ASL/CBF Pipeline

Structure & Objectives

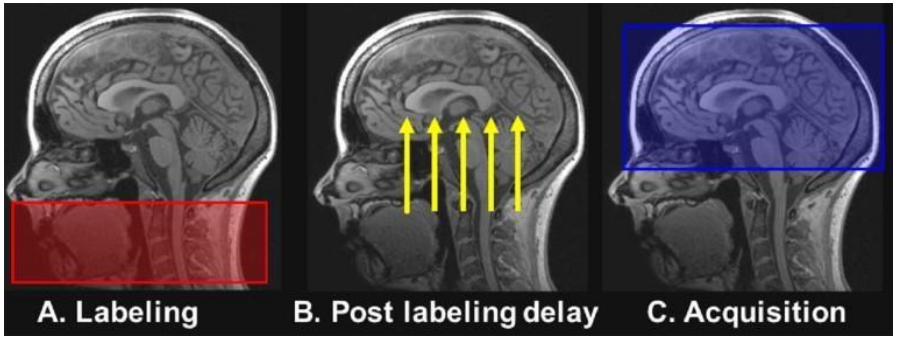
Lauren Beard

Outline

- Overview of ASL MRI
- Overview of pipeline procedure
- Breakdown of ASL-specific pipeline processes
- Output directory structure
- Primary outputs

Arterial Spin Labeling (ASL)

- Definition: MRI technique used for **quantifying CBF** using magnetically labeled arterial spins as an endogenous tracer
- Method:
  - Two brain images are acquired: one with a magnetic inversion at the neck to label the inflowing arterial blood, and one without the inversion
  - The two images are subtracted to cancel out the static brain tissue signal and reveal a perfusion-weighted image
- Multiple types:
  - PASL: pulsed ASL
  - CASL: continuous ASL
  - **pCASL: pseudo-CASL**



ASL Pipeline

ASL-Specific Pipeline Requirements

Design File: specify modules and sets parameters

- Online design file: specific to subjects that were reconstructed online
- Offline design file: specific to subjects that were reconstructed offline

Cohort File: csv of all subjects to be run

- Includes: bblid, datexscanid, path to raw ASL image, path to antsCT output, path to M0 image

* Note: some subjects had 2 M0 images collected in order to improve SNR
    - These two image should be averaged to create a single M0 image for each subject

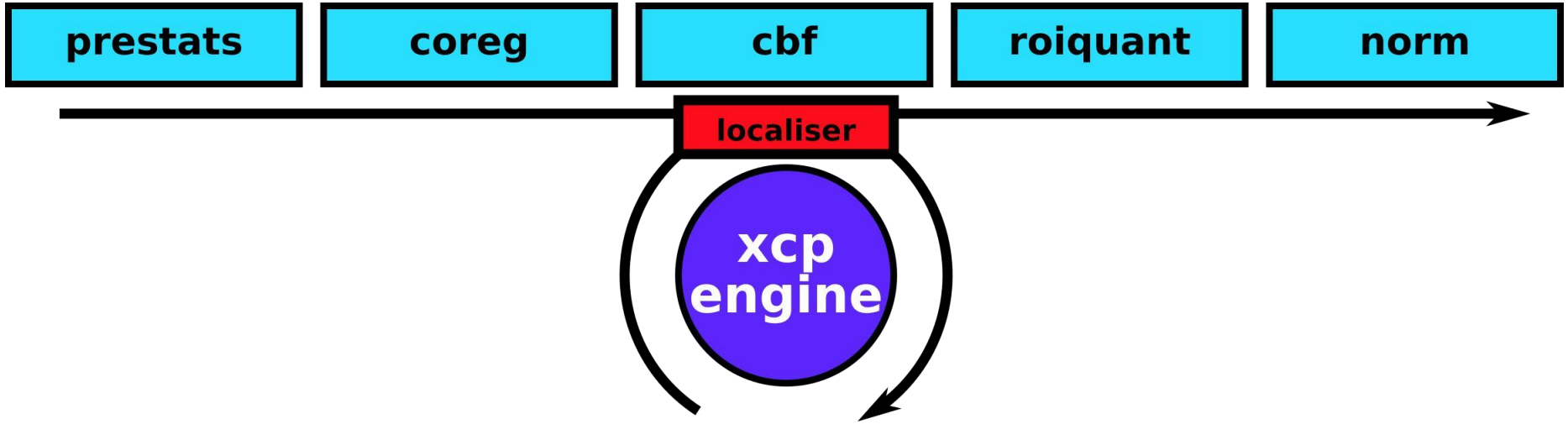
Default ASL Parameters

FWHM: 6 mm ● Smoothing, typically 4-8 in ASL lit.	Alpha: 0.72 ● Labeling efficiency, corrects for background suppression pulses
Lambda: 0.9 mL/g ● Blood to brain partition coefficient for gray matter	M0 scale: 10 ● M0: magnetization of arterial blood
$T_{1,blood}$: 1.65 seconds ● Longitudinal relaxation time of arterial blood	Post labeling delay (PLD): 1.5 ms

- Used to compute CBF Factor:

$$CBF = \frac{6000 \cdot \lambda \cdot (SI_{control} - SI_{label}) \cdot e^{\frac{PLD}{T_{1,blood}}}}{2 \cdot \alpha \cdot T_{1,blood} \cdot SI_{PD} \cdot (1 - e^{-\frac{\tau}{T_{1,blood}}})} [ml/100g/min]$$

ASL Pipeline Modules



ASL-Specific Module Details

Mask Creation

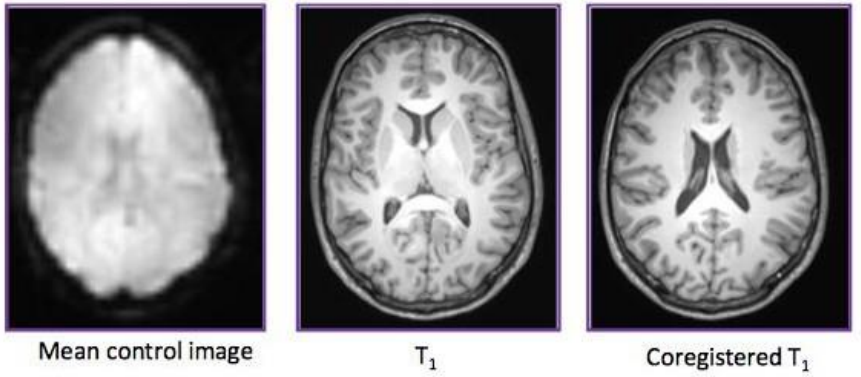
- Check for pre-existing map
- Create mask that determines whether image is tagged or untagged
- Fills 3D holes in the mask
  - Throw out voxels for which data is not available in all subjects and for those voxels that are below a certain threshold
    - Threshold = 0.1* (not stringent)
  - Fill in order to allow for voxel analysis across subjects

Realignment

- Remove the artificial motion component caused by systematic label/control signal modulations
- Realigns the ASL images to the reference volume
- Coregistration is to the first image, and resampling of images is into the space of the first image
- Sets realignment defaults: must pass to create resliced images
  - Higher quality setting → slower/more accurate realignment

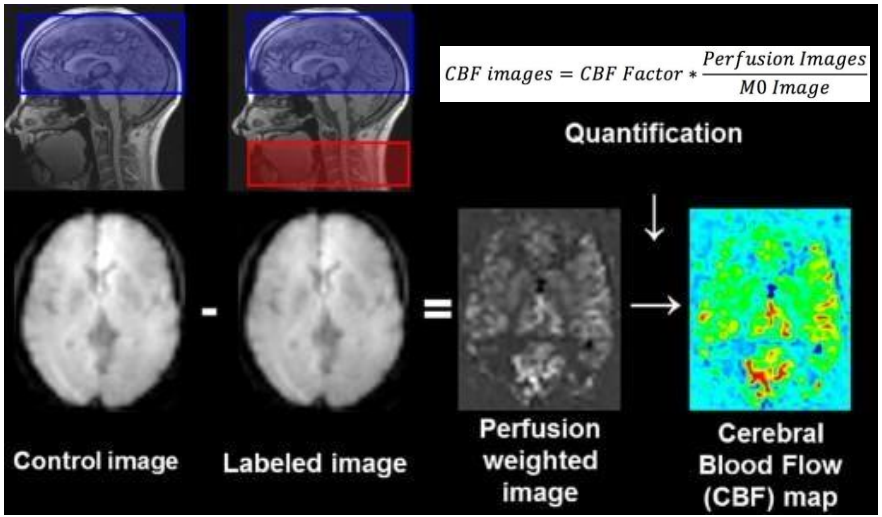
Coregistration

- T1 images and ASL: very different intensities
- Coregister the realigned ASL image to the subject's T1 image
- Coreg tool: FSL's epi_reg
  - BBL-specific adjustments: search angle 180 degrees (rather than original 90)
- Steps: first pre-align using FLIRT and the T1 brain, then adjust using BBR and the whole-head T1 brain
  - Target image: T1
  - Source image: mean ASL image

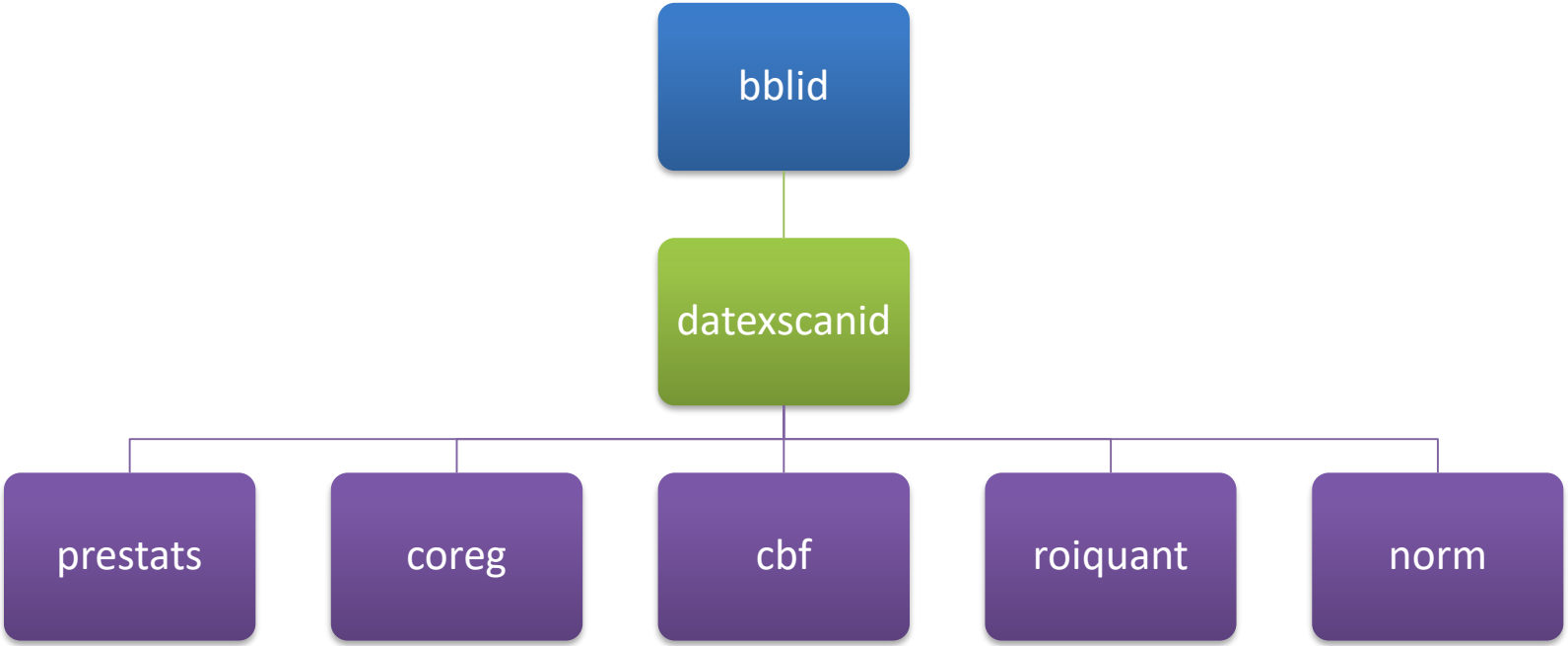


CBF Computation

- Creates perfusion images and mean perfusion image
  - Control image - tagged image
  - Smoothing happens prior to this subtraction to mitigate noise propagation
- Compute CBF factor and CBF images



Output Directory Structure



Primary Output

meanPerfusion: the voxelwise estimate of perfusion averaged over all label-control volume pairs.

negative_voxels: the number of grey matter voxels with negative cerebral blood flow estimates in the mean perfusion image.

negative_voxels_ts: the number of grey matter voxels with negative cerebral blood flow estimates over all time.

perfusion: a voxelwise time series of perfusion estimates.

tag_mask: a 1-dimensional mask indicating whether each volume is tagged (1) or untagged (0).