



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

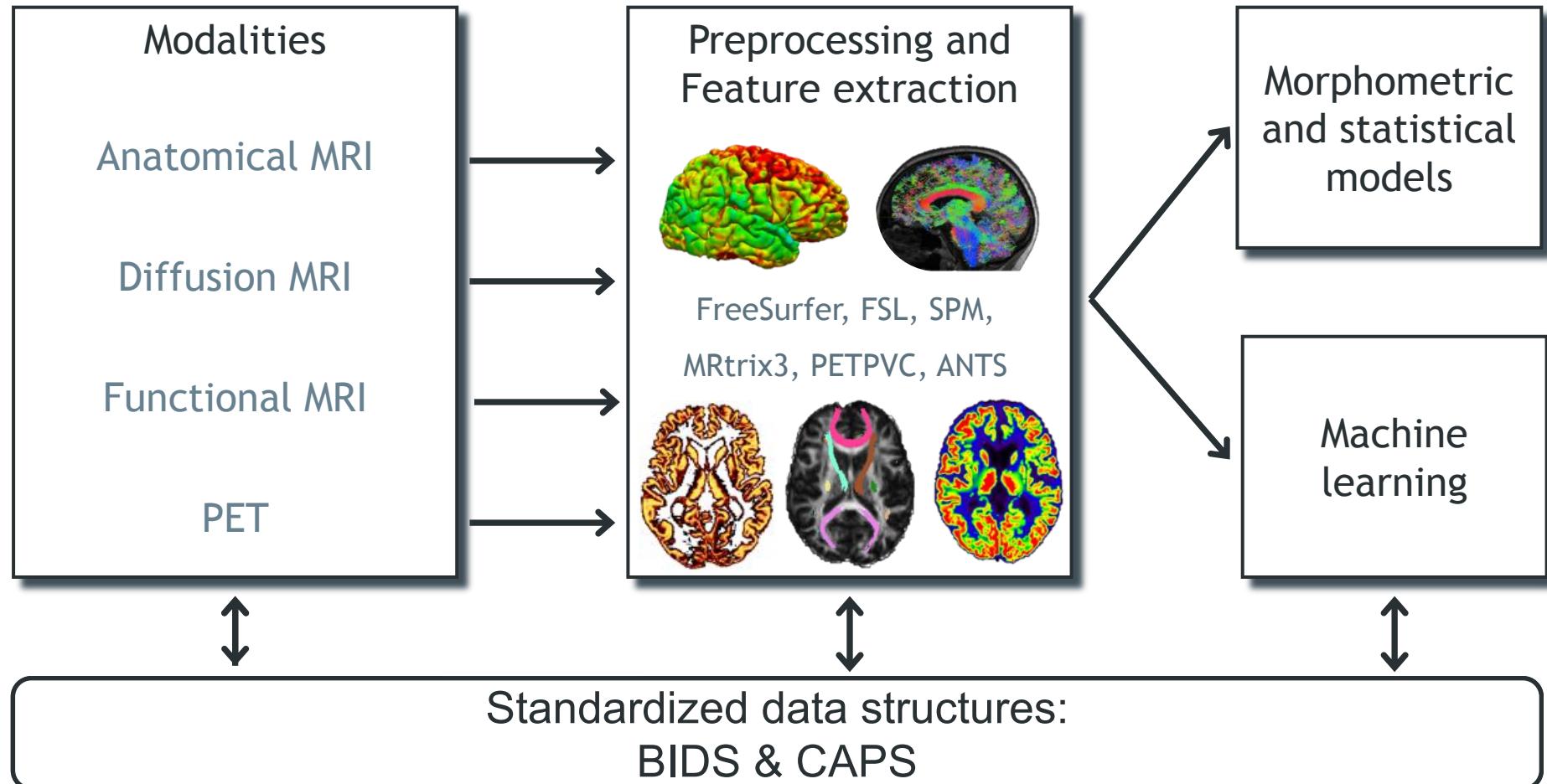
Motivation

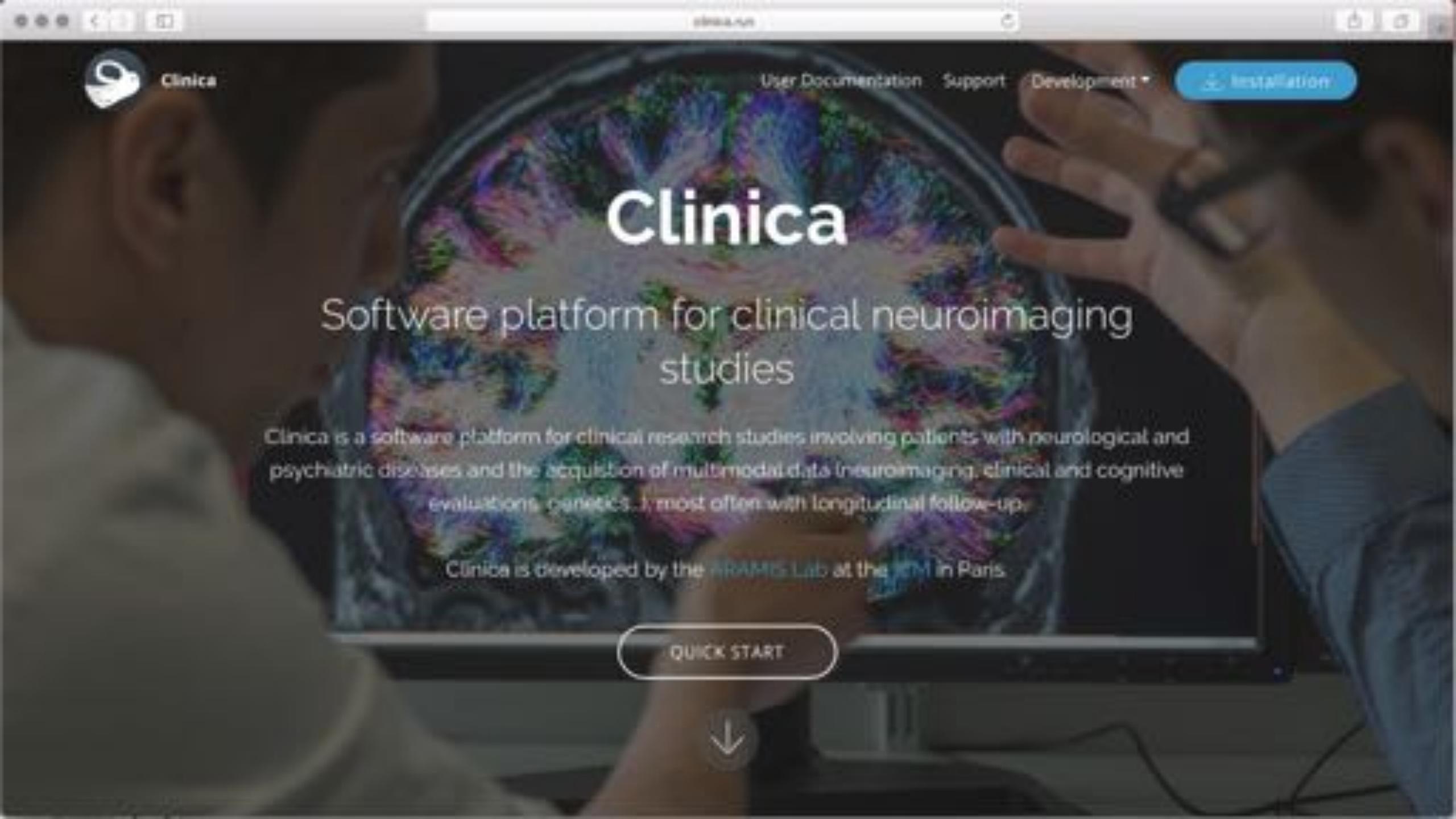
- Stop the waste of resources

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

Software platform for clinical neuroimaging studies





Clinica

clinica.org

User Documentation

Support

Development

Installation

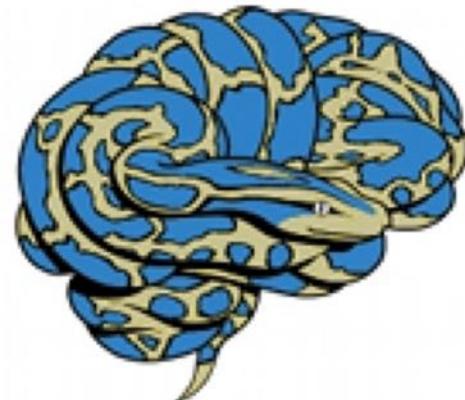
Clinica

Software platform for clinical neuroimaging studies

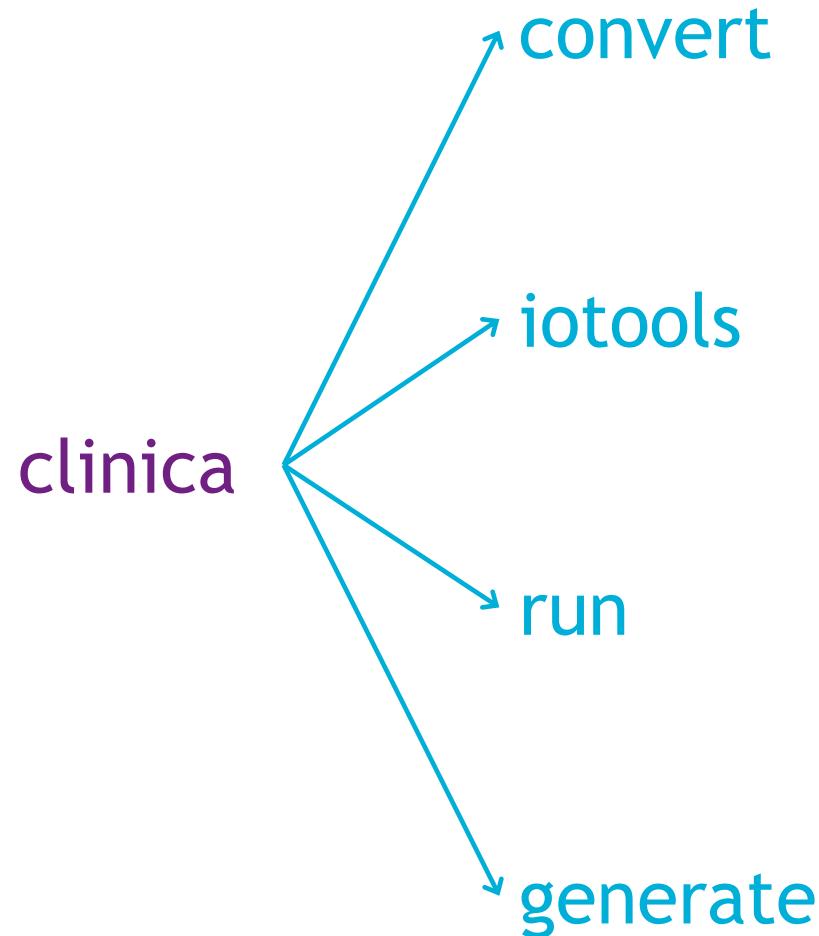
Clinica is a software platform for clinical research studies involving patients with neurological and psychiatric diseases and the acquisition of multimodal data (neuroimaging, clinical and cognitive evaluations, genetics...) most often with longitudinal follow-up.

Clinica is developed by the PRAMiS Lab at the JINM in Paris.

QUICK START



Nipype



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_MPRADE
|   — 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:

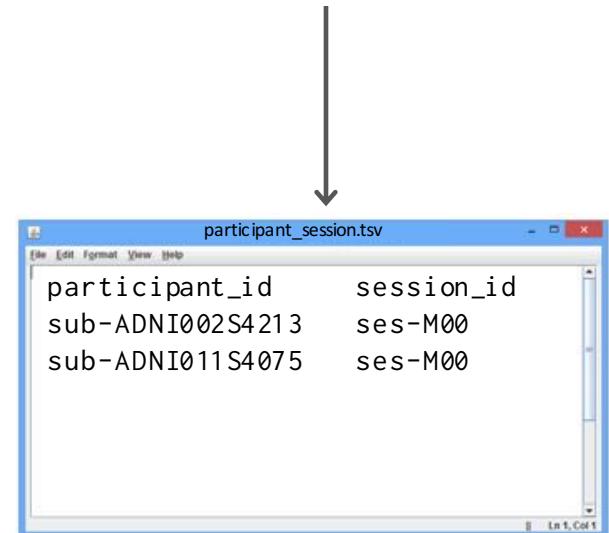
- ADNI (Alzheimer's Disease Neuroimaging initiative)
- AIBL (Australian Imaging Biomarker & Lifestyle Flagship Study of Ageing)
- OASIS (Alzheimer's Disease and age-related dementia)
- + internal studies to which we collaborate



clinica iotools

create-subjects-visits

```
ADNI_BIDS
|__ sub-ADNI002S4213
|  |__ ses-M00
|  |  |__ anat
|  |  |  |__ sub-ADNI002S4213_ses-M00_T1w.nii.gz
|  |  |__ dwi
|  |  |  |__ sub-ADNI002S4213_ses-M00_acq-axial_dwi.bval
|  |  |  |__ sub-ADNI002S4213_ses-M00_acq-axial_dwi.bvec
|  |  |  |__ sub-ADNI002S4213_ses-M00_acq-axial_dwi.nii.gz
|  |  |__ pet
|  |  |  |__ sub-ADNI002S4213_ses-M00_task-rest_acq-av45_pet.nii.gz
|  |  |  |__ sub-ADNI002S4213_ses-M00_task-rest_acq-fdg_pet.nii.gz
|  |  |__ sub-ADNI002S4213_ses-M00_scans.tsv
|__ sub-ADNI011S4075
|__ ...
```



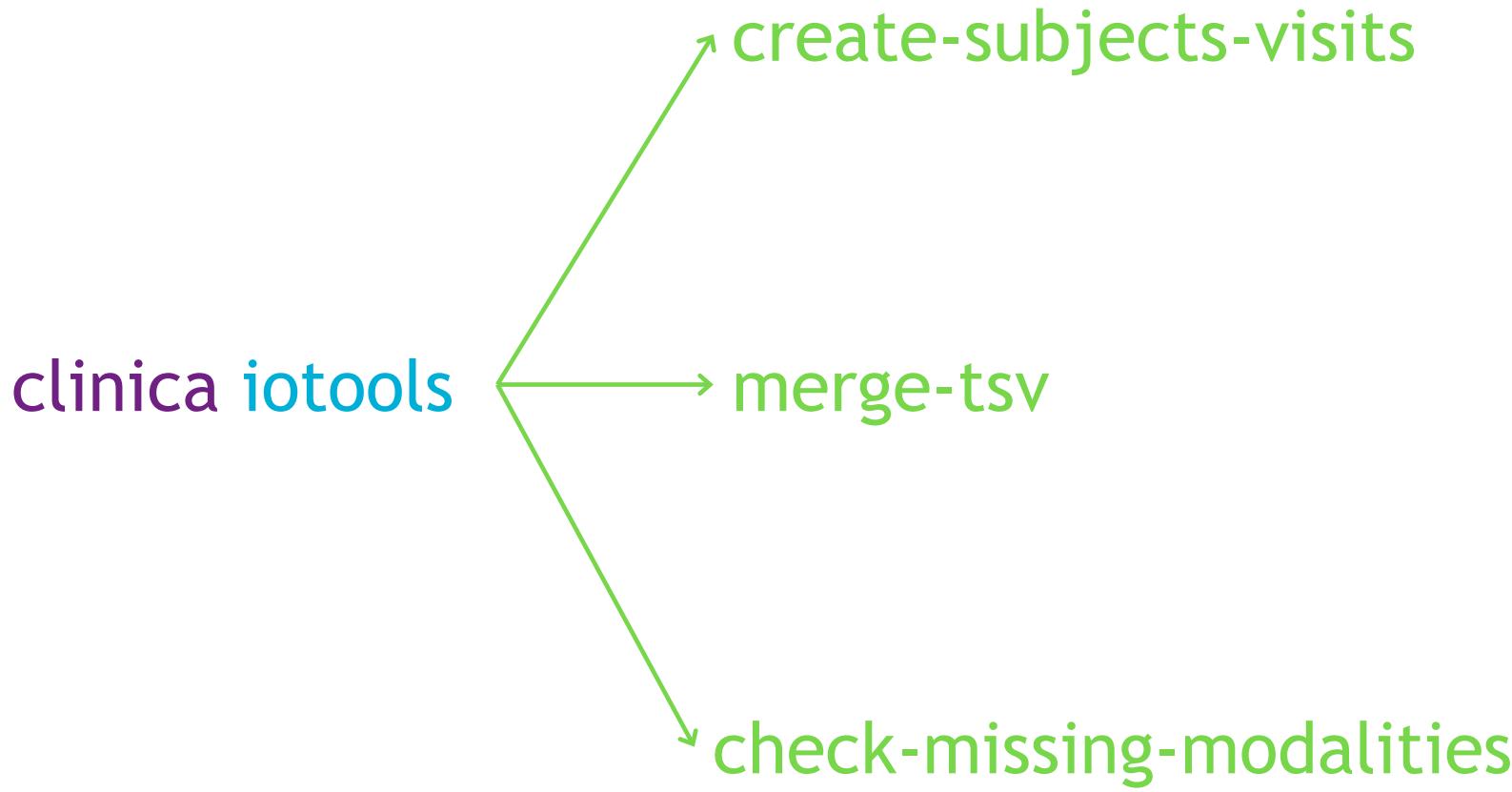
participant_id	session_id
sub-ADNI002S4213	ses-M00
sub-ADNI011S4075	ses-M00

clinica iotools

create-subjects-visits
merge-tsv

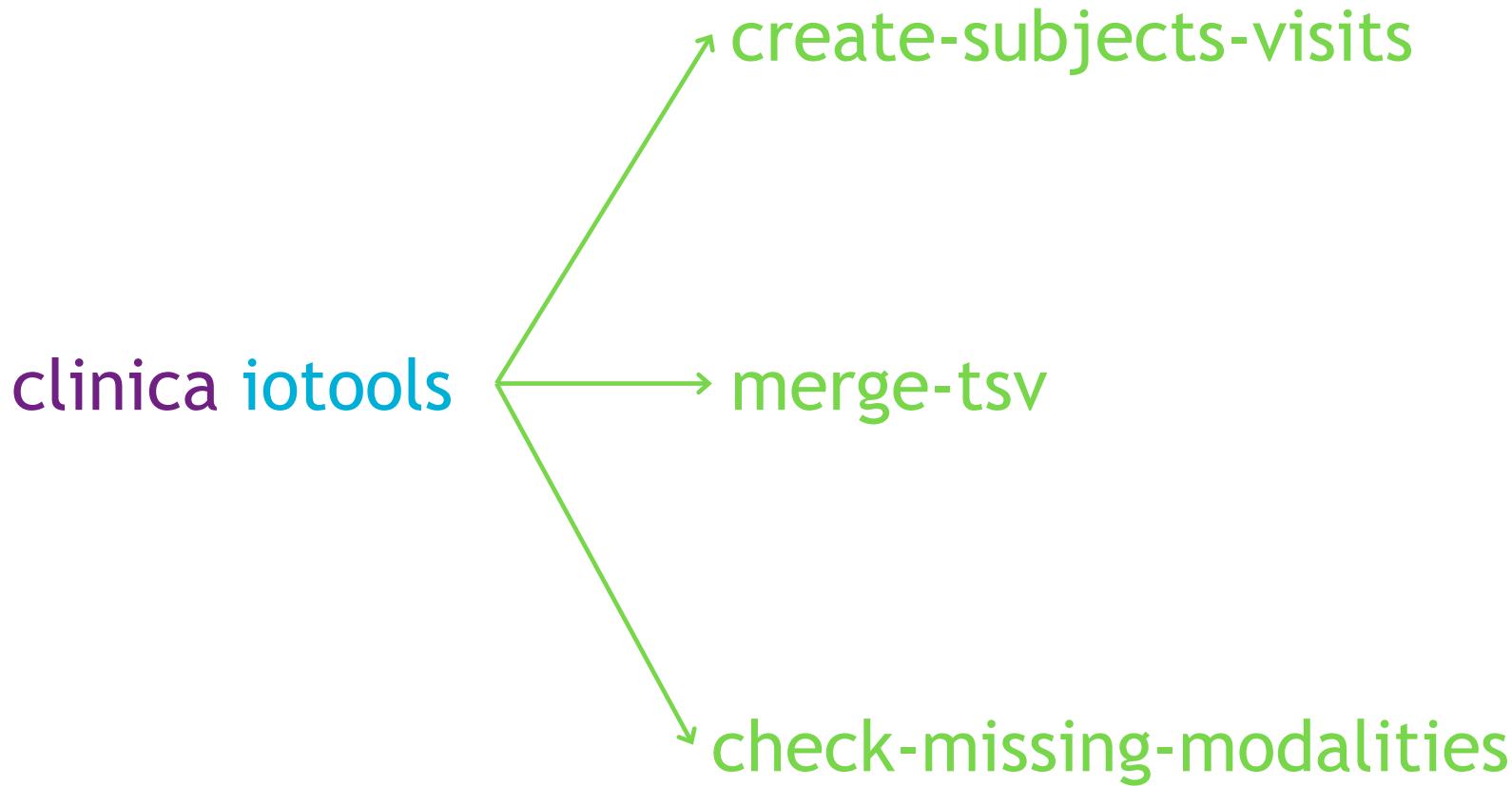
participant_id	session_id	date_of_birth_ROI-0	..._ROI-1	...
sub-01	ses-M00	25/04/41	...	9.824750	0.023562	
sub-01	ses-M18	25/04/41	...	8.865353	0.012349	
sub-02	ses-M00	09/01/91	...	9.586342	0.027254	

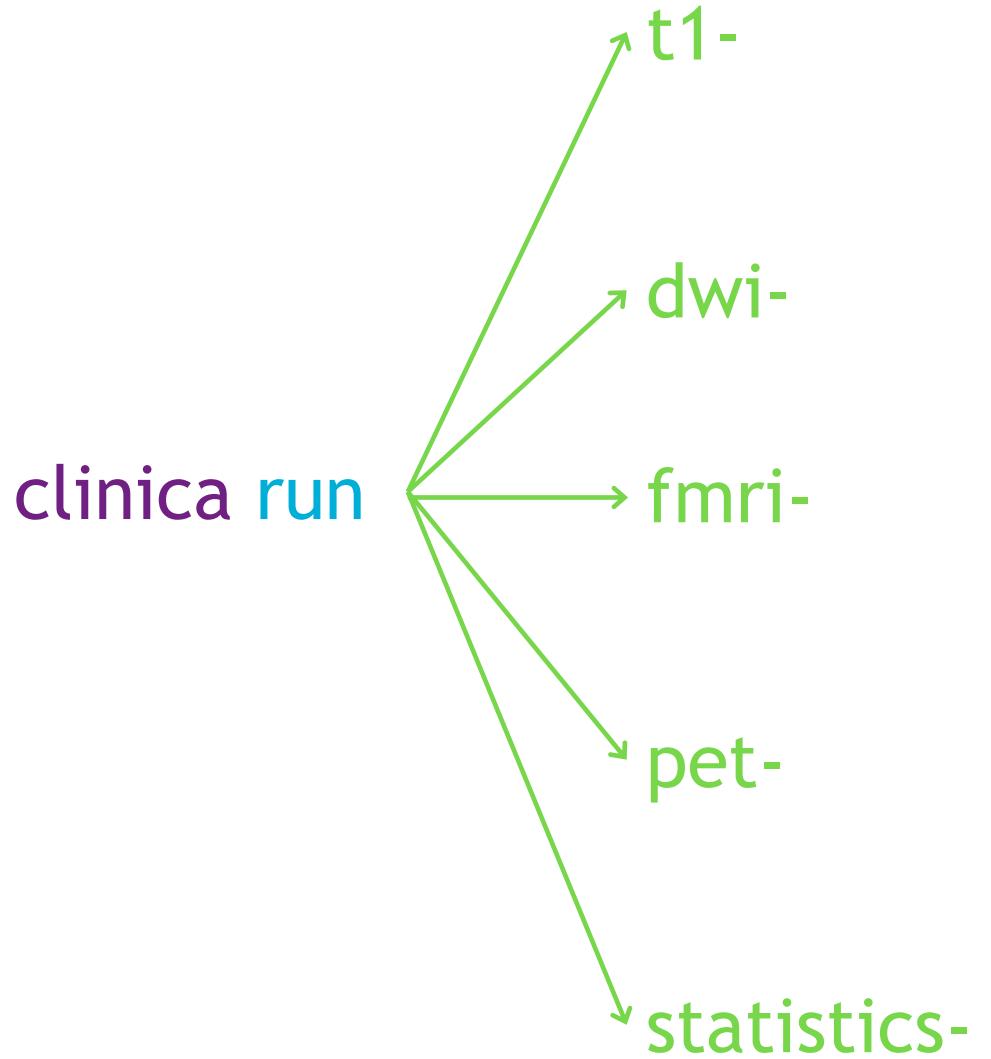
From BIDS and CAPS



participant_id	FLAIR	T1w
sub-01	1	1
sub-02	1	0
sub-03	1	0

From BIDS

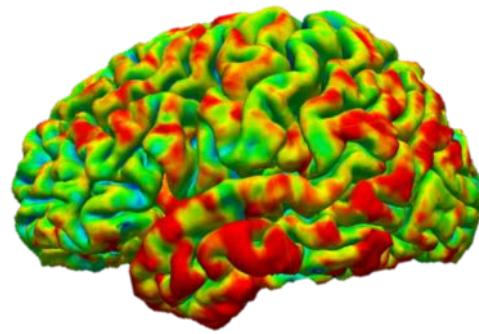




clinica run t1-freesurfer-cross-sectional BIDS CAPS



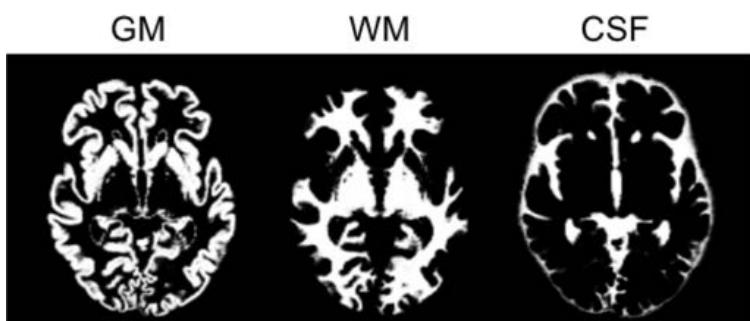
Cortical surfaces
Subcortical structures



Cortical thickness

- FreeSurfer

clinica run t1-volume-new-template BIDS CAPS



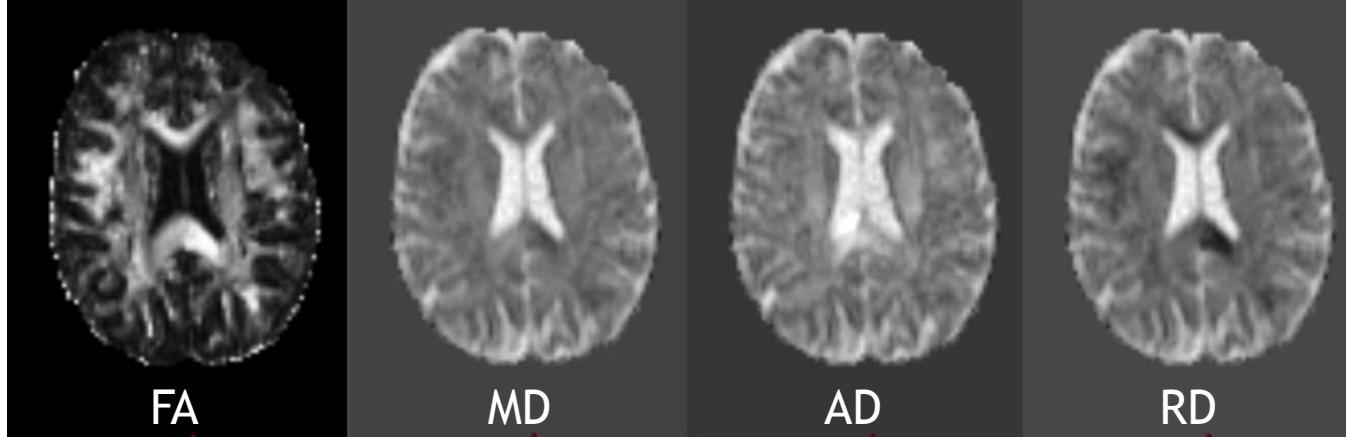
Tissue probability maps



Group template

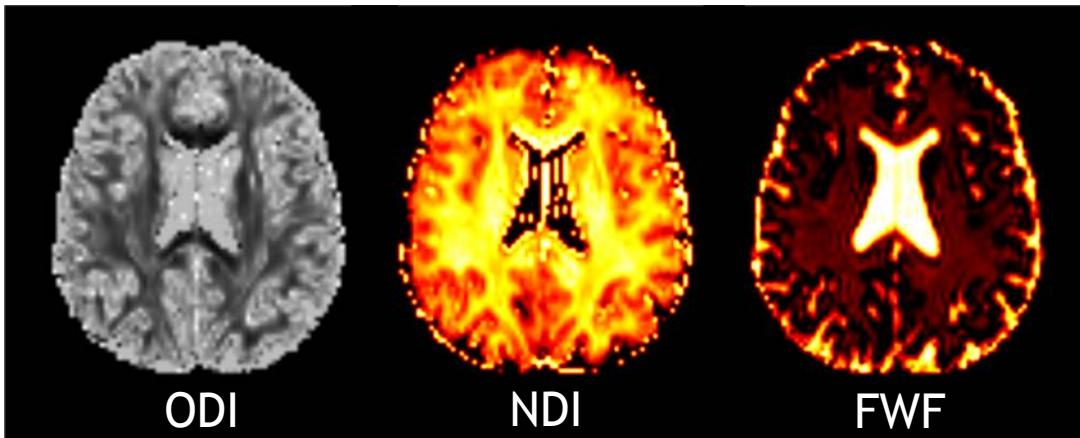
- SPM

clinica run dwi-processing-dti CAPS



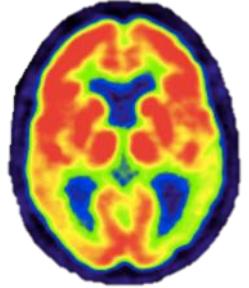
- ANTs
- MRtrix3

clinica run dwi-processing-noddi CAPS

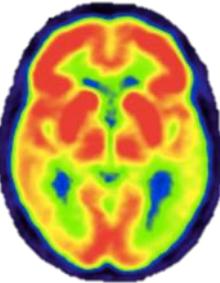


- ANTs
- NODDI Matlab Toolbox

clinica run pet-volume BIDS CAPS



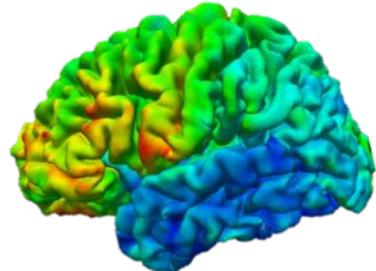
PET
in native space



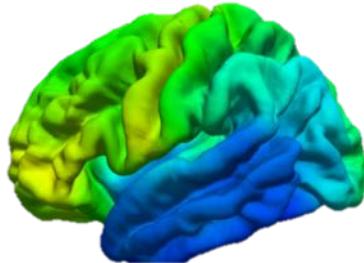
PET
in MNI space

- SPM
- PETPVC

clinica run pet-surface BIDS CAPS



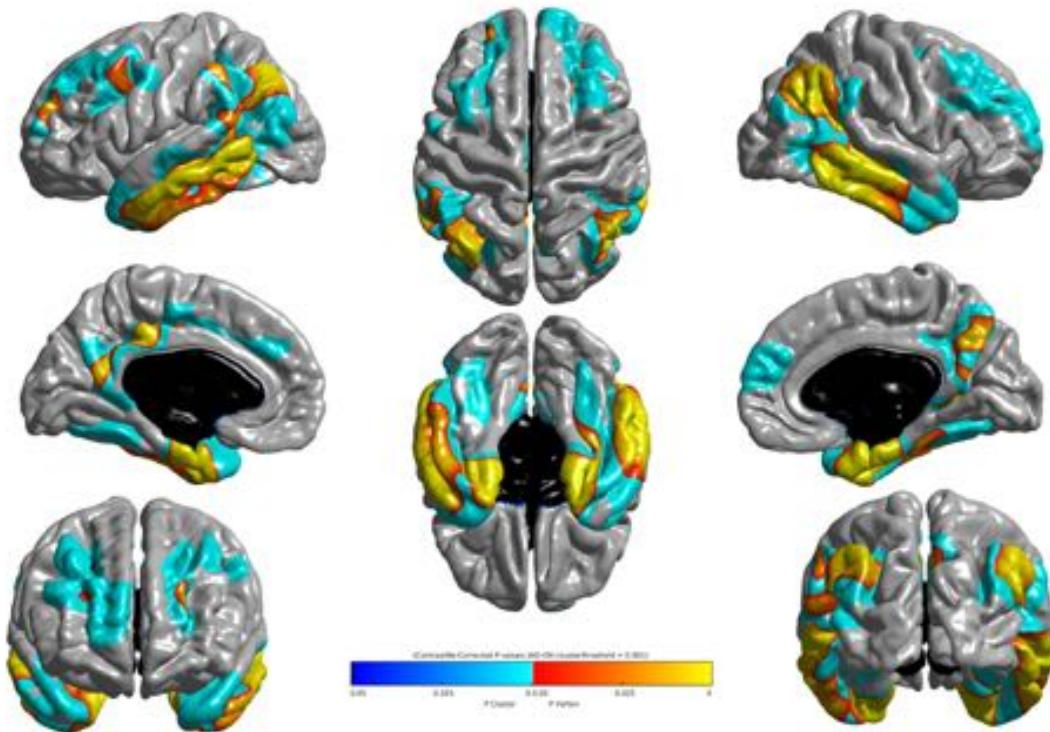
Projected PET
in native space



Projected PET
in fsaverage space

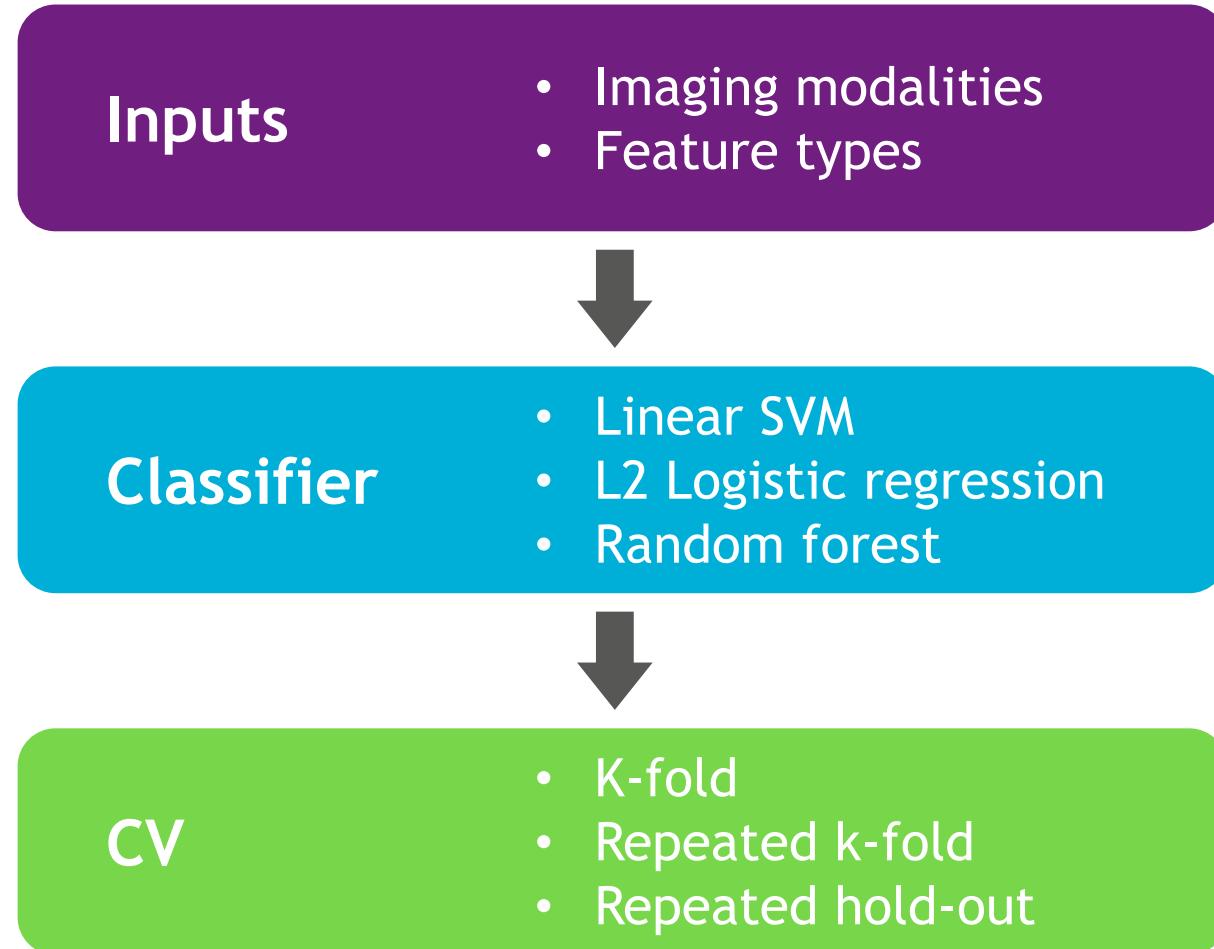
- FreeSurfer
- SPM
- FSL
- PETPVC

```
clinica run statistics-surface CAPS <analysis_params>
```



- FreeSurfer
- Statistics and Machine Learning Matlab Toolbox

Machine learning modules



Jupyter notebook

- <http://clinica.run/doc/OHBM2018-PRNI/>



Performing individual classification with Clinica

Clinica: Software platform for clinical neuroimaging studies

[Clinica](#) is a software platform for clinical research studies involving patients with neurological and psychiatric diseases and the acquisition of multimodal data (neuroimaging, clinical and cognitive evaluations, genetics...), most often with longitudinal follow-up.

To run this notebook, you will need to install Clinica. Installation instructions can be found [here](#).

Software framework

- <https://gitlab.icm-institute.org/aramislab/AD-ML>

Usage example

```
clinica run t1-freesurfer_cross_sectional ADNI_BIDS ADNI_CAPS
```

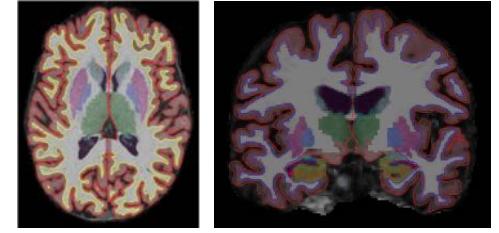
Inputs:

```
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
|   |   |__ sub-ADNI05_ses-M00
|   |   |   __ bem
|   |   |   __ label
|   |   |   __ mri
|   |   |   __ scripts
|   |   |   __ src
|   |   |   __ stats
|   |   |   __ surf
|   |   |   __ ...
|   |__ ...
```

t1-freesurfer-cross-sectional



Usage example

```
clinica run t1-freesurfer_cross_sectional ADNI_BIDS ADNI_CAPS  
clinica run pet-surface ADNI_BIDS ADNI_CAPS
```

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  
|— ...
```



Usage example

```
clinica run t1-freesurfer_cross_sectional ADNI_BIDS ADNI_CAPS  
clinica run pet-surface ADNI_BIDS ADNI_CAPS
```

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  
|   |— ...
```

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

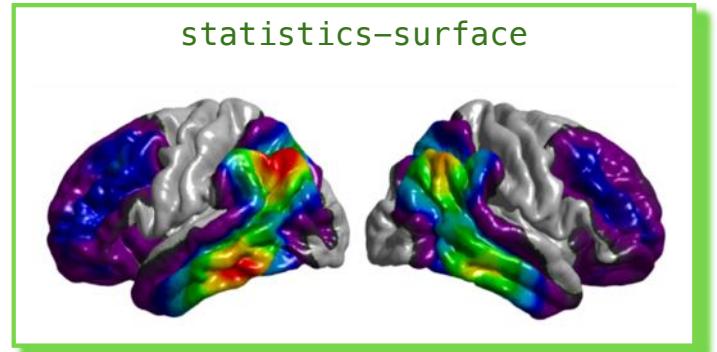
```
clinica run t1-freesurfer_cross_sectional ADNI_BIDS ADNI_CAPS
clinica run pet-surface ADNI_BIDS ADNI_CAPS
clinica run statistics-surface ADNI_CAPS <analysis_parameters>
```

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
|   |       |   |— sub-ADNI05_ses-M00
|   |       |   |   |— bem
|   |       |   |   |— label
|   |       |   |   |— mri
|   |       |   |   |— scripts
|   |       |   |   |— src
|   |       |   |   |— stats
|   |       |   |   |— surf
|   |       |— ...
|       |— group-ADvsCN_glm.json
|       |— group-ADvsCN_AD-lt-CN_measure-fdg_fwhm-20_FDR.jpg
|       |— group-ADvsCN_AD-lt-CN_measure-fdg_fwhm-20_FDR.mat
|       |— group-ADvsCN_AD-lt-CN_measure-fdg_fwhm-20_TStatistics.jpg
|       |— group-ADvsCN_AD-lt-CN_measure-fdg_fwhm-20_TStatistics.mat
|       |— group-ADvsCN_AD-lt-CN_measure-fdg_fwhm-20_correctedPValue.jpg
|       |— group-ADvsCN_AD-lt-CN_measure-fdg_fwhm-20_correctedPValue.mat
```



Imaging *c9orf72* mutation carriers

JAMA Neurology | **Original Investigation**

Early Cognitive, Structural, and Microstructural Changes in Presymptomatic *C9orf72* Carriers Younger Than 40 Years

Anne Bertrand, MD, PhD; Junhao Wen, MS; Daisy Rinaldi, PhD; Marion Houot, MS; Sabrina Sayah, MS; Agnès Camuzat, PhD; Clémence Fournier, PhD; Sabrina Fontanella, MS; Alexandre Routier, MS; Philippe Couratier, MD; Florence Pasquier, MD, PhD; Marie-Odile Habert, MD; Didier Hannequin, MD, PhD; Olivier Martinaud, MD, PhD; Paola Caroppo, MD, PhD; Richard Levy, MD, PhD; Bruno Dubois, MD; Alexis Brice, MD; Stanley Durrleman, PhD; Olivier Colliot, PhD; Isabelle Le Ber, MD, PhD; for the Predict to Prevent Frontotemporal Lobar Degeneration and Amyotrophic Lateral Sclerosis (PREV-DEMALS) Study Group

Reproducible machine learning studies

- Based on 3 public datasets in Alzheimer's disease (ADNI, AIBL, OASIS)
- Standardized data management based on BIDS
- Standardized preprocessing for MRI and PET
- Baseline machine learning approaches (SVM, random forest...)
- Open source code: <https://gitlab.icm-institute.org/aramislab/AD-ML>

Reproducible machine learning studies

Yet Another ADNI Machine Learning Paper? Paving the Way Towards Fully-Reproducible Research on Classification of Alzheimer's Disease

Authors

Authors and affiliations

Jorge Samper-González, Ninon Burgos, Sabrina Fontanella, Hugo Bertin, Marie-Odile Habert, Stanley Durrleman, Theodoros Evgeniou, Olivier Colliot , the Alzheimer's Disease Neuroimaging Initiative



Reproducible evaluation of classification methods in Alzheimer's disease: framework and application to MRI and PET data

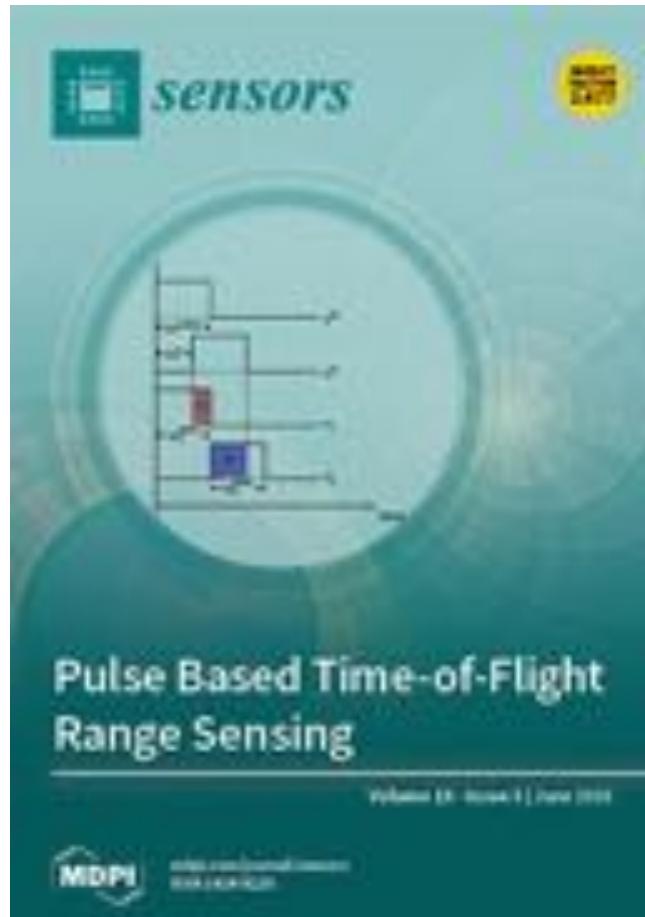
Jorge Samper-González,  Ninon Burgos, Simona Bottani, Sabrina Fontanella, Pascal Lu, Arnaud Marcoux, Alexandre Routier, Jérémie Guillon, Michael Bacci, Junhao Wen, Anne Bertrand, Hugo Bertin, Marie-Odile Habert, Stanley Durrleman, Theodoros Evgeniou,  Olivier Colliot, the Alzheimer's Disease Neuroimaging Initiative, the Australian Imaging Biomarkers and Lifestyle flagship study of ageing

doi: <https://doi.org/10.1101/274324>

<https://gitlab.icm-institute.org/aramislab/AD-ML>

bioRxiv
THE PREPRINT SERVER FOR BIOLOGY

Development of novel classification method for Alzheimer's disease/cognitive normal discrimination in structural MRI



Supervoxels-Based Histon as a New Alzheimer's Disease Imaging Biomarker

César A. Ortiz Toro *✉, Consuelo Gonzalo-Martín †,*✉, Angel García-Pedrero ✉ and Ernestina Menasalvas Ruiz †✉

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Alexis Guyot



www.clinica.run

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Thomas Jacquemont
Pascal Lu
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Tristan Moreau
Alexandre Routier
Jorge Samper-Gonzalez
Elina Thibeau-Sutre
Junhao Wen

Software platform for clinical neuroimaging studies

