



Clinica

Software platform for clinical neuroimaging studies



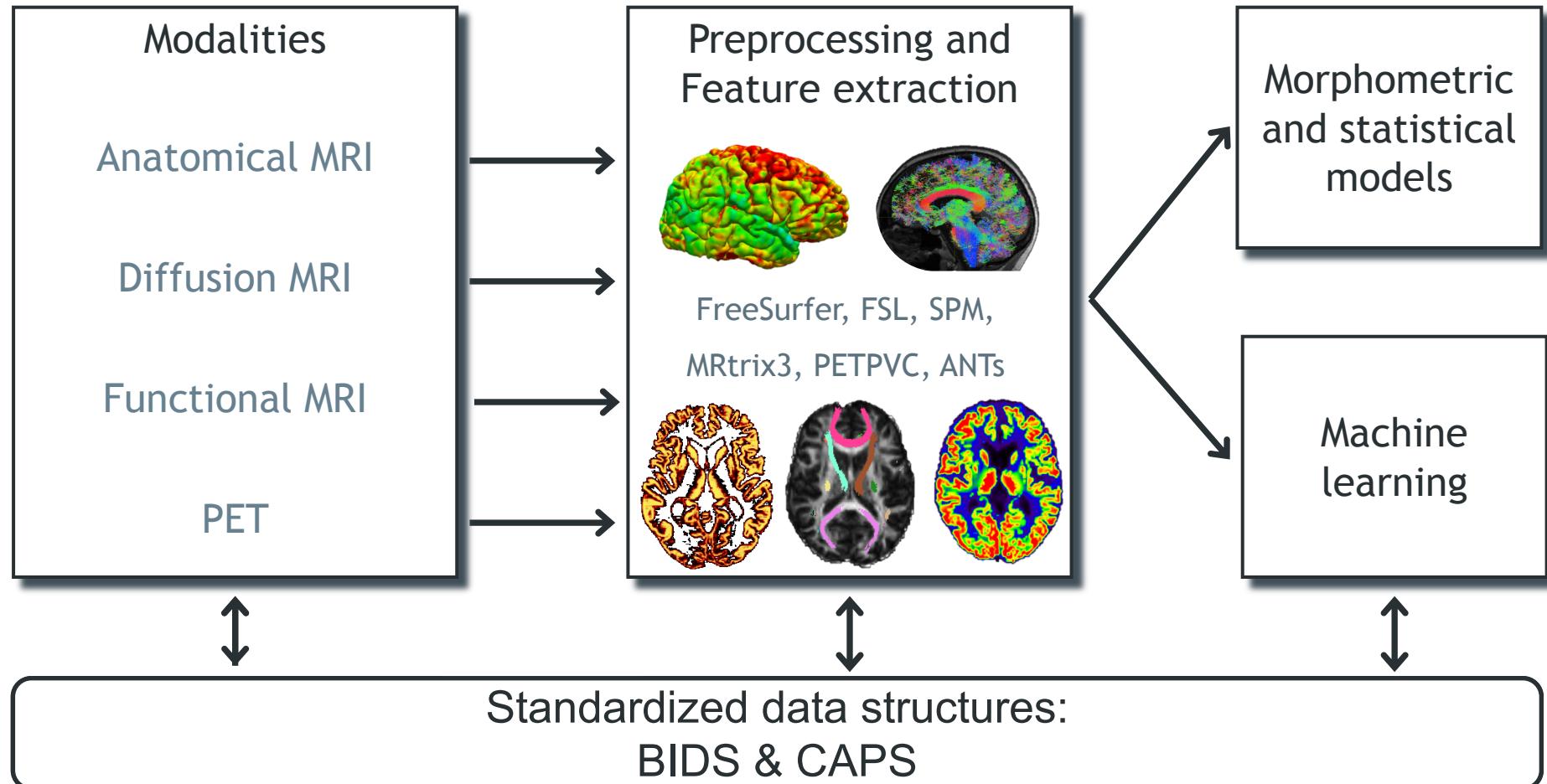
Clinical neuroscience studies

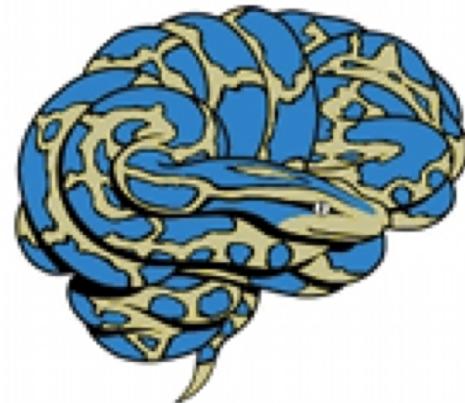
- Involving **in-vivo** data from **human** participants (patients and controls)
- Studied with **multimodal** data
 - Neuroimaging
 - Clinical scores
 - Genetic and other omics
- Often with **longitudinal follow-up**

The goal of Clinica

- Apply advanced **processing** and **data science** methods to clinical studies

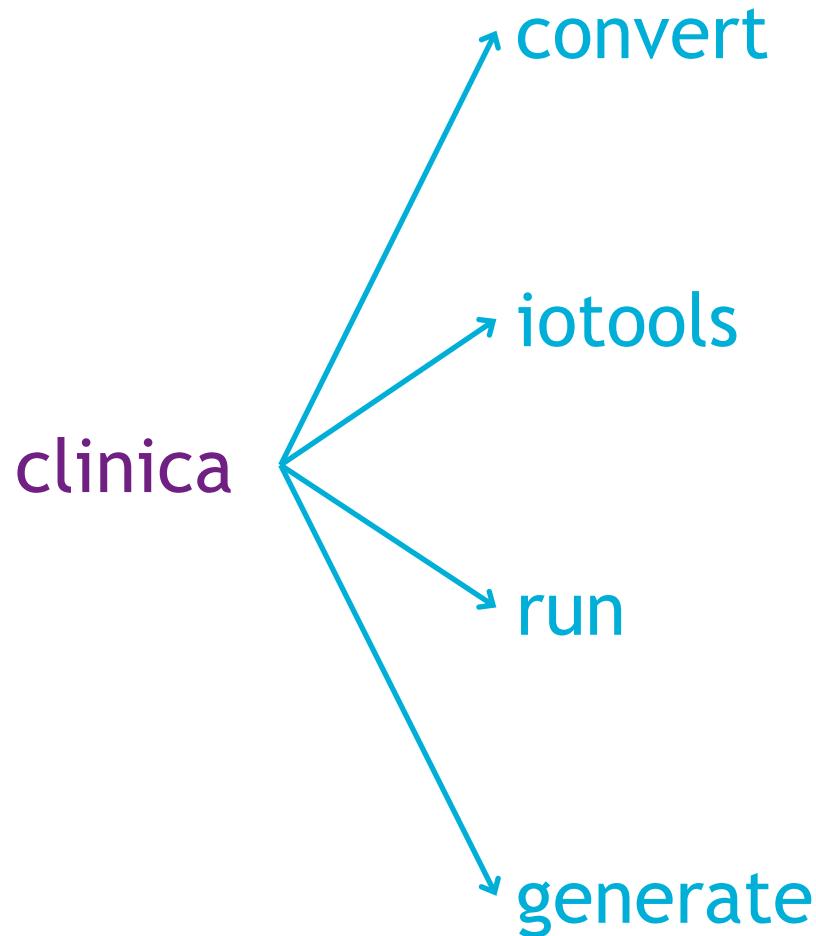
Software platform for clinical neuroimaging studies





Nipype

Interacting with Clinica



Datasets

BIDS / CAPS management

Processing pipelines

Templates for developers

```
clinica convert adni-to-bids ADNI_unorganized ADNI_BIDS
```

ADNI_unorganized

```
|— 094_S_4089
|  ...
|  — Accelerated_SAG_IR-SPGR
|  — AV45_Coreg_Avg_Standardized_Image_and_Voxel_Size
|  ...
|  — Axial_DTI
|  — Axial_FLAIR
|  — Axial_T2_Star
|  — Calibration_Scan
|  — Coreg_Avg_Standardized_Image_and_Voxel_Size
|  ...
|  — HHP_6_DOF_AC-PC_registered_MPRAGE
|  — MT1_GradWarp_N3m
|  — Sag_IR-SPGR
|  — 2011-06-29_14_37_16.0
|  — 2011-10-18_12_15_56.0
|    — S125692
|      — ADNI_094_S_4089_MR_Sag_IR-SPGR__br_raw_20111019095510271_80_S125692_I261478.dcm
|      — ADNI_094_S_4089_MR_Sag_IR-SPGR__br_raw_20111019095512256_62_S125692_I261478.dcm
|      ...
|  — 2011-12-14_15_53_24.0
|  — ...
|  — Sag_IR-SPGR_REPEAT
|  — Spatially_Normalized_Masked_and_N3_corrected_T1_image
|  — T2-weighted_trace
|— 094_S_4162
|— ...
```

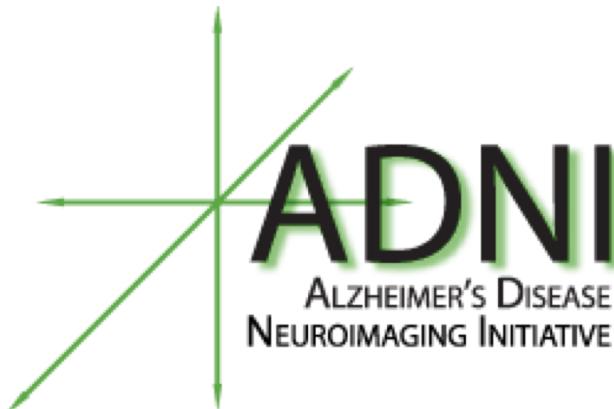
ADNI_BIDS

```
|— sub-ADNI094S4089
|  — ses-M00
|    — anat
|      — sub-ADNI094S4089_ses-M00_T1w.nii.gz
|    — dwi
|      — sub-ADNI094S4089_ses-M00_acq-axial_dwi.bval
|      — sub-ADNI094S4089_ses-M00_acq-axial_dwi.bvec
|      — sub-ADNI094S4089_ses-M00_acq-axial_dwi.nii.gz
|    — pet
|      — sub-ADNI094S4089_ses-M00_task-rest_acq-av45_pet.nii.gz
|      — sub-ADNI094S4089_ses-M00_task-rest_acq-fdg_pet.nii.gz
|      — sub-ADNI094S4089_ses-M00_scans.tsv
|  — ses-M03
|  — ses-M12
|  — ses-M24
|— sub-ADNI094S4162
|— ...
```

Brain Imaging Data Structure
(BIDS)

Converters available for:

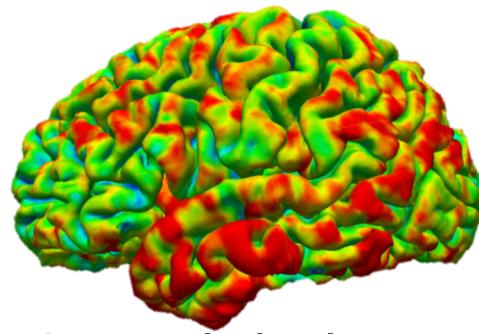
- ADNI (Alzheimer's Disease Neuroimaging initiative)
- AIBL (Australian Imaging Biomarker & Lifestyle Flagship Study of Ageing)
- OASIS (Alzheimer's Disease and age-related dementia)
- + internal studies to which we collaborate



clinica run t1-freesurfer BIDS CAPS



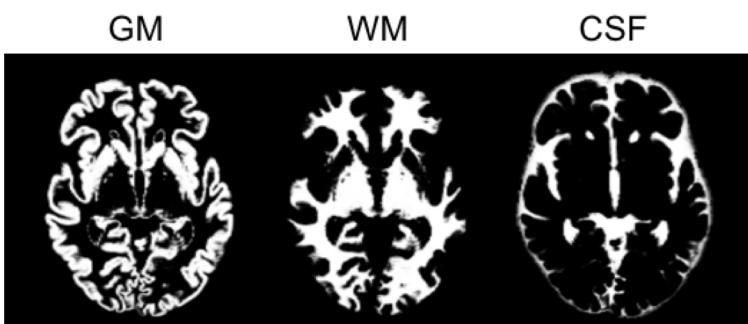
Cortical surfaces
Subcortical structures



Cortical thickness

- FreeSurfer

clinica run t1-volume BIDS CAPS



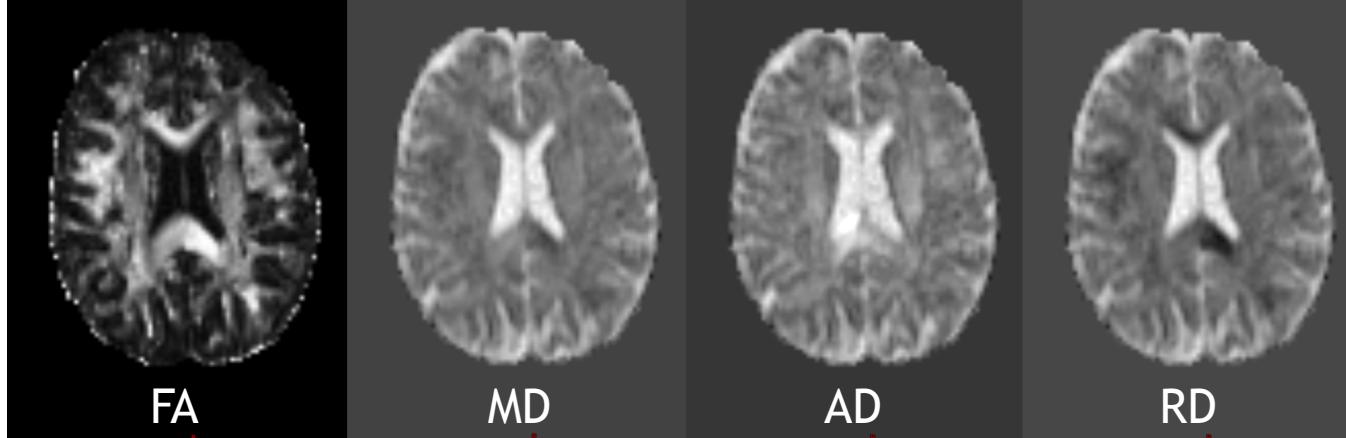
Tissue probability maps



Group template

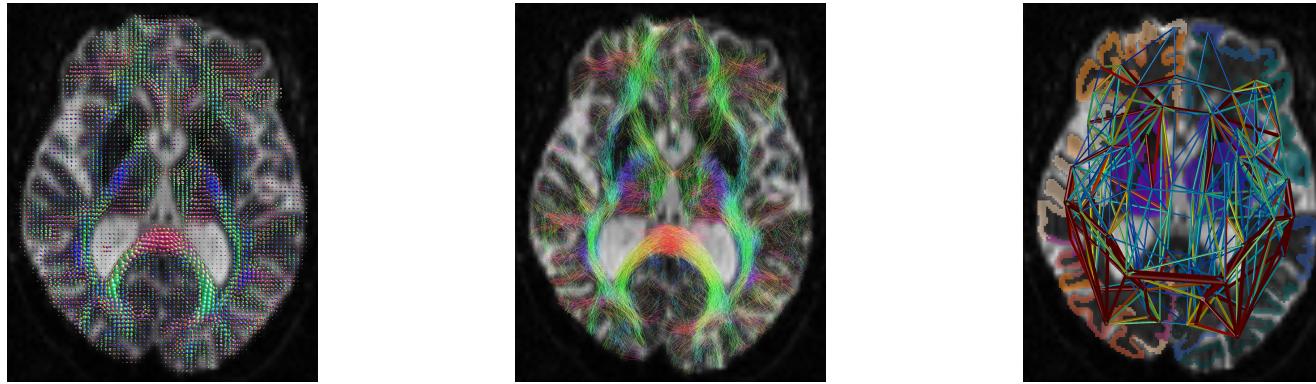
- SPM

clinica run dwi-dti CAPS



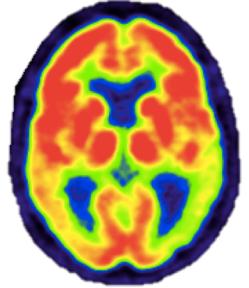
- ANTs
- MRtrix3

clinica run dwi-connectome CAPS

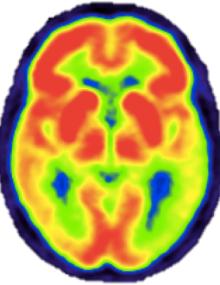


- FreeSurfer
- MRtrix3

clinica run pet-volume BIDS CAPS



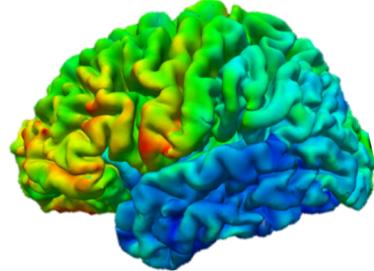
PET
in native space



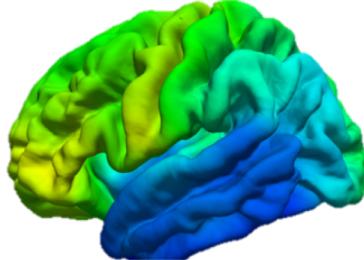
PET
in MNI space

- SPM
- PETPVC

clinica run pet-surface BIDS CAPS



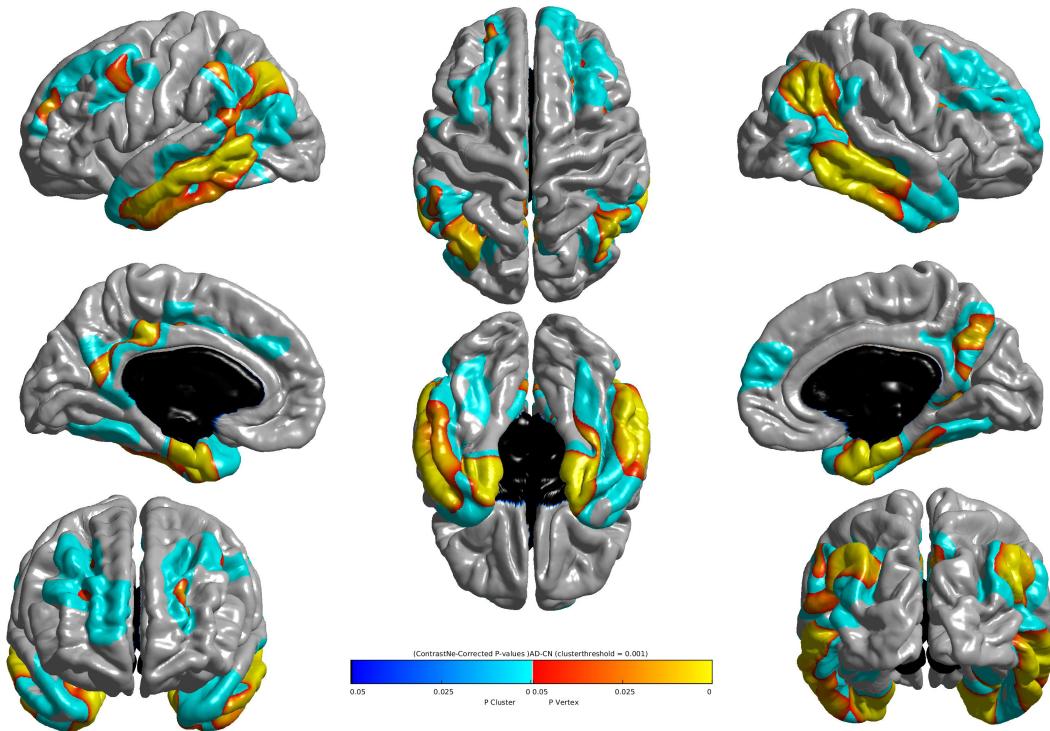
Projected PET
in native space



Projected PET
in fsaverage space

- FreeSurfer
- SPM
- FSL
- PETPVC

clinica run statistics-surface CAPS <analysis_params>



- FreeSurfer
- SurfStat
- Group comparisons / correlations

Machine learning modules

Inputs

- Imaging modalities
- Feature types



Classifier

- Linear SVM
- L2 Logistic regression
- Random forest



CV

- K-fold
- Repeated k-fold
- Repeated hold-out



Samper-González et al., *NeuroImage*, 2018;
<https://github.com/aramis-lab/AD-ML>

Within the team

- Reuse internal development within the team
- Reproducible evaluation of AD classification with ADNI dataset (*Samper-González et al., 2018*)



With neuro(radio)logists

- Imaging of neurodegenerative disease
(*Bertrand et al., 2018; Wen et al., 2018*)



With external users and collaborators

- Contributions to ADNI-2-BIDS converter
- Development of novel classification method for AD
(*Toro et al., 2018*)





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www.clinica.run

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Jorge Samper-Gonzalez
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Adam Wild

Software platform for clinical neuroimaging studies



Usage example

15

```
clinica run t1-freesurfer_cross_sectional ADNI_BIDS ADNI_CAPS  
clinica run pet-surface ADNI_BIDS ADNI_CAPS  
clinica run statistics-surface ADNI_CAPS <analysis_parameters>
```

Inputs:

```
ADNI_BIDS  
|— participants.tsv  
|— ...  
|— sub-ADNI04  
|— sub-ADNI05  
|   — ses-M00  
|   |— anat  
|   |   — sub-ADNI05_ses-M00_T1w.nii.gz  
|   |— pet  
|   |   — sub-ADNI05_ses-M00_task-rest_acq-FDG_pet.json  
|   |   — sub-ADNI05_ses-M00_task-rest_acq-fdg_pet.nii.gz  
|   |— sub-ADNI05_ses-M00_scans.tsv  
|— ses-M03  
|— ses-M06  
|— ses-M12  
|— ses-M24  
|— ses-M48  
|— sub-ADNI05_sessions.tsv  
|— ...
```

Outputs:

```
ADNI_CAPS  
|— subjects  
|   — sub-...  
|   — sub-ADNI04  
|   — sub-ADNI05  
|       — ses-M00  
|           — t1  
|               — freesurfer_cross_sectional  
|           — pet  
|               — surface  
|                   — sub-ADNI05_ses-M00_hemi-lh_midcorticalsurface  
|                   — sub-ADNI05_ses-M00_hemi-rh_midcorticalsurface  
|                   — sub-ADNI05_ses-M00_task-rest_acq-fdg_pet_space-fsaverage_suVR-pons_pVC-iy_hemi-lh_fwhm-0_projection.mgh  
|                   ...  
|                   — sub-ADNI05_ses-M00_task-rest_acq-fdg_pet_space-fsaverage_suVR-pons_pVC-iy_hemi-lh_fwhm-25_projection.mgh  
|                   — sub-ADNI05_ses-M00_task-rest_acq-fdg_pet_space-fsaverage_suVR-pons_pVC-iy_hemi-rh_fwhm-0_projection.mgh  
|                   ...  
|                   — sub-ADNI05_ses-M00_task-rest_acq-fdg_pet_space-fsaverage_suVR-pons_pVC-iy_hemi-rh_fwhm-25_projection.mgh  
|                   — sub-ADNI05_ses-M00_task-rest_acq-fdg_pet_space-native_suVR-pons_pVC-iy_hemi-lh_projection.mgh  
|                       — sub-ADNI05_ses-M00_task-rest_acq-fdg_pet_space-native_suVR-pons_pVC-iy_hemi-rh_projection.mgh  
|— ...  
|   — group-ADvsCN_AD-lt-CN_measure-fdg_fwhm-20_correctedPValue.mat
```

participant_id	session_id	sex	group	age
sub-ADNI01	ses-M0	Female	CN	71.1
sub-ADNI02	ses-M0	Male	CN	81.3
sub-ADNI03	ses-M0	Male	CN	75.4
sub-ADNI04	ses-M0	Female	CN	73.9
sub-ADNI05	ses-M0	Female	AD	64.1
sub-ADNI06	ses-M0	Male	AD	80.1
...				

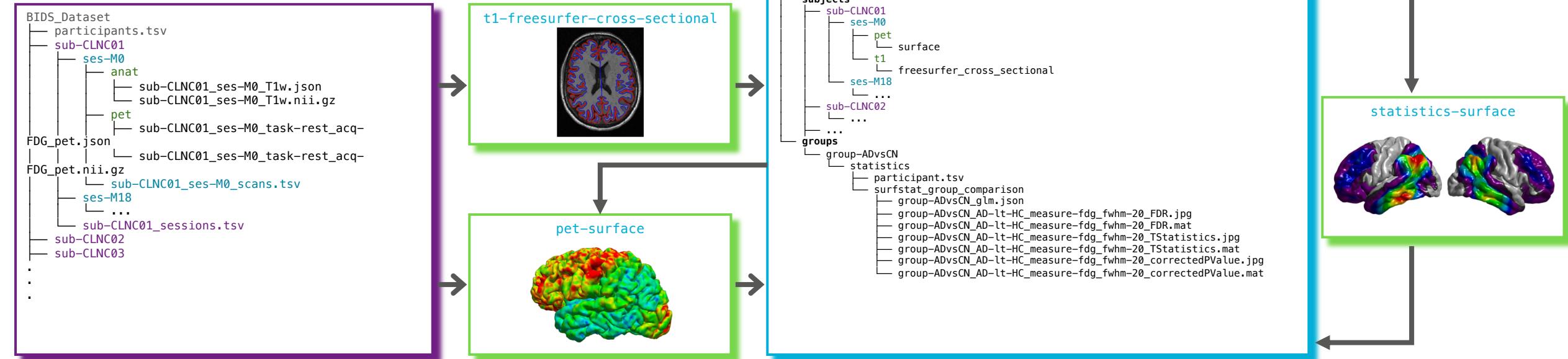
ADvsCN_participants.tsv

Usage example

```
# Step 1 - Run FreeSurfer in order to extract cortical surfaces:  
clinica run t1-freesurfer-cross-sectional BIDS_Dataset CAPS_Dataset  
  
# Step 2 - Project FDG-PET onto the cortex:  
clinica run pet-surface BIDS_Dataset CAPS_Dataset --pet_tracer fdg  
  
# Step 3 - Group comparison between patients with AD and CN subjects  
# ADvsCN will define the group_label:  
clinica run statistics-surface CAPS_Dataset \  
    ADvsHC_participants.tsv "1 + age + sex + group" "group" "%s %s %s  
    ADvsHC group_comparison --feature_type pet_fdg_projection
```

participant_id	session_id	sex	group	age
sub-CLNC01	ses-M0	Female	CN	71.1
sub-CLNC02	ses-M0	Male	CN	81.3
sub-CLNC03	ses-M0	Male	CN	75.4
sub-CLNC04	ses-M0	Female	CN	73.9
sub-CLNC05	ses-M0	Female	AD	64.1
sub-CLNC06	ses-M0	Male	AD	80.1
...				

ADvsHC_participants.tsv



Motivation

- Stop the waste of resources

Objectives

- Spend less time on data management and processing
- Easily share data and results within institutions and with external collaborators
- Make research more reproducible
- Highlight methods developed in the team