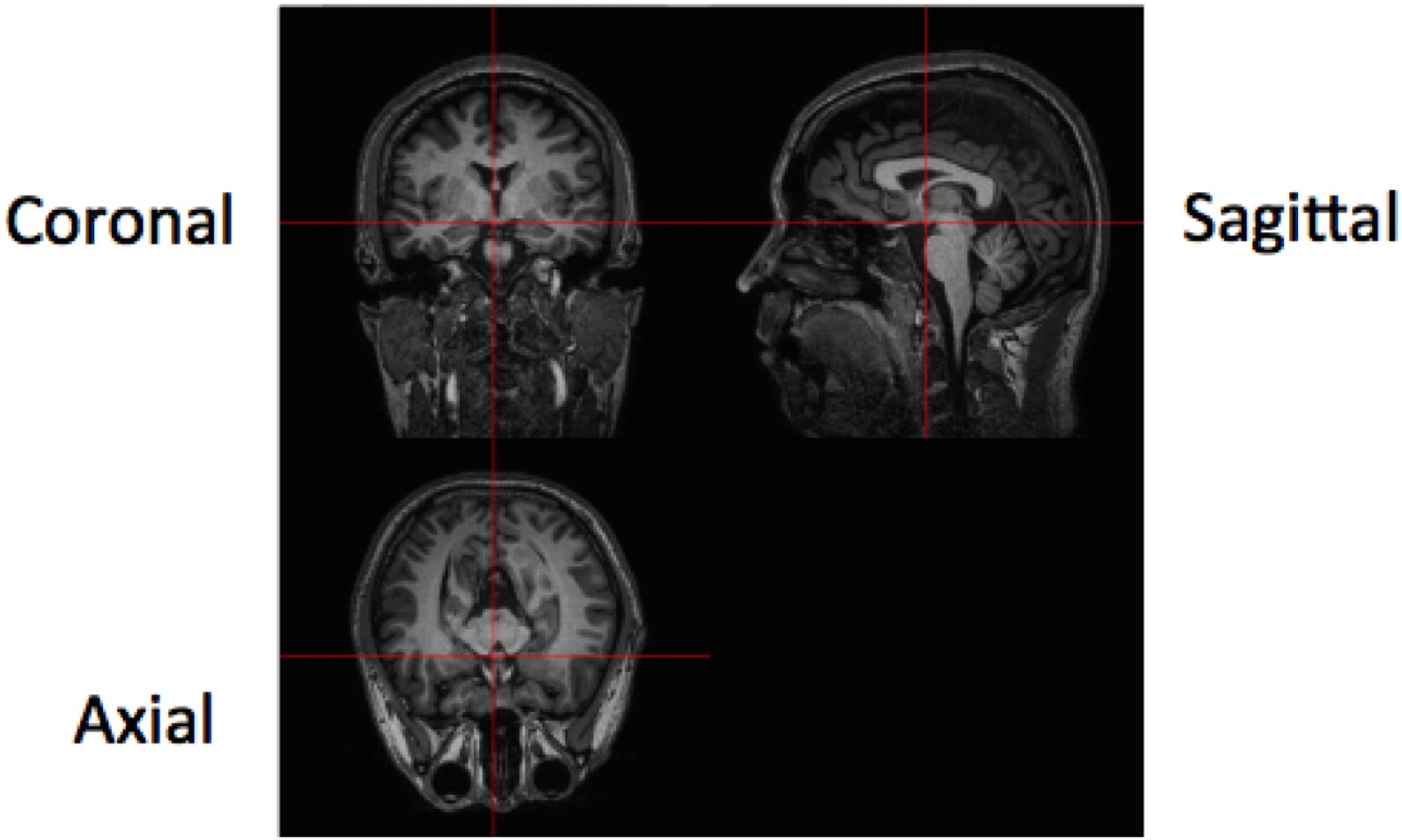




Structural MRI

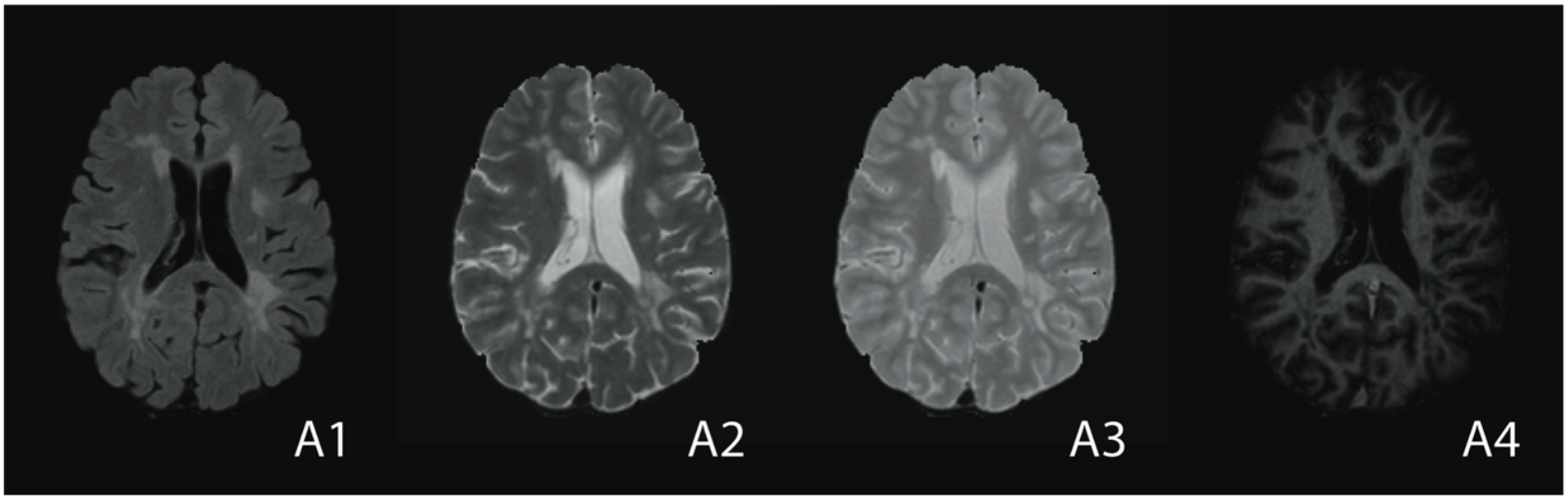


43	42	47	32	38	33
40	45	48	42	49	44
40	55	57	57	51	55
56	56	58	79	121	165
68	99	149	179	199	190
187	199	186	139	108	81
165	115	47	39	69	76
29	24	29	74	107	93
29	42	55	58	71	87
46	40	45	40	61	92
44	46	43	31	62	88

Structural MRI



Structural MRI



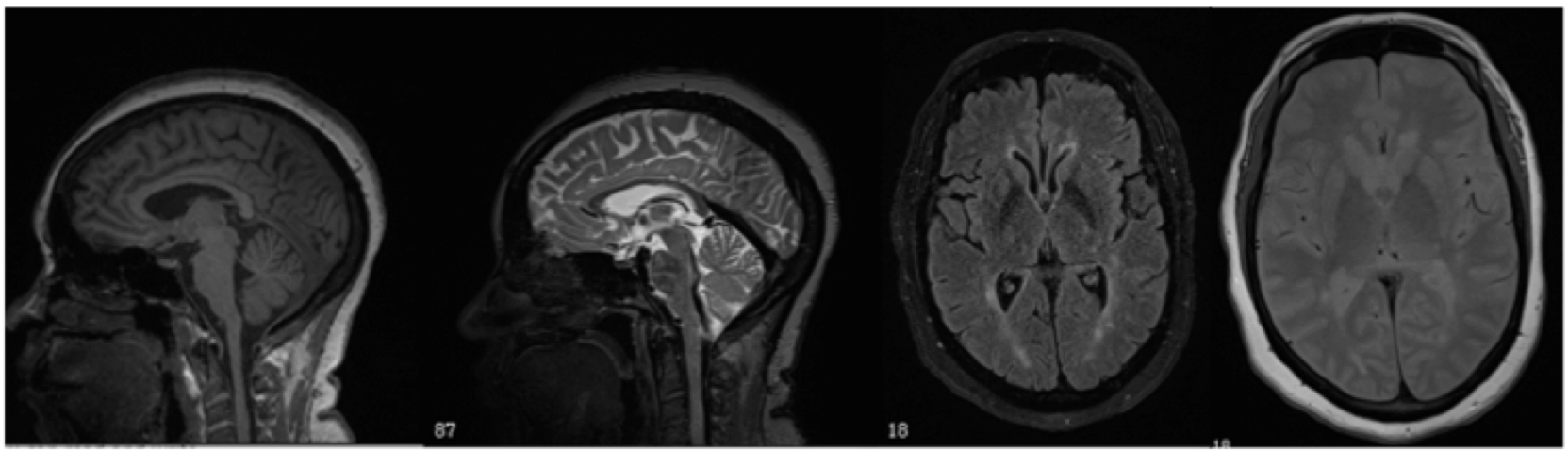
A1. Fluid-attenuated inversion recovery (FLAIR)
A2. T2-weighted (T2-w)
A3. Proton density (PD)
A4. T1-weighted (T1-w)

Image Preprocessing

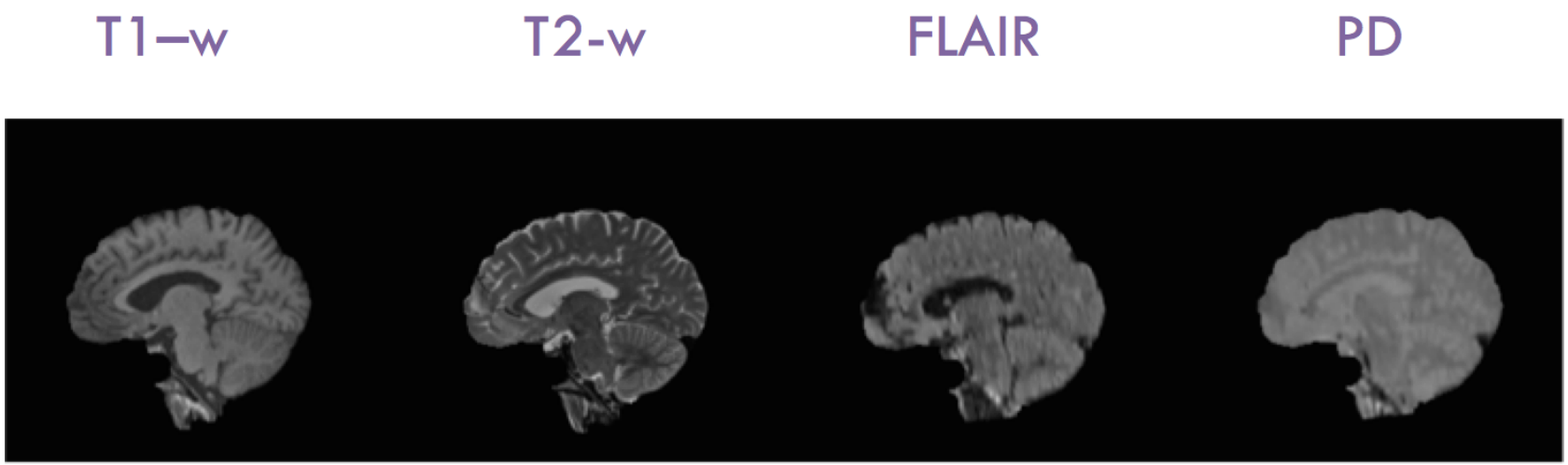
The stuff you have to do before you perform statistical analysis.

Before

T1–w T2-w FLAIR PD



After



Outline

Packages for Image Preprocessing

- NIfTI file format (oro.nifti)
- Image preprocessing (fslr)
- Other R packages (ANTsR , oro.dicom, extrantsr)

Select packages for Image Post-Processing

- Intensity Normalization (WhiteStripe, RAVEL)
- Multiple sclerosis lesion segmentation (oasisr, SuBLIME)

NIfTI file format

Neuroimaging Informatics Technology Initiative (NIfTI) file format:

- Files with a .nii or .nii.gz extension
- Standardized representation of images
- Most commonly used type of analytic file
- Developed to facilitate cross-platform, cross-software interpretability
- 3-dimensional (3D) array: stacking individual slices on top of each other

NIfTI file format

The R package oro.nifti:

- Use the writeNIfTI, readNIfTI functions in the oro.nifti package
- Reads and writes NIfTI files
- Works with nifti R objects (S4 objects)
- Default for writeNIfTI is to save compressed NIfTI files

NIfTI file format

Let's switch to R and explore the NIfTI file format with oro.nifti.

Using data from Kirby 21, an open source multi-modal MRI reproducibility study with 21 healthy subjects (www.nitrc.org/projects/multimodal)

fslr: an FSL port to R

1. FSL is useful, open-source, scriptable software for neuroimaging analysis
2. Problem: Requires coding in bash
3. Solution: fslr Ports many of the main functions of FSL into R
4. Disclaimer: May not work on Windows operating systems

Muschelli, J., Sweeney, E.M., Lindquist M.A. and Crainiceanu, C.M. (2015) fslr: Connecting the FSL software with R. The R Journal.

Package: fslr

Setting up fslr:

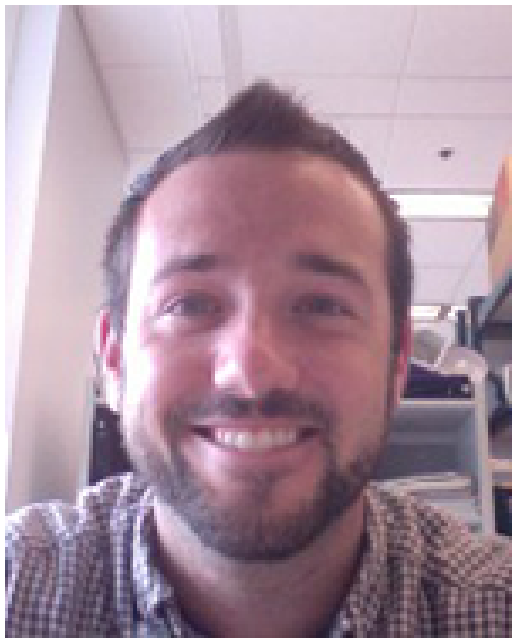
1. Install FSL
   http://fsl.fmrib.ox.ac.uk/fsl/fslwiki/FslInstallation#Installing_FSL
2. Install the R packages fslr and oro.nifti

   ```
   install.packages("fslr")
   ```

3. In R, set your part to fsl with

   ```
   options(fsl.path= "/path/to/fsl/")
   ```

The creator of fslR: John Muschelli



Blog: hopstat.wordpress.com
Twitter: @StrictlyStat

Under the Hood

```
fsl_bet : function (infile, outfile = NULL, retimg = TRUE,
reorient = FALSE, intern = FALSE, opts = "",
betcmd = c("bet2", "bet"), ...)

{betcmd = match.arg(betcmd)
cmd <- get.fsl()
cmd <- paste0(cmd, sprintf("%s \"%s\" \"%s\" %s", betcmd,
infile, outfile, opts))
res = system(cmd, intern = intern)
ext = get.imgext()
outfile = paste0(outfile, ext)
if (retimg) {
img = readnii(outfile, reorient = reorient, ...)
return(img)
}
return(res) }
```

ANTsR

ANTsR is a package providing ANTs features in R as well as imaging-specific data representations, spatially regularized dimensionality reduction and segmentation tools

```
install.packages("devtools")
```

```
library(devtools)
install_github("stnava/cmaker")
install_github("stnava/ITKR")
install_github("stnava/ANTsR")
```

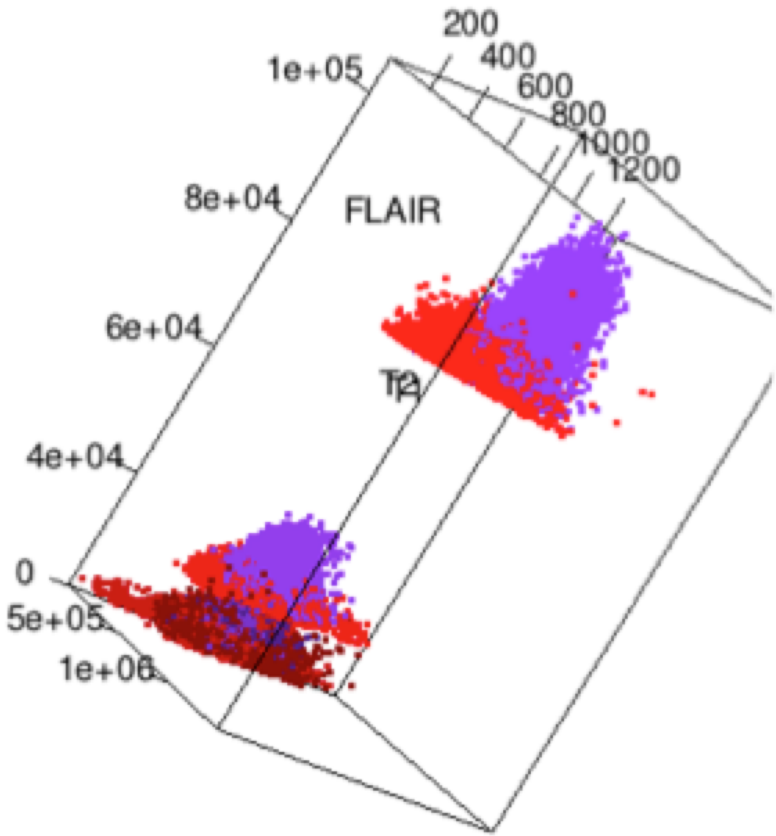
More R packages

More R packages for structural MRI analysis:

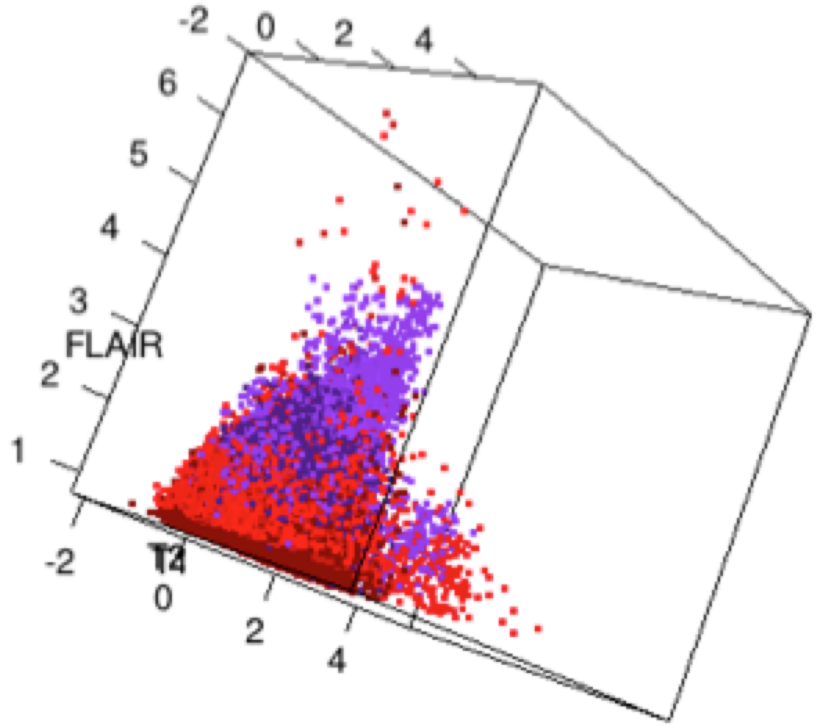
```
install.packages("oro.dicom") # working with DICOM images
install_github("muschellij2/extrantsr") # EXTRA ANTsR functions
```

Intensity Normalization

Before Normalization



After Normalization



Intensity Normalization

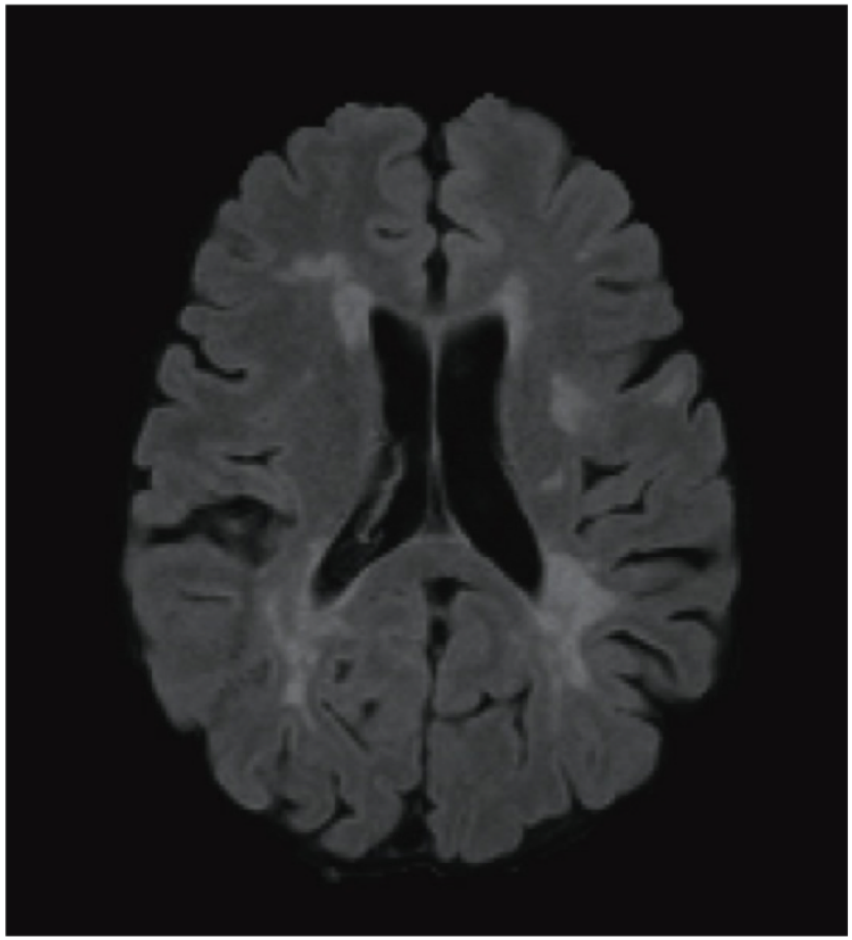
Intensity normalization packages

```
install.packages("WhiteStripe")
library(devtools)
install_github("Jfortin1/RAVEL")
```

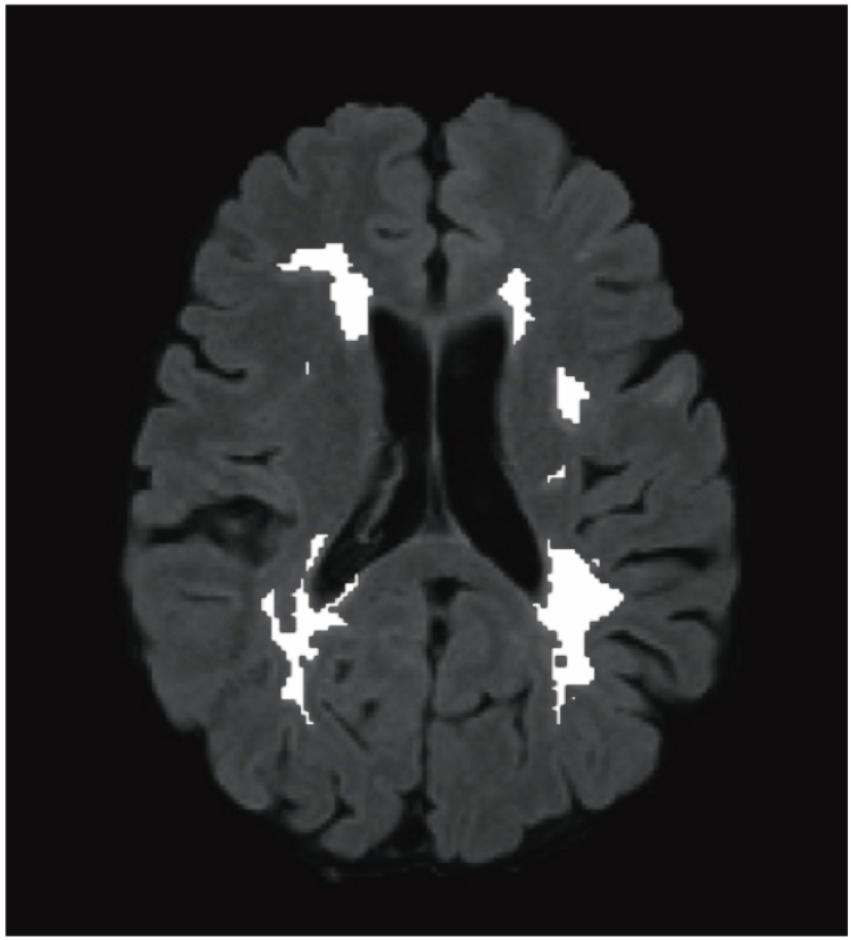
Fortin, J. P., Sweeney, E. M., Muschelli, J., Crainiceanu, C. M., Shinohara, R. T., and the Alzheimer?s Disease Neuroimaging Initiative. (2016) Removing inter-subject technical variability in magnetic resonance imaging studies. NeuroImage.

Shinohara, R.T., Sweeney, E.M., Goldsmith, J., Shiee, N., Mateen, F.J., Calabresi P.A., Jarso, S., Pham, D.L., Reich, D.S., and Crainiceanu, C.M. (2014). Statistical normalization technique for magnetic resonance imaging. Neurouimage Clinical.

MS Lesion Segmentation



MS Lesion Segmentation



MS Lesion Segmentation

- R package: oasis

```
install.packages(oasis)
```

- R package: SuBLIME

```
library(devtools)
install_github("emsweene/
SuBLIME_package")
```

Sweeney, E.M. , Shinohara, R.T., Shiee, N., Mateen, F.J., Chudgar, A.A., Cuzzocreo, J.L., Calabresi P.A., Pham, D.L., Reich, D.S., and Crainiceanu, C.M. (2013) OASIS is Automated Statistical Inference for Segmentation with applications to multiple sclerosis lesion segmentation in MRI. NeuroImage: Clinical, 2, 402-413.

Sweeney, E.M. , Shinohara, R.T., Shea, C.D., Reich, D.S., and Crainiceanu, C.M. (2013) Automatic lesion incidence estimation and detection using multi-modality longitudinal MRIs. American Journal of Neuroradiology 34(1), 68-73.

Want to learn more?

Introduction to Neurohacking in R (Coursera)
(www.coursera.org/learn/neurohacking/)