Practical Image Math with ROIs

in Neuroimaging

- Automated, Semi-automated, Manual
- Structure ID (Volumetric measures)
- Masking tracts (Mask multiplication: Measurement)
- Overlays (Mask addition: Identifying Commonalities)
- Brain Extraction (Mask multiplication)
- Segmentation (Tissue Type Identification)

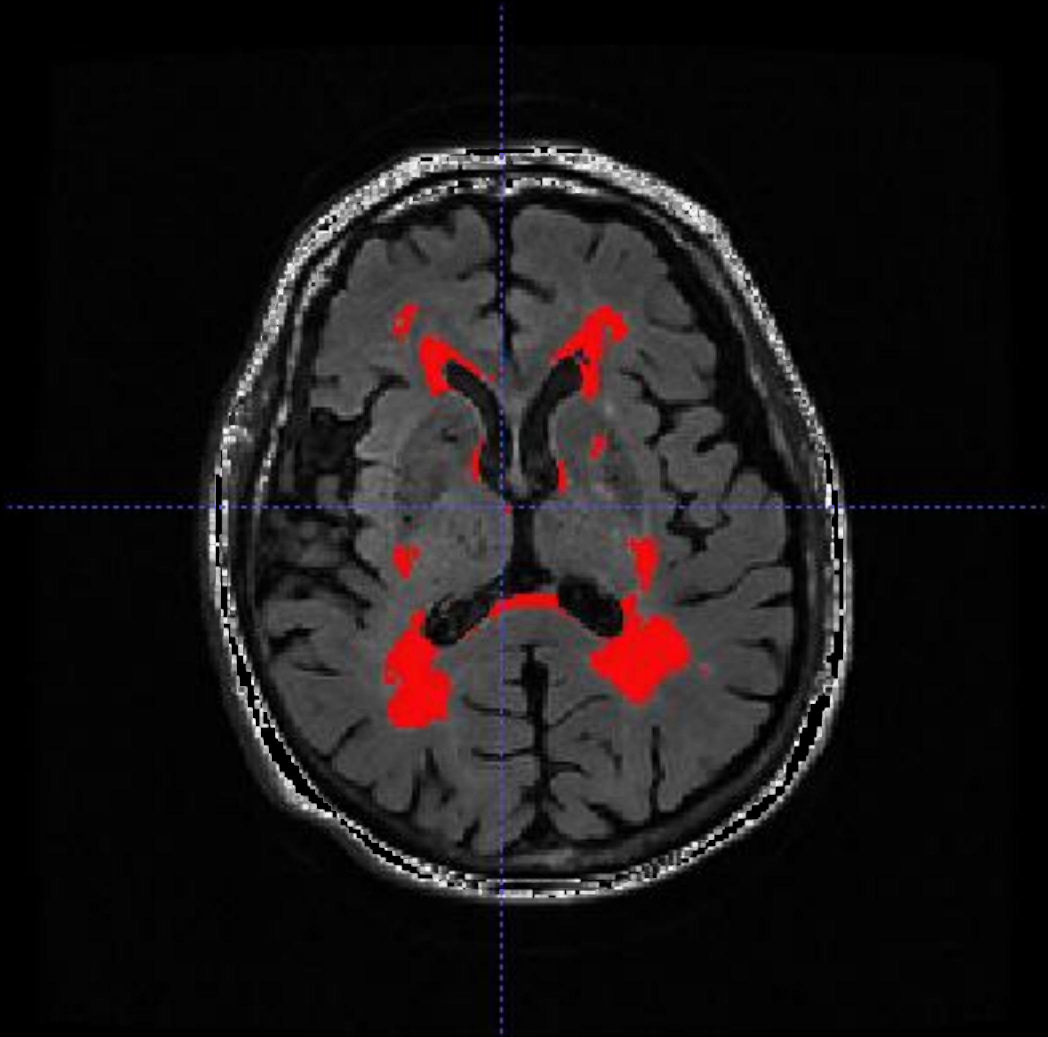
ROI & VOI

ROI = Region of Interest. It may be 2D (on a photograph) or 3D in a volume.

VOI =Volume of Interest. It is always 3D.

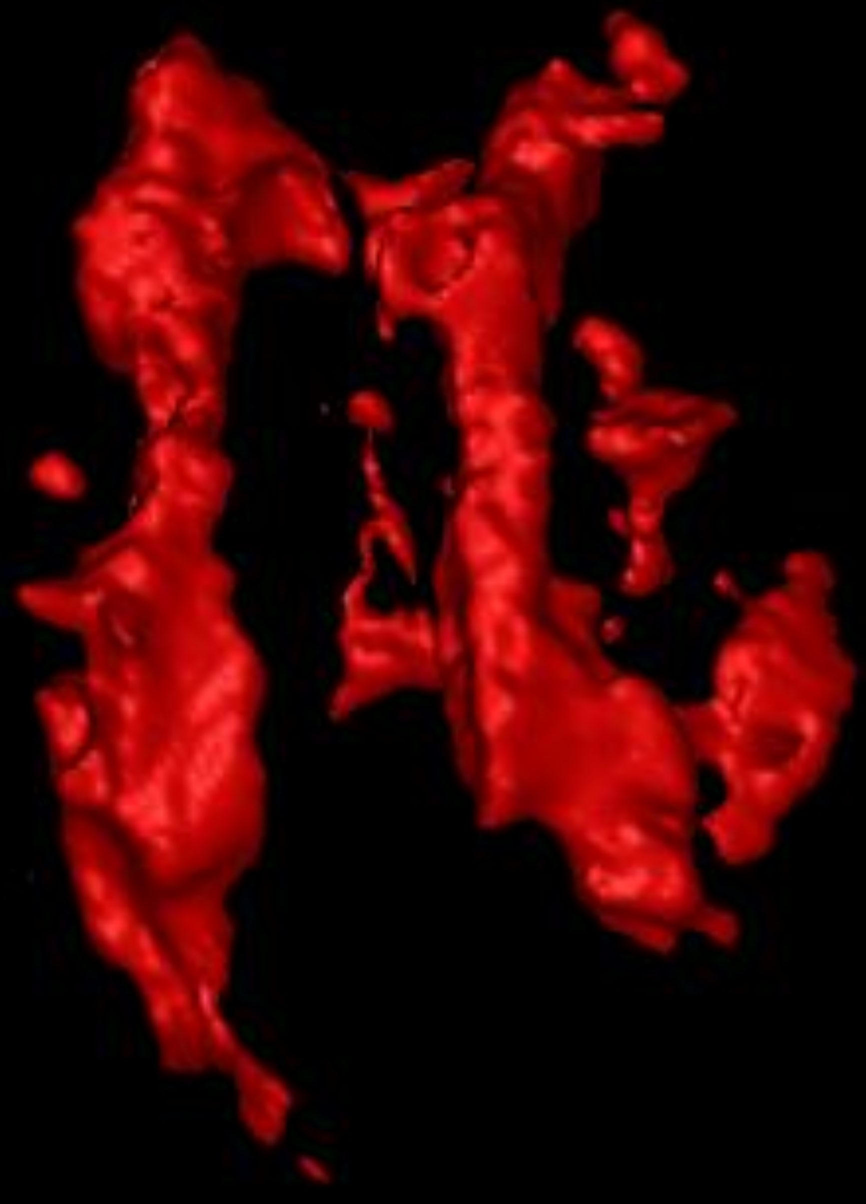
When we manually identify ROIs in the brain: (e.g., brain structures, lesions, tissue types, activations), we do so slice by slice (2D), but the finished object is 3D.

Finding WMH* ROIs, slice by slice



*white matter hyperintensities

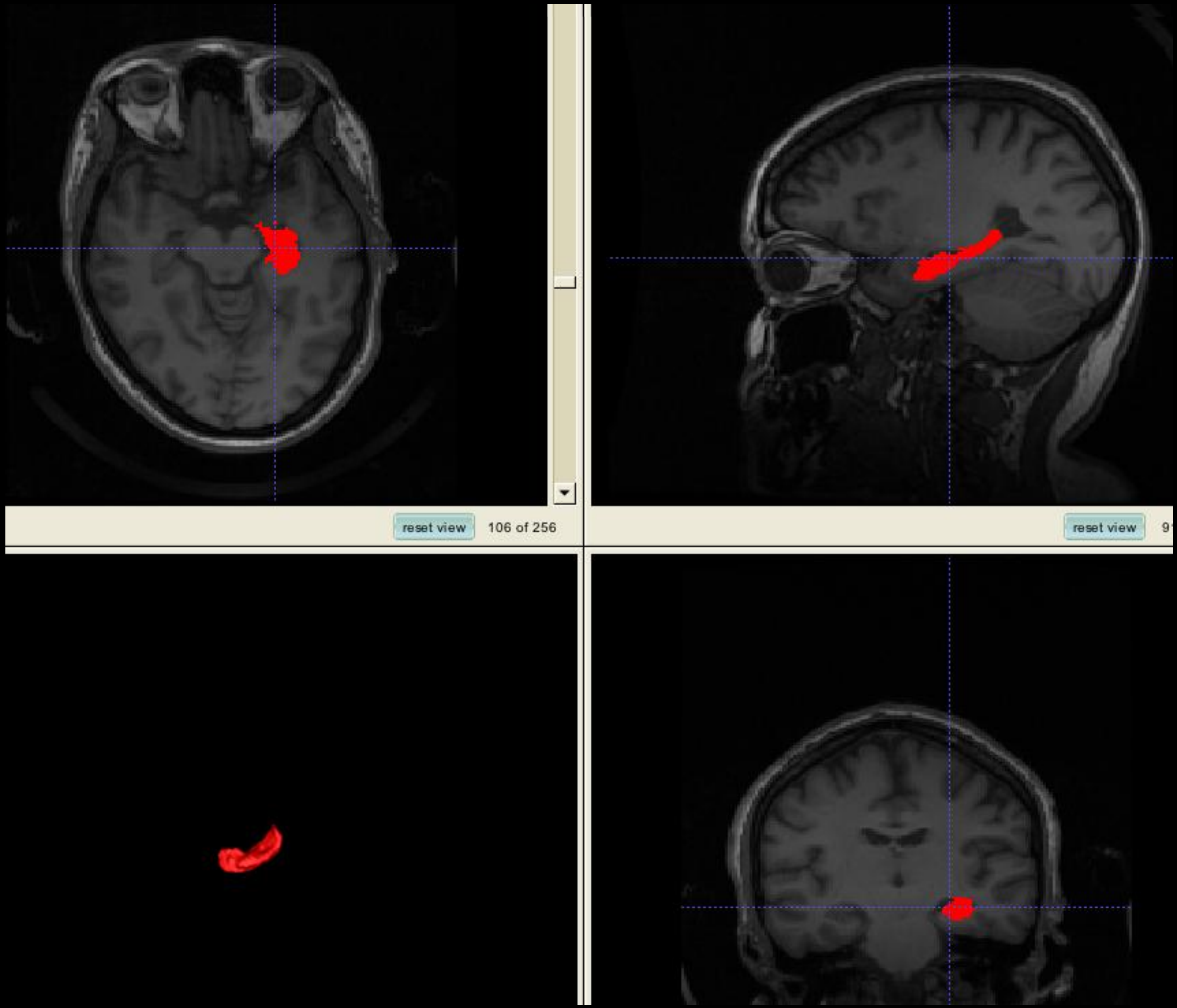
Putting WMH ROIs together in a 3D rendering



Finding and Masking Structures

One common neuroimaging task is to identify a particular brain structure.

Automated Hippocampus Masking: FSL



Finding and Masking Tracts

The brain has white matter tracts (i.e., wiring, axon bundles).

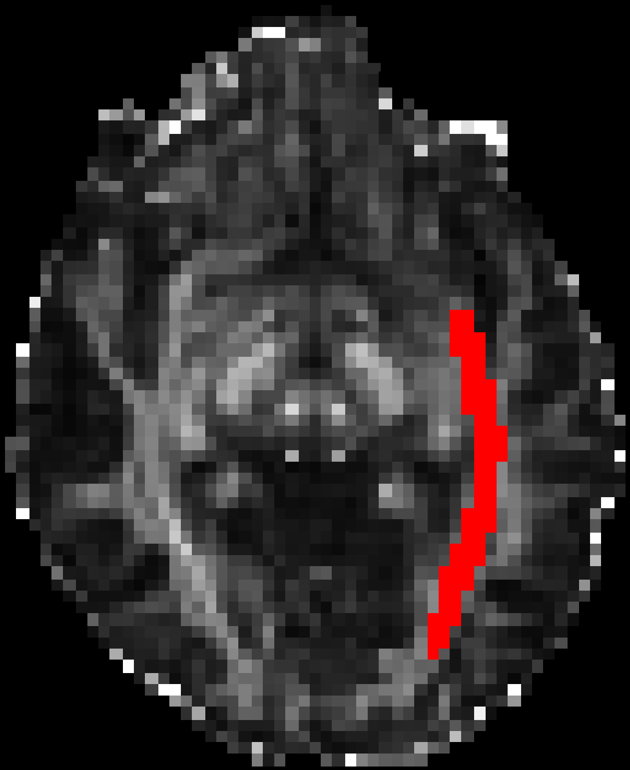
Tracts vary among individuals: they change with age, education, disease…

We can ID the tracts in a variety of ways.

Once we ID the tract, we can create a 1/0 roi mask.

Automated (but constrained) tracking of the Inferior Occipital Fasciculus.

Automated methods are useful, perhaps critical for identifying white matter tracts

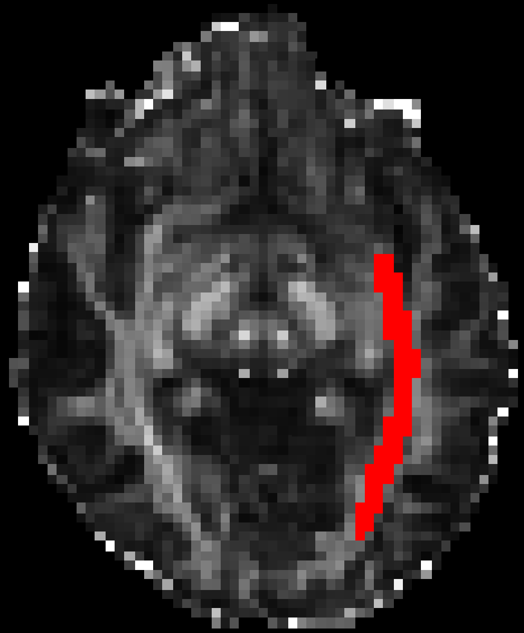


FSL 4.X probtrackx

We can multiply other images (anisotropy, diffusivity, wmh) by the mask to measure values in the tract.

- e.g., IOF x FA = FA values of IOF.

Mean FA of IOF: 0.44
# of voxels: 614



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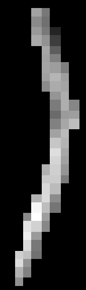
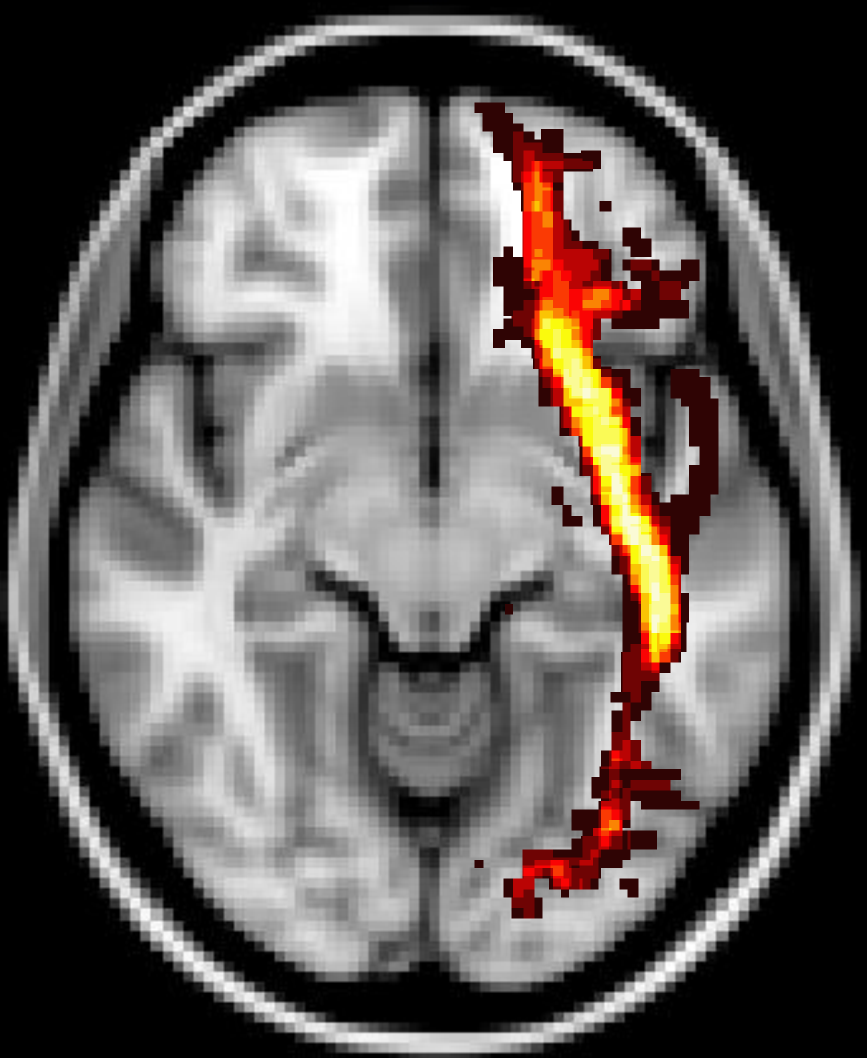


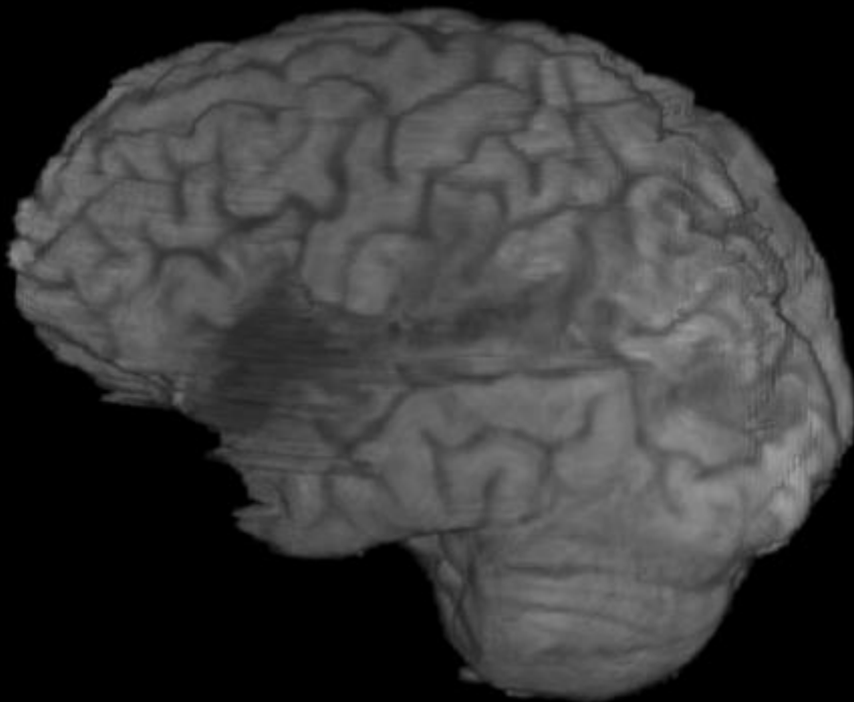
FA=Fractional Anisotropy
IOF=Inferior Longitudinal Fasciculus

IOF+IOF+IOF….



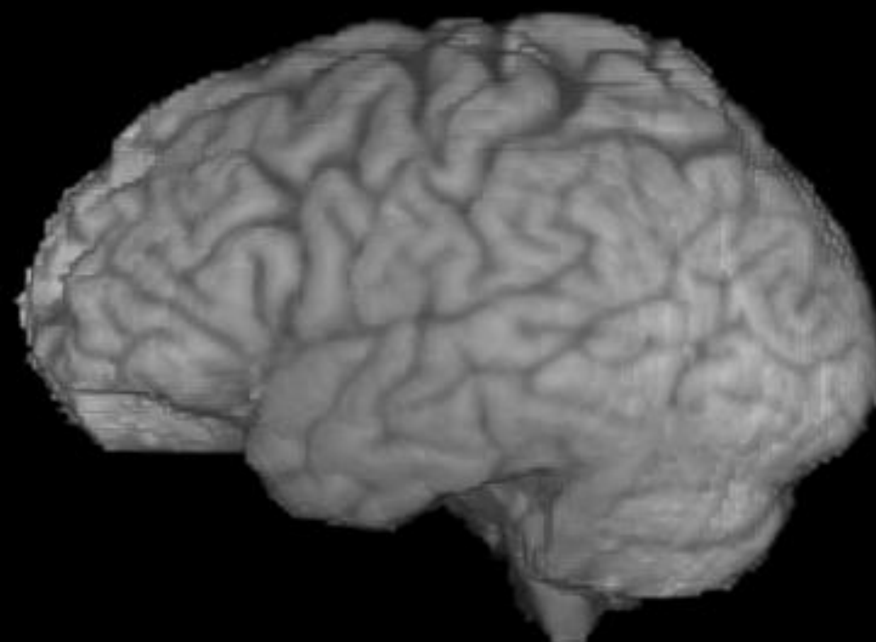
We can add binary IOF masks to identify overlap

Brain damage can affect function.



3D Rendering:
Normal Brain

3D Rendering:
Lesioned Brain



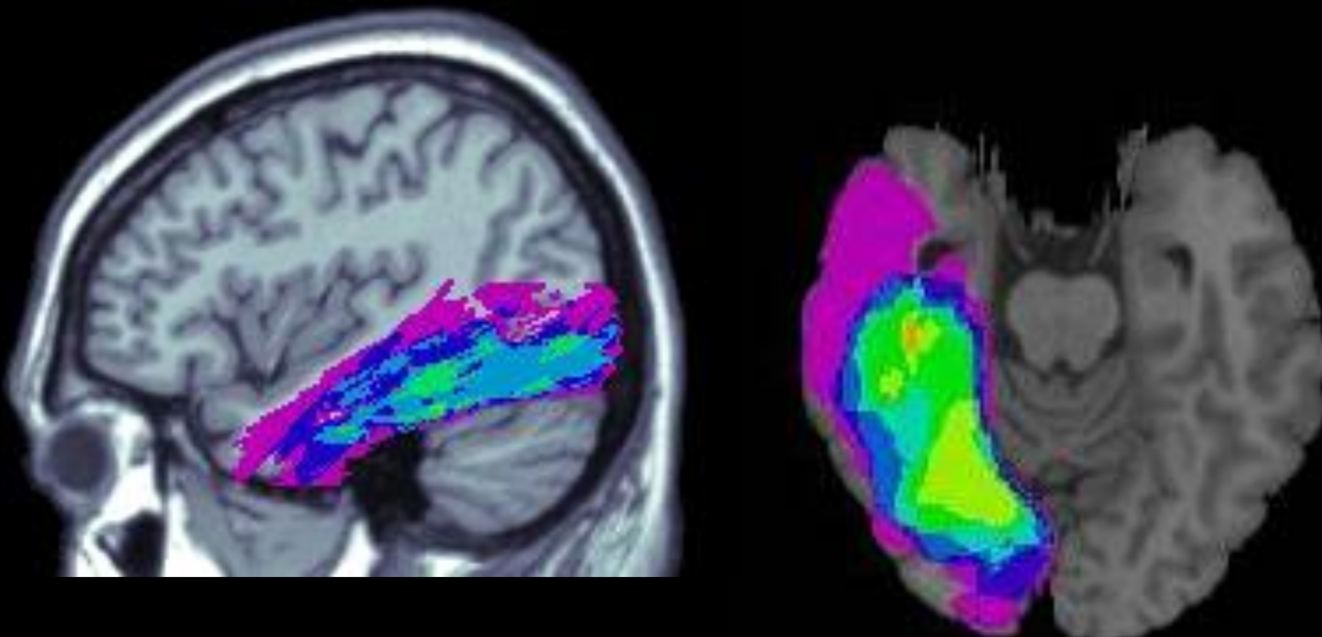
Mapping abnormalities

To test hypotheses that the location of damage or the amount or severity of damage result in particular deficits, we must mask damaged areas.

Like structure ID, ID of abnormalities is mostly manual.

Lesions Causing agraphia: Manual ID

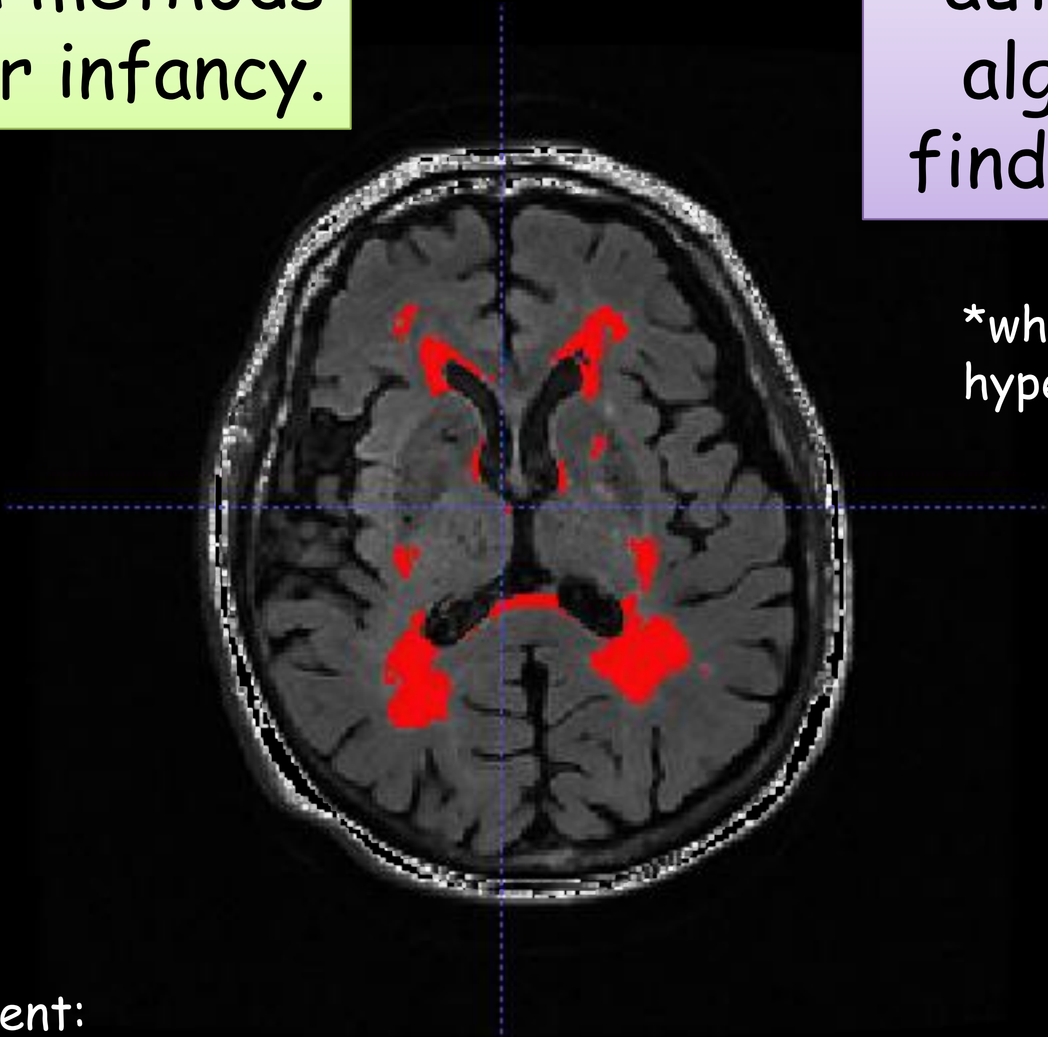
image+image+image… to identify overlap.



From Rapcsak & Beeson (2004). (Thanks to Hyesuk Cho)

Automated & semi-automated methods are in their infancy.

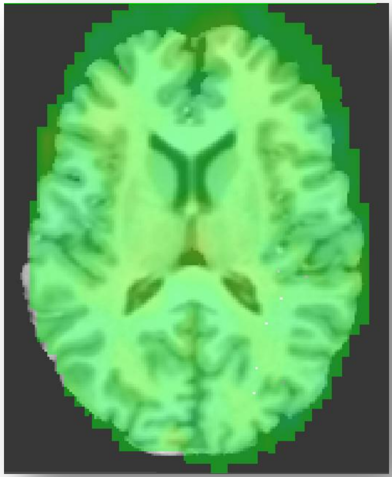
Here, a semi-automated algorithm finds WMH*



*white matter hyperintensities

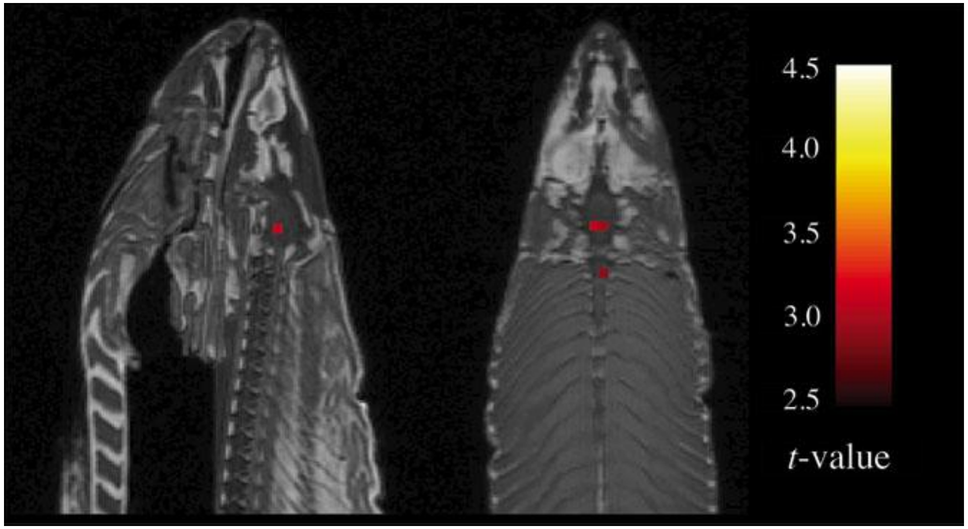
Thought experiment:
How would you determine the following:
-Do the WMH overlap with any tracts?
-Does Fractional anisotropy drop in WMH?

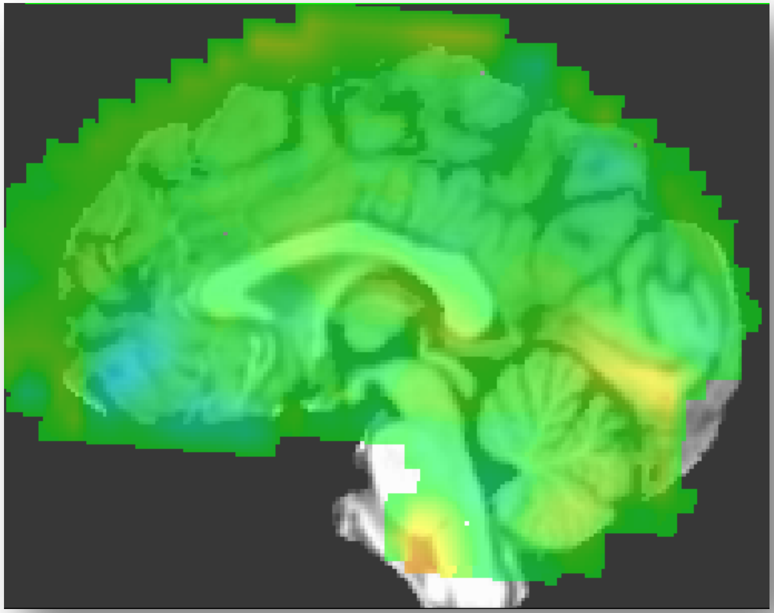
Functional MRI



fMRI measures activation in the grey matter.

Yet, it is easy to find functional activations outside grey matter, outside of the brain, or in the brain of a dead salmon.





Thanks to Kyle Almryde

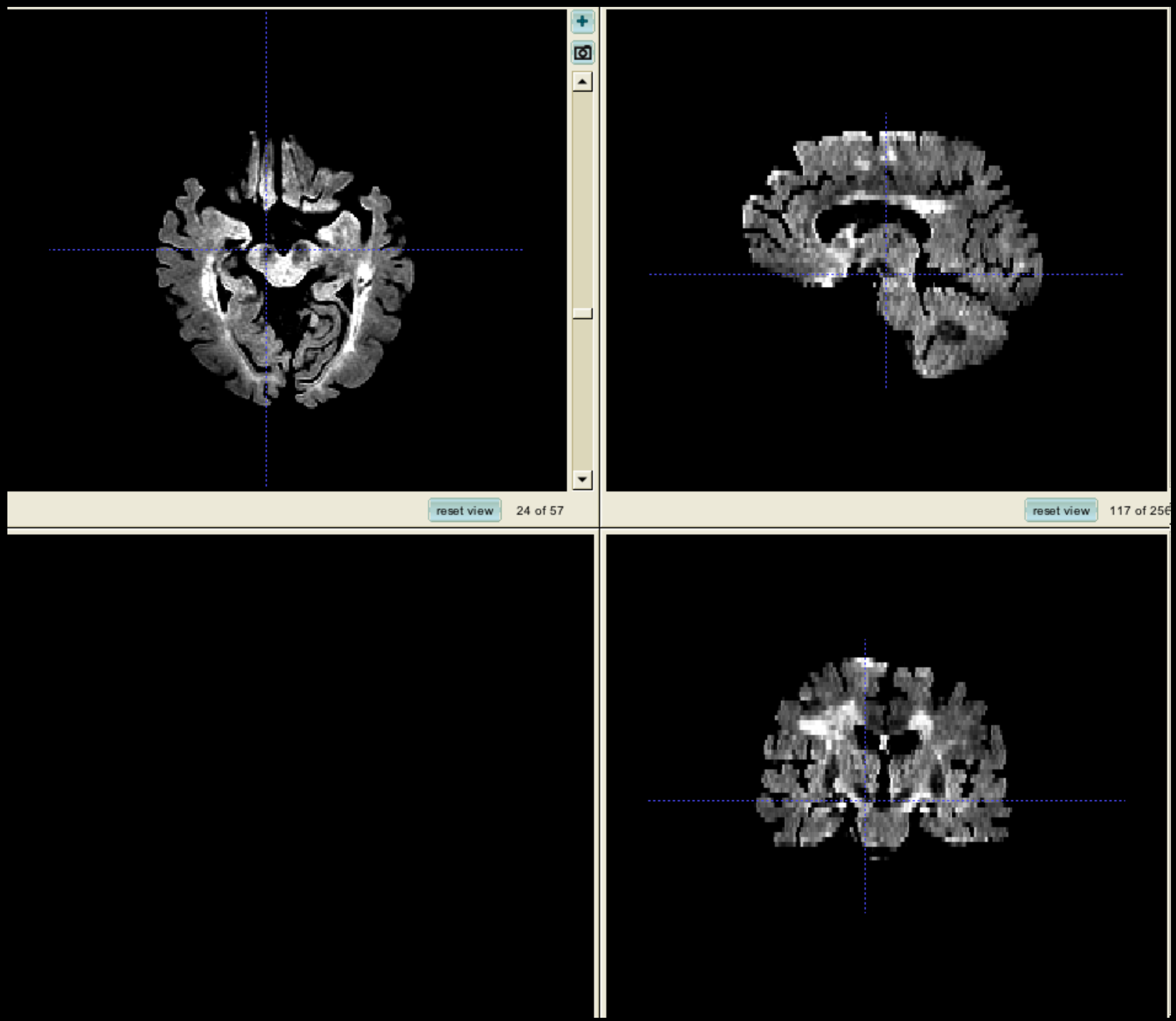
Brain Extraction

Brain extraction is the process of removing the nonbrain from the image you want to analyze.

It is an important part of processing fmri data, because we know we are not interested in activation outside the brain.

Brain extraction generates a brain mask that can be multiplied by the original to get the extracted brain.

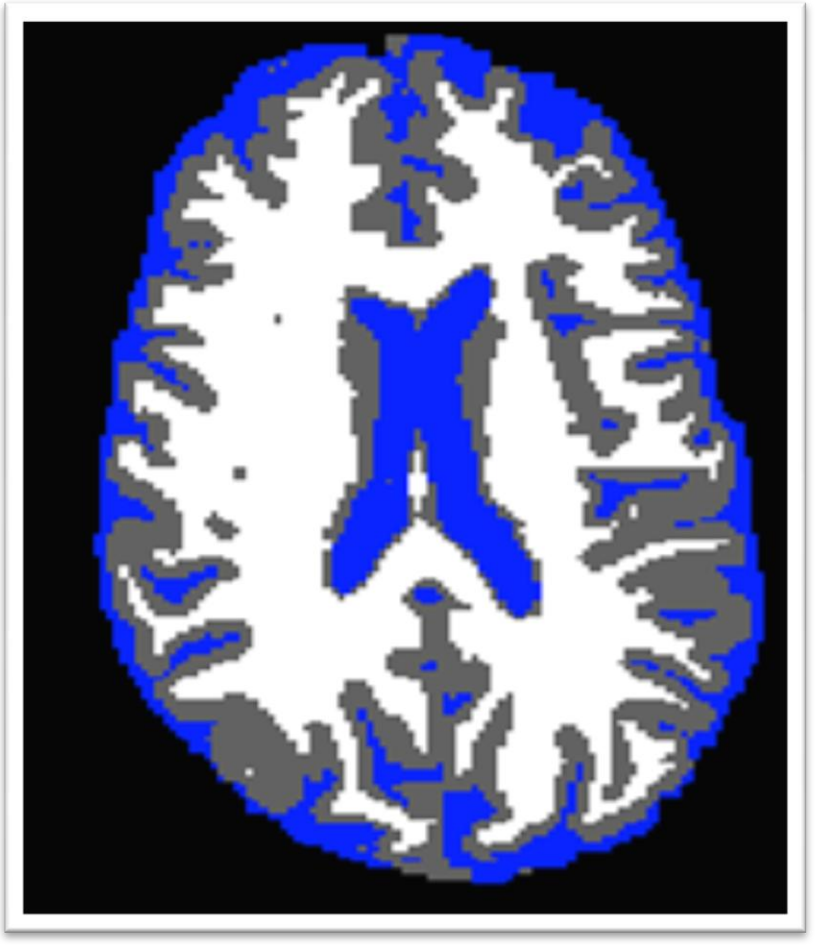
Flair image X Brain mask = Extracted brain.



Segmentation

Segmentation is the process of identifying tissue types: Grey Matter (GM), White Matter (WM) and Cerebrospinal Fluid (CSF)

Thought experiment: Could segmentation help with fmri analysis?



Summary

Array addition and multiplication are very common neuroimaging tools.

Most programs have "image math" utilities that will do these manipulations, along with subtraction and division.

Much of the time, image math revolves around the use of masks (ROIs and VOIs) that can be added, or multiplied to identify, compare, measure or clean image data.

Common tasks are identification of structures & lesions; overlap maps for lesions, tracts & activations; brain extraction; and segmentation.

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