

PRE-PROCESSING OF VOLUMETRIC BRAIN IMAGING DATA

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- 3. Motion correction for functional imaging data
- 4. Image registration
- 5. Spatial normalisation / MR-image segmentation
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- Pre-processing is demonstrated in SPM software with the course example data:
 - NRM2018 grand challenge data: <u>https://openneuro.org/datasets/ds001705/versions/1.0.1</u>

WHY PREPROCESSING?

Typical imaging study includes:

- Various images from different modalities with different data formats
 - Structural MRIs (high anatomical detail)
 - Functional images (limited anatomical detail)
- Different orientations between images
- Movement within image modalities





TIw MRI

DATA FORMATS & CONVERSION

- After image reconstruction, the data are stored in PACS storage
 - PACS = Picture Archiving and Communication Systems

DICOM (.dcm)

- Extensive image format used in data archives
- I dicom file = I slice of brain, consists of e.g. 256 x 256 pixels
- 2D-slices are combined into 3D-images (voxel data)



FUNCTIONAL 4D-IMAGING DATA

4D-images of dynamic data:

• Time-series of static 3D-images



DATA FORMATS & CONVERSION

NIfTI two files .img + .hdr, or single .nii file

- Standard neuroimaging file format
- Supported by several neuroimaging software: SPM, FSL, AFNI, FreeSurfer, ...
- Conversion software: SPM, Mango, MRIcro, etc.



DATA FORMATS & CONVERSION

NIfTI (.img + .hdr, or .nii)

• Simple format; header contains only image orientation information





MOTION

- Increases variance and decreases sensitivity
- May create artificial effects, or e.g. correlate with the imaged task
- Possibly increases during long scans
- Preferrably restricted using head restraint while scanning



MOTION CORRECTION

- Rigid-object transformation = rotation and translation
- Realigns the brains inside the 3D image volumes
- Realignment corrects only the motion between the sequential 3D images, not within the images



MOTION CORRECTION QC









http://mres.uni-potsdam.de/index.php/2023/06/27/interpolating-unevenly-spaced-data-with-matlab/

IMAGE REGISTRATION



IMAGE REGISTRATION

• Process of estimating the optimal transformation between images



Handbook of Medical Image Processing and Analysis (2nd Edition), 2009

IMAGE REGISTRATION QC



Normalised Mutual Information Coregistration

X1 = 0.989*X -0.108*Y +0.104*Z +0.904 Y1 = 0.110*X +0.994*Y -0.011*Z -9.382 Z1 = -0.103*X +0.022*Y +0.994*Z +4.679 Original Joint Histogram



..tivespace_motion.nii

Final Joint Histogram



..tivespace_motion.nii

fuzzy

sharp

REGISTRATION TO STANDARD SPACE IMAGE

- Brains differ in size and shape
 - Individual native space images are not suitable for the voxel-level statistical analysis
- Native-space images are matched approximately with a template image in a standard space



REGISTRATION TO STANDARD SPACE IMAGE

- Affine transformations (12df)
- A. Translations (3df)
- B. Rotations (3df)
- C. Shearing/skewing (3df)
- D. Scaling/zoom (3df)

 Nonlinear transformations using deformation fields





SPATIAL NORMALISATION

- MRI-based normalisation via MRI-segmentation
 - Tissue class segments (GM,WM, CSF) are matched with template TPMs





Segment

Tissue Probability Maps in standard MNI space



Native space PET



Normalise

Forward

Inverse

PET-template

SMOOTHING

- The resulting normalised images are noisy
 - Violates the normality assumption in the voxel-level statistical analysis
- Smoothing increases signal-to-noise ratio and compensates the normalisation errors
- Drawback: reduced spatial resolution



Gaussian 8mm FWHM smooth





MASK IMAGES



GM

CSF





http://www.turkupetcentre.net/petanalysis/image_pve.html

PARTIAL VOLUME EFFECT

Voxel-level data: Müller-Gärtner (MG) method:



PARTIAL VOLUME EFFECT

Regional data: Geometric Transfer Matrix (GTM) method:







$$C_{measured} = GTM \times C_{true}$$

Regional estimates of corrected data



QUALITY CONTROL



QUALITY CONTROL

Uncorrected



Motion corrected



QUALITY CONTROL





FURTHER DETAILS

- Yoder KK, Basic PET Data Analysis Techniques.
 Positron Emiss Tomogr Recent Dev Instrumentation, Res Clin Oncol Pract. December 2013.
- R. Frackowiak, K. Friston et al., Human brain function, 2003 online book: https://www.fil.ion.ucl.ac.uk/spm/doc/books/hbf2/
- Nifti format
 - https://brainder.org/2012/09/23/the-nifti-file-format/
- NRM2018 grand challenge data:
 - https://openneuro.org/datasets/ds001705/versions/1.0.1
- Turku PET centre analysis reference:
 - http://www.turkupetcentre.net/petanalysis/