

Structural MRI

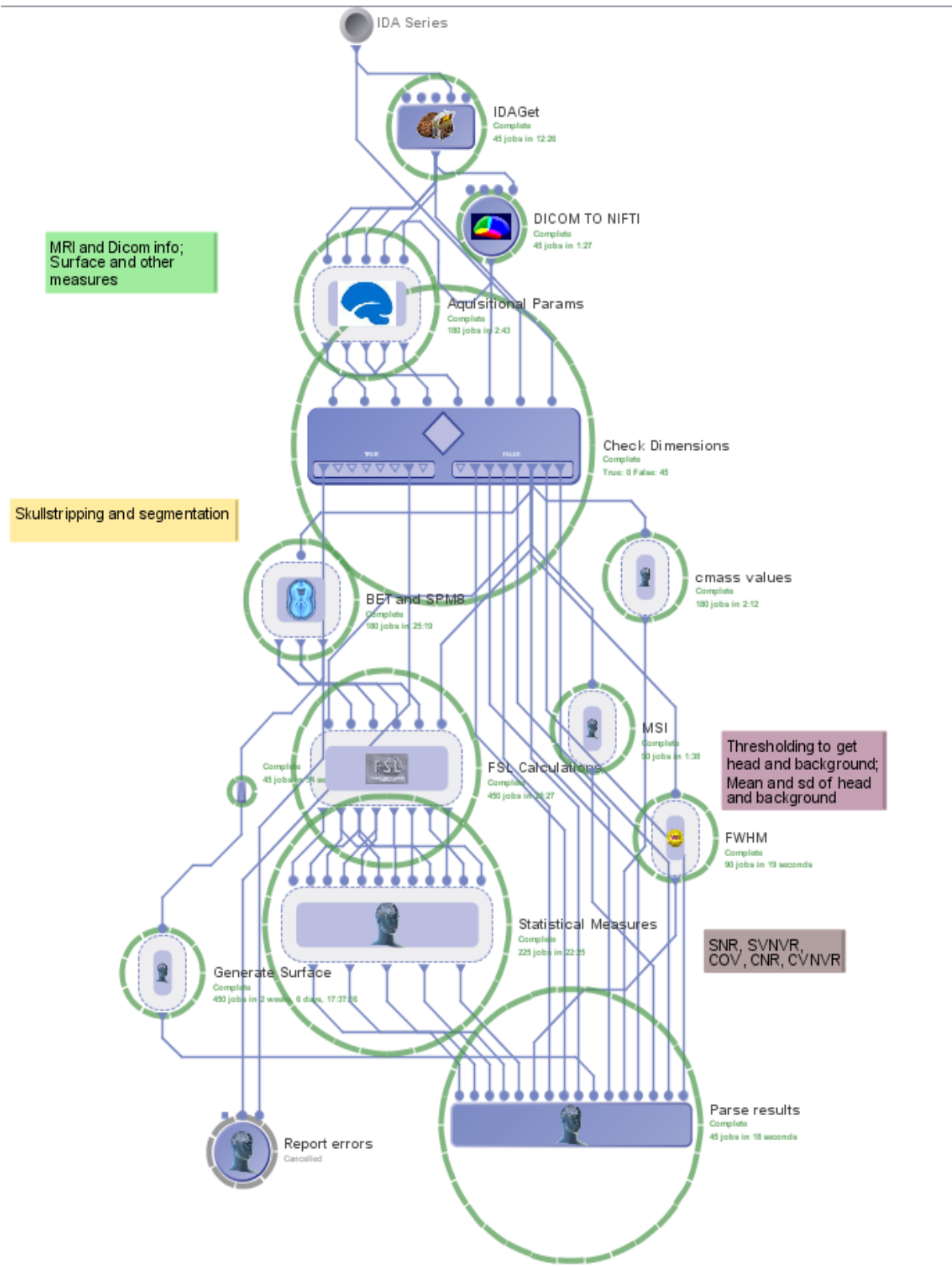
Preprocessing:

1. IDAGet module downloads dicoms for each subject from the IDA
2. DCM2NII converts the dicoms to nifti format
3. Several tools are used to extract the important information from the dicom and nifti headers
 - a. FreeSurfer's MRIConvert
 - b. AFNI's dicom_hdr
 - c. DICOM Summarize extracts patient metadata
4. XML check script takes in the various header information, checks for discrepancies and warning signs that the data is not suitable for analysis and reports all problems to the Conditional module
5. Conditional module shuttles all suitable data to the main QC part of the workflow and all data that xml_check has determined to be unsuitable to the error reporting module
6. SPM separates grey and white matter for use in the calculations section

QC Calculations:

1. Center of mass using BIRN tools
2. Mean Slice Intensity (MSI)
3. Signal to Noise Ratio (SNR)
 - a. Signal intensity of image is divided by signal intensity of the background
4. Signal Variance to Noise Variance Ratio (SVNVR)
 - a. SNR using variance
5. Contrast to Noise Ratio (CNR)
 - a. Mean of grey and white matter signal intensities are subtracted from each other and divided by mean signal intensity of the background
6. Contrast Variance to Noise Variance Ratio (CVNVR)
 - a. CNR using variance
7. Coefficient of Variation (COV)
 - a. Mean image intensity divided by standard deviation of background intensity
8. Full Width at Half Maximum (FWHM)
 - a. AFNI software calculates this
 - b. Determined using the variance of derivatives method of Worsley et al. Computed for each axis in the image volume. Also, measures the number of "resolvable elements" by dividing the number of voxels in the brain by the geometric mean of the FWHM of each axis.

sMRI workflow



MRI and Dicom info;
Surface and other
measures

Skullstripping and segmentation

Thresholding to get
head and background;
Mean and sd of head
and background

SNR, SVNVR,
COV, CNR, CVNVR

Functional MRI (human)

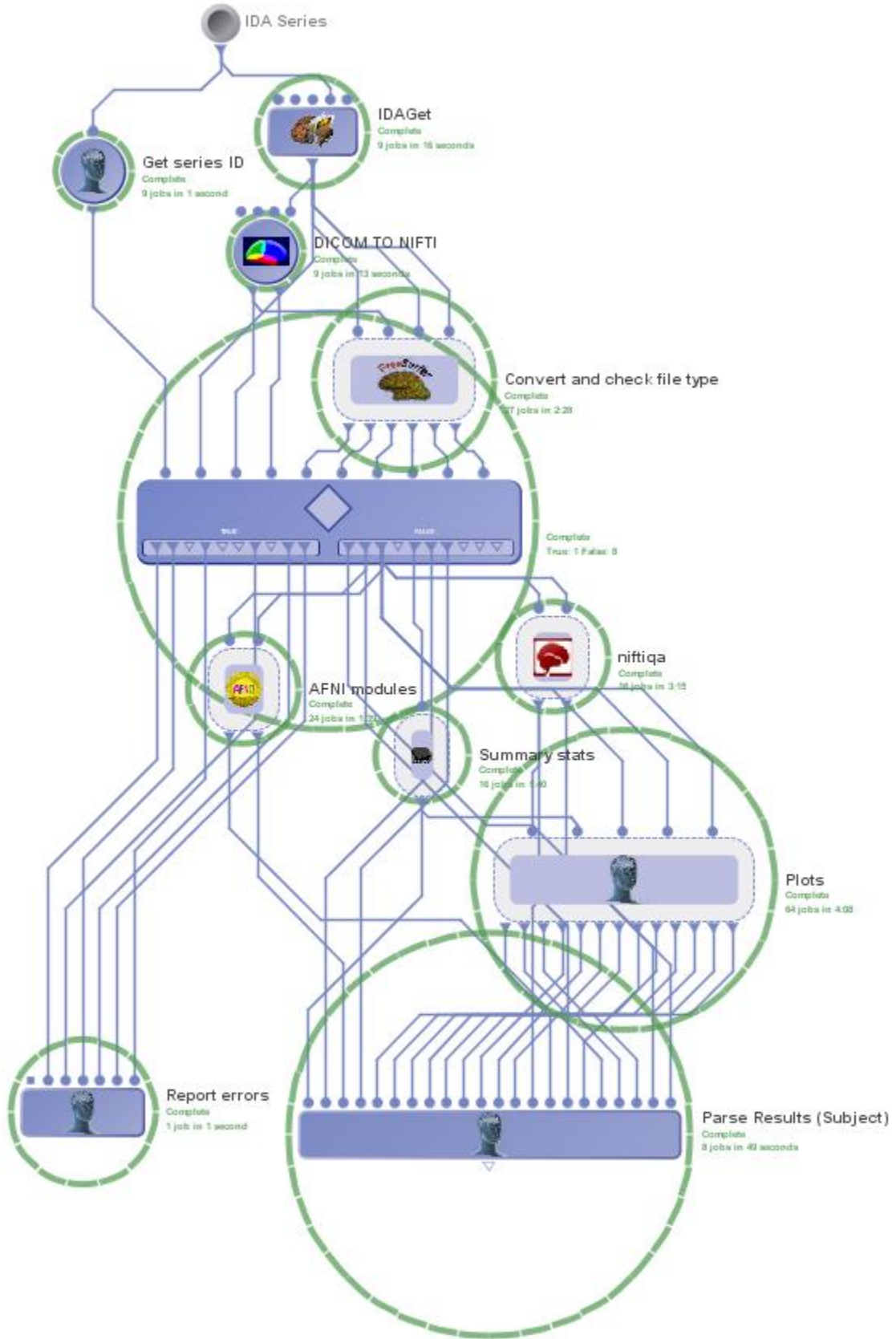
Preprocessing:

1. The same preprocessing steps are used as above: IDAGet, DCM2NII, MRIConvert, DICOM Summarize, Dicom hdr, XML check, and a conditional modules to filter out unresolvable errors.
2. In this workflow, DCM2NII servers an additional purpose of reporting errors about the validity of the data in terms of validating the number of dicoms and volumes.

QC Calculations and Analysis:

1. Signal to Noise ratio is calculated in the same way as in sMRI protocol, but for each volume in the time series.
2. 2 FSL motion outliers graphs
 - a. Dvars over time, a measure of how much the intensity of image changes in comparison to previous time point
 - b. Framewise Displacement over time
3. FSL MCFLIRT is used to make 3 plots
 - a. Mean Displacement (absolute and relative)
 - b. Estimated Rotations in radians (for x y and z planes)
 - c. Estimated Translations (for x y and z planes)
4. A BIRN based tool called NIFTIQA produces a variety of files and metrics:
 - a. Masks of each slice in the image with histogram of intensities
 - b. The mean image of all the time series volumes, as well as thumbnails of each slice, and a histogram of intensities
 - c. Mean slice intensity values and graph
 - d. A detailed slice report containing information about the number of voxels, mean intensity, standard deviation, snr, and minimum and maximum intensities for each slice
 - e. SNR image and histogram
 - f. Standard Deviation image and histogram
 - g. Image of the slope with histogram
5. Another BIRN based tool called FMRIQA_GENERATE produces more files, metrics, and plots:
 - a. For the X, Y, and Z planes, many graphs are created
 - a. Center of Mass by volume plot and histogram calculated both the normal images and masked images
 - b. FWHM plot and histogram
 - b. Mean intensity per volume plot and histogram
 - c. Additional calculations are made on the masked image
 - a. Mean of running difference per volume (masked tdiff vol means) plot and histogram
 - b. Mean Intensity per volume (similar to mean slice intensity) plot and histogram
 - c. Mean of the mean of volume difference plot and histogram (m diff vol means)
 - d. Percent of outlier voxels (using AFNI 3dToutcount) image, plot, and histogram
 - e. SFNR image
 - f. Slice variation image and color graph
 - g. Spectrum max (over ROI) image plot and histogram, which measure the frequency (Hz) by the magnitude
 - h. Spectrum mean (same as above but for mean)
 - i. Standard deviation MRI image which highlights outlier regions such as the eyes
6. AFNI tools called afni_proc calculates the TSNR (temporal SNR: ratio of mean signal to the temporal standard deviation, averaged across subjects)

fMRI human workflow



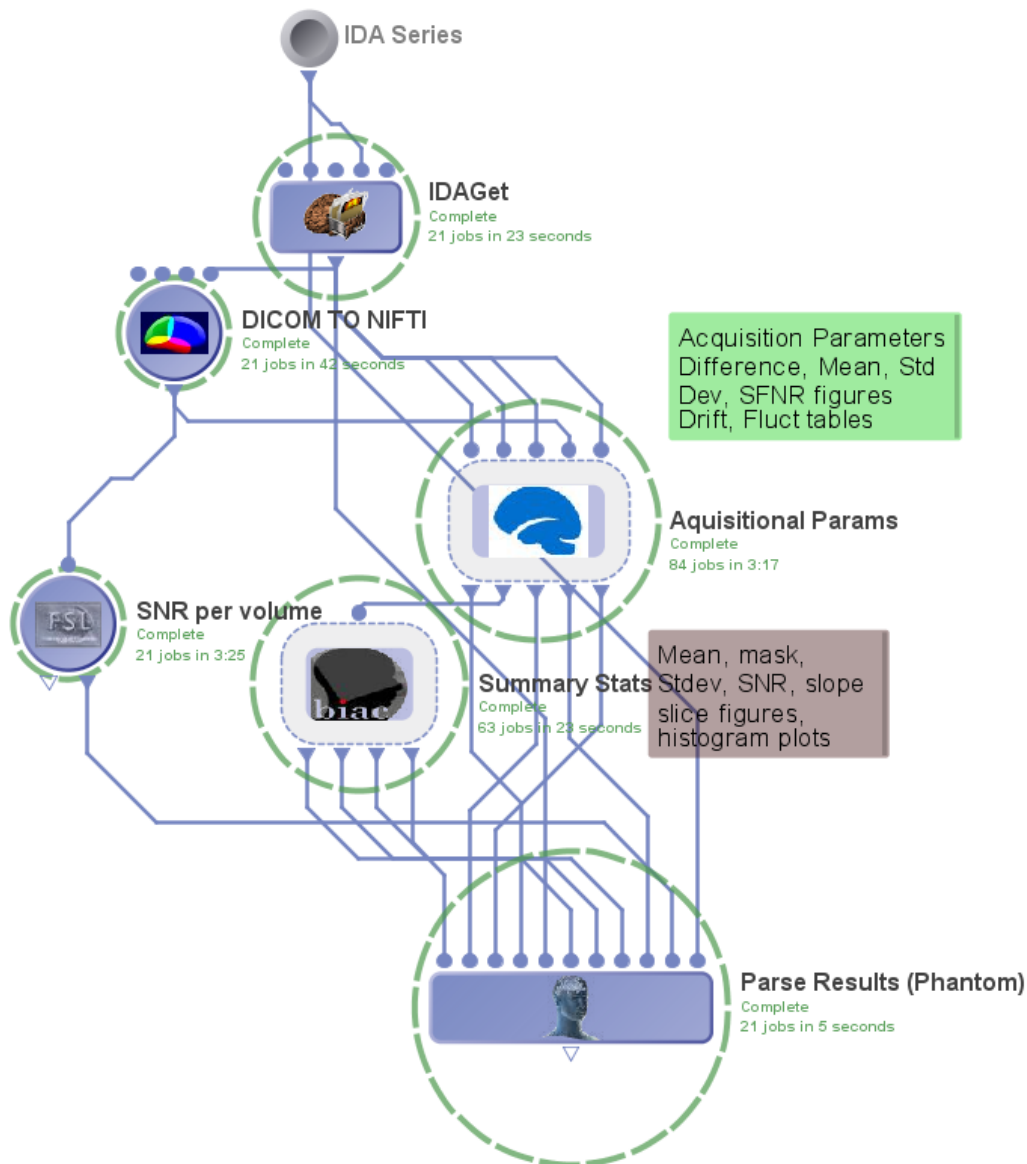
FMRI (Phantom)

1. This protocol is a diminished version of the human protocol. The preprocessing steps are the same as all workflows.

QC Calculations:

1. SNR per volume using FSL
2. FMRIQA_PHANTOMQA, a reduced form of FMRIQA_GENERATE, is run to produce:
 - a. Mean image
 - b. Odd even difference image
 - c. Standard deviation image
 - d. SFNR image
 - e. Center of mass plots of x, y, and z planes
 - f. Plot of raw signal, spectrum magnitude, and relative standard percents

fMRI phantom workflow



Diffusion Tensor Imaging

Preprocessing:

1. Same steps as previous workflows. In this modality, DCM2NII is used to extract the b-values and diffusion gradient directions matrix from the dicom headers. This process has been found to be somewhat unreliable and we are working on an alternative solution.

QC Calculations and Imaging:

1. Center of mass is calculated on the nifti image the same as in the sMRI workflow but with multiple volumes corresponding to the gradient directions.
2. Signal to Noise ratio per volume is calculated in the same way as in the fMRI protocol, but with multiple volumes corresponding to the gradient directions.
3. The NIFTIQA module from the fMRI workflow is adapted for use in this DTI workflow. It produces many similar outputs:
 - a. Masked image for each volume with images of each slice
 - b. Mean image of all the volumes and a histogram of intensities
 - c. Mean slice intensity plot with a detailed report of each slice (the same information as in fMRI)
 - d. Slope, SNR, and Std Dev, images and intensity histograms
4. TrackVis's DTI Recon is run on the dicoms to create the adc, B0, DWI, FA, and e1-3 images that will be used create the fiber tracts and calculate additional metrics
5. DTI_tracker and spline filter create the fiber tracts
6. The e1, e2, and e3 images from dti recon are averaged to create the mean diffusivity image
7. Center of mass is calculated on the B0 image

DTI workflow

