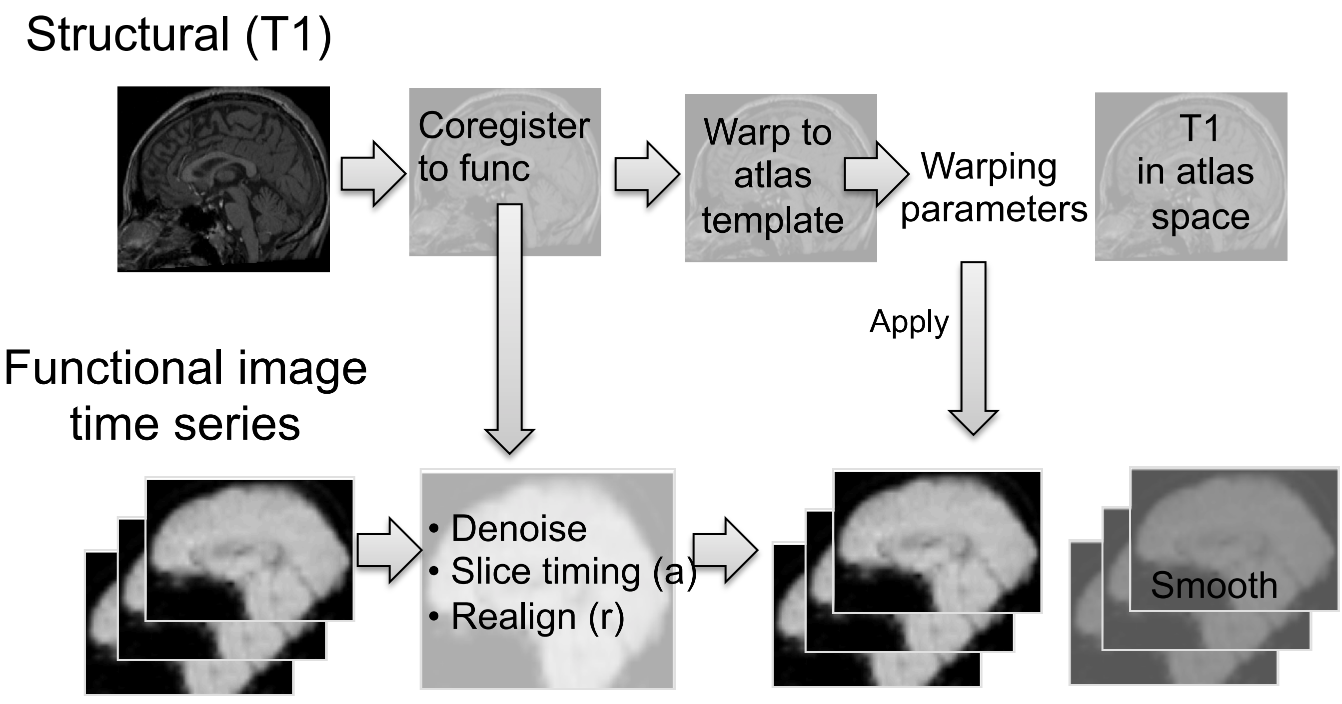
Module 9:
Pre-processing II

Pre-processing Pipeline

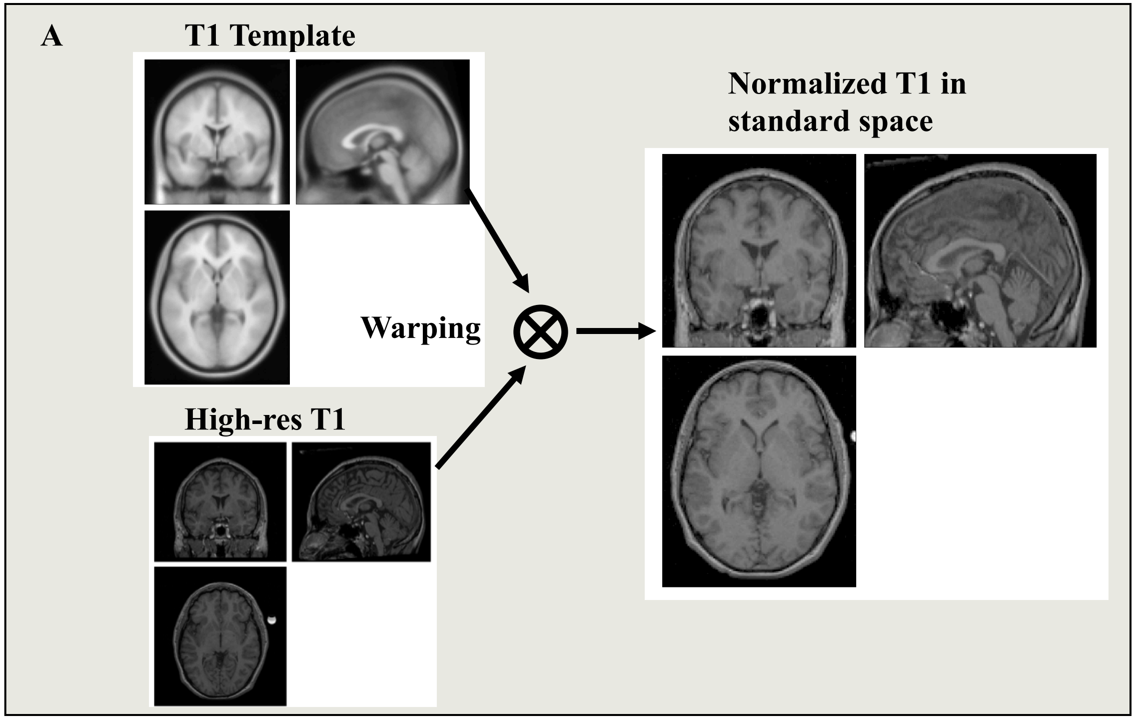


Preprocessing is performed both on the fMRI data and structural scans collected prior to the experiment.

Normalization

- All brains are different. The brain size of two subjects can differ in size by up to 30%.
- There may also be substantial variation in the shapes of the brain.
- Normalization allows one to stretch, squeeze and warp each brain so that it is the same as some standard brain.

The structural MR image used in the coregistration procedure is warped onto a template image.



Normalization

Pros

- Spatial locations can be reported and interpreted in a consistent manner.
- Results can be generalized to larger population
- Results can be compared across studies.
- Results can be averaged across subjects

Cons

- Reduces spatial resolution.
- Introduces potential errors.

Brain Atlases

- Talairach space (Talairach and Tournoux,1988)
  - Based on single subject (A cadaver of a 60 year old female)
  - Based on a single hemisphere.
  - The origin (0,0,0) is set at the Anterior Commisure.
  - Oriented so that a line joining the Anterior Commissure (AC) and the Posterior Commisure (PC) is horizontal.

Brain Atlases

- Montreal Neurological Institute (MNI)
  - Combination of many MRI scans on normal controls (152 in current standard).
  - All right-handed subjects.
  - More representative of population.

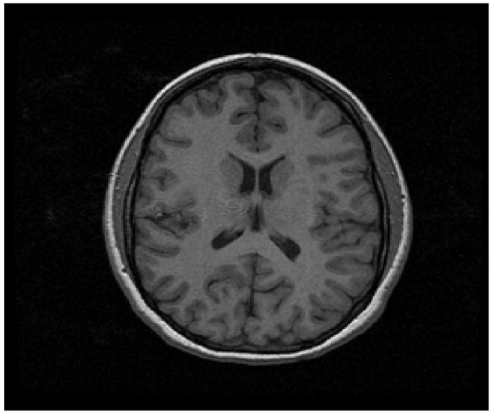
Normalization Methods

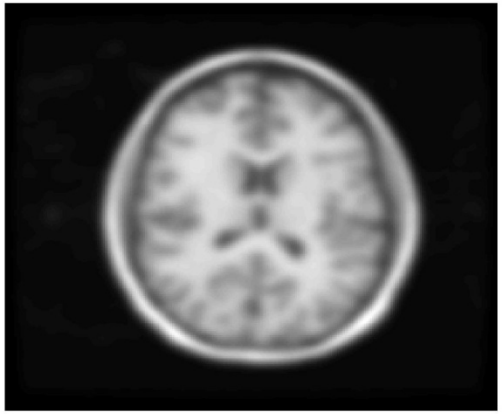
- Landmark-based methods
  - Align anatomical features in different brains
- Volume-based registration
  - Linear (e.g. affine) and nonlinear transformations
- Computational Anatomy
  - Diffeomorphic transformations
- Surface-based methods
  - Work on cortical surfaces

Spatial Filtering

- In fMRI it is common to spatially smooth the acquired data prior to statistical analysis.

- Can increase signal-to-noise, validate distributional assumptions and remove artifacts.





Spatial Filtering

Pros

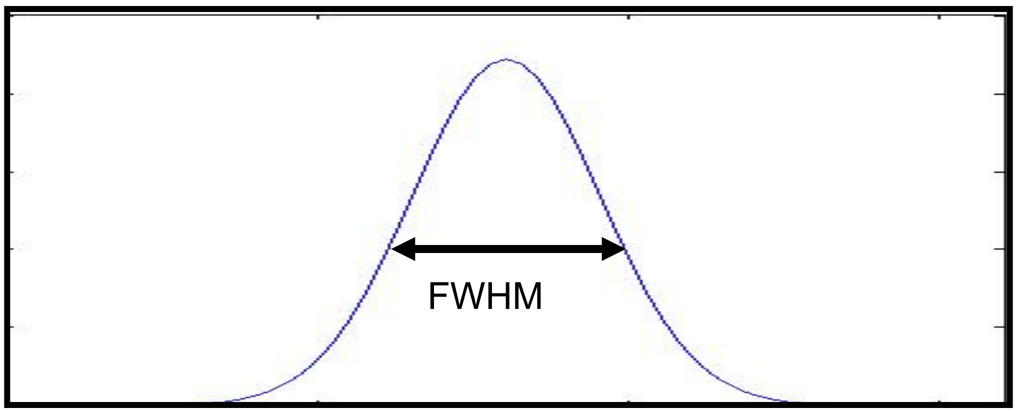
- May overcome limitations in the normalization by blurring any residual anatomical differences.
- Could increase the signal-to-noise ratio (SNR).
- May increase the validity of the statistical analysis.
- Required for Gaussian random fields.

Cons

- The image resolution is reduced.

Spatial Filtering

The size of the kernel is determined by the full width at half maximum (FWHM), which measures the width of the kernel at 50% of its peak value.

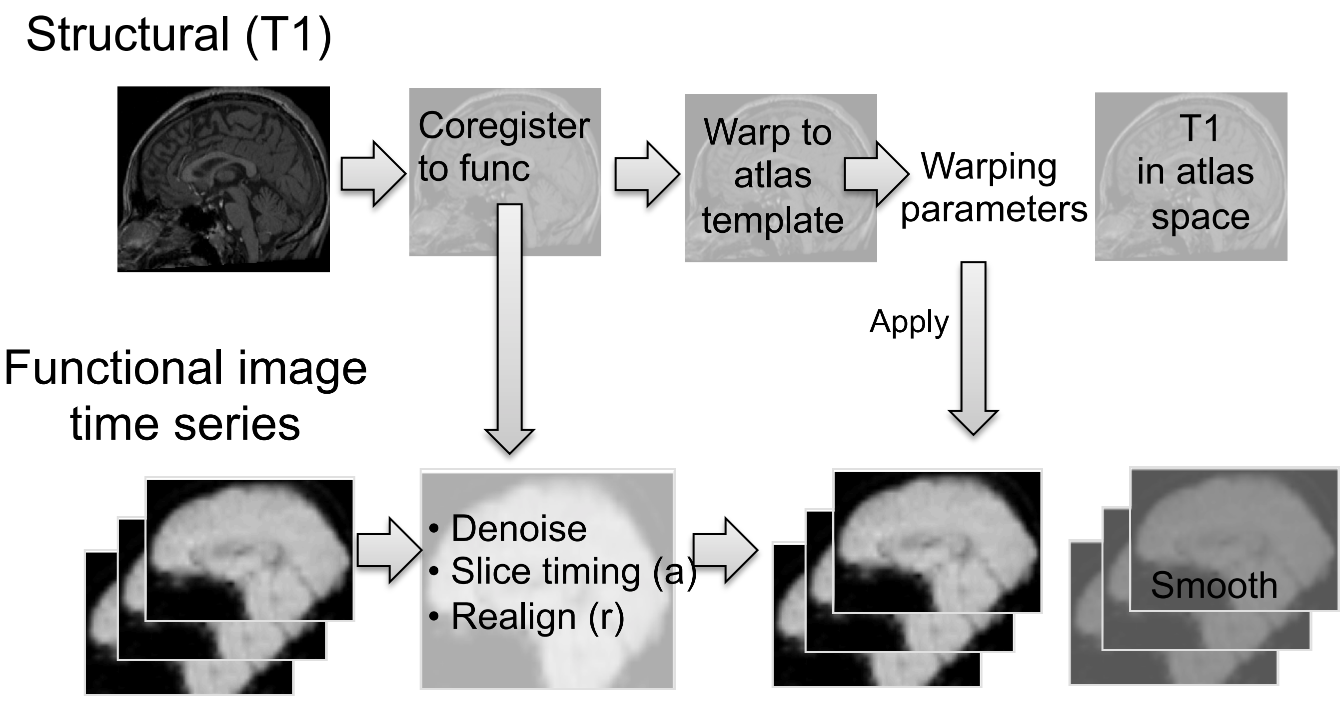


$$\sigma = \frac{FWHM}{2\sqrt{2\ln(2)}}$$

Comments

- The matched filter theorem states that a filter that is matched to the signal will give optimum signal to noise.
- Typically, the amount of smoothing is chosen *a priori* and independently of the data.
- Furthermore, the same amount of smoothing is applied throughout the whole image.
- Adaptive smoothing could be an option.
  - Non-stationary spatial Gaussian Markov random field.
  - Smoothing varies across space and time.

Pre-processing Pipeline



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End of Module