ARAMIS LAB
BRAIN DATA SCIENCE

www.aramislab.fr

ninonburgos.com

22nd November 2023

Neuro Open-science Workshop

Clinica

Open-source software platform for neuroimaging studies

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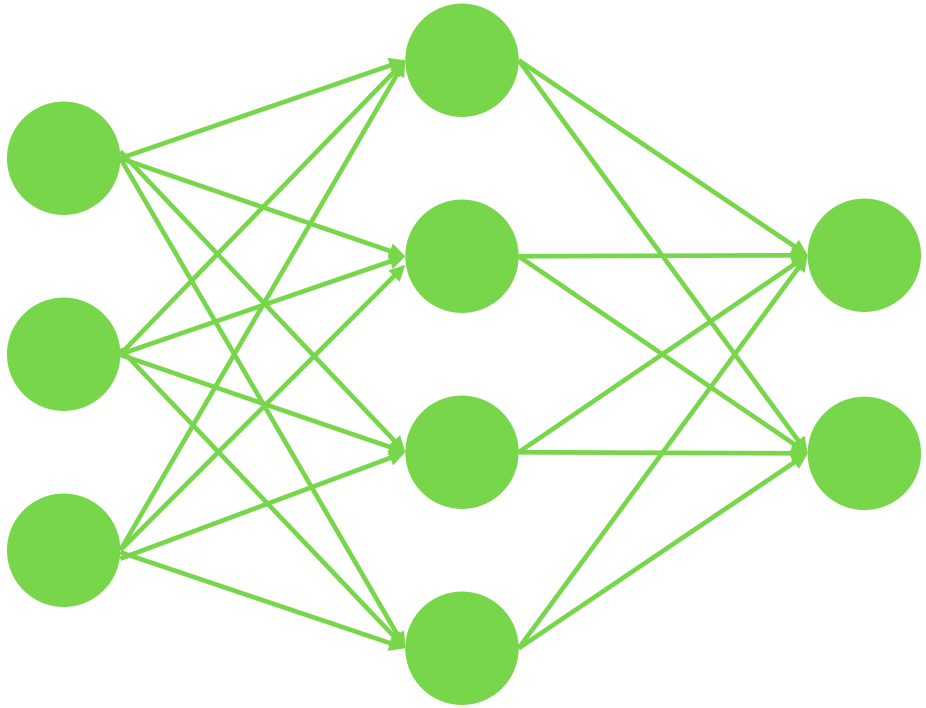
ARAMIS Lab, Paris Brain Institute

Genesis

Once upon a time in a lab…

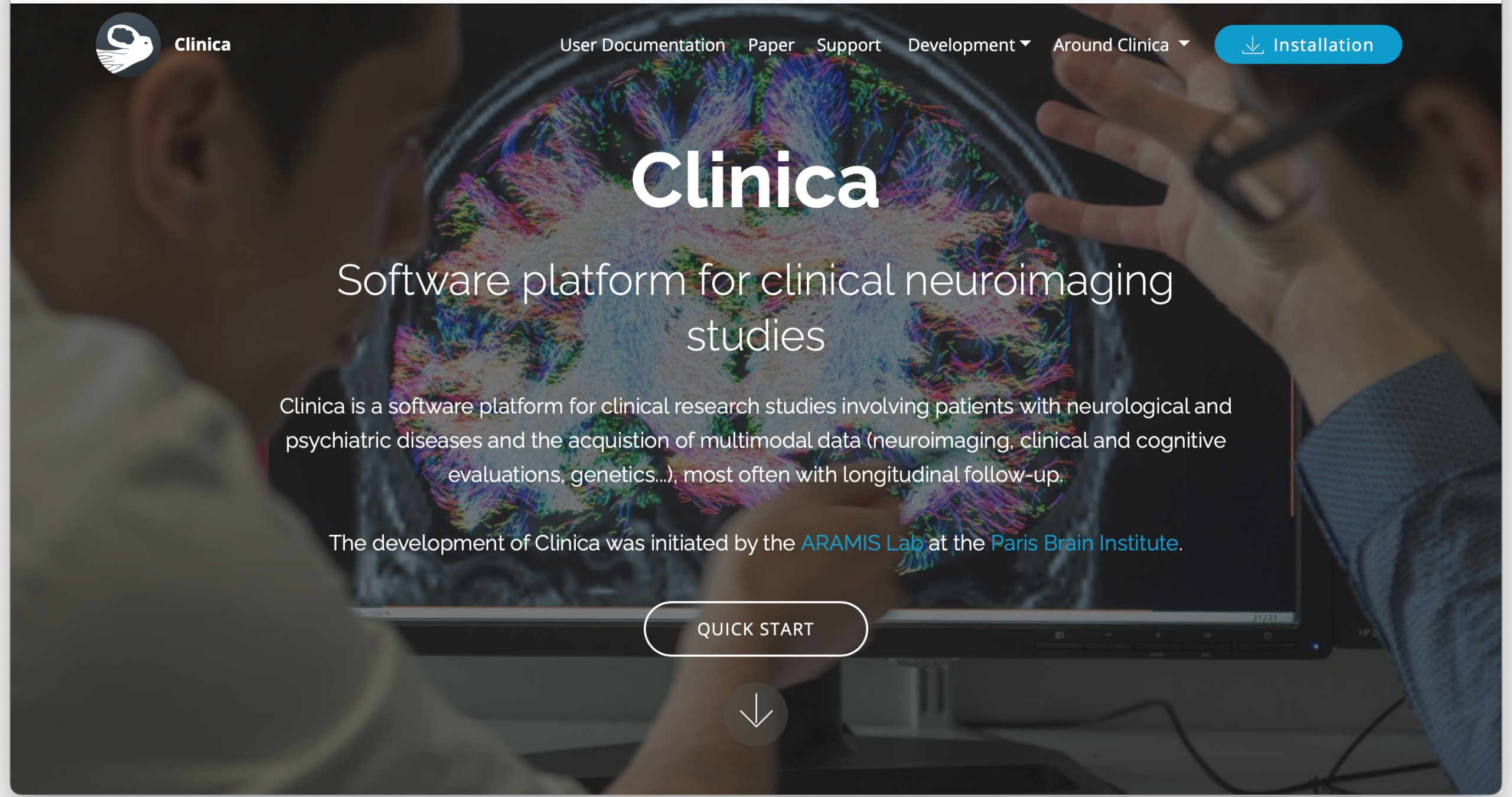


Motivation

- 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



Clinica

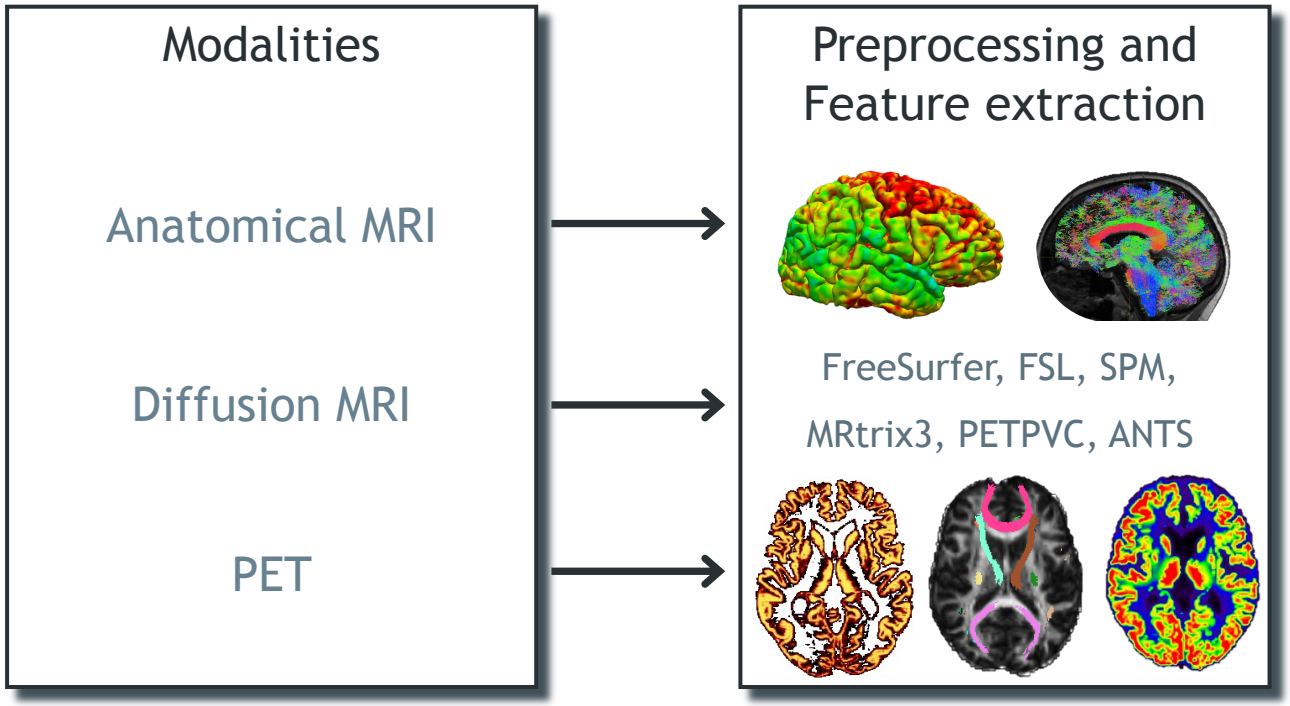
Software platform for clinical neuroimaging studies

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.

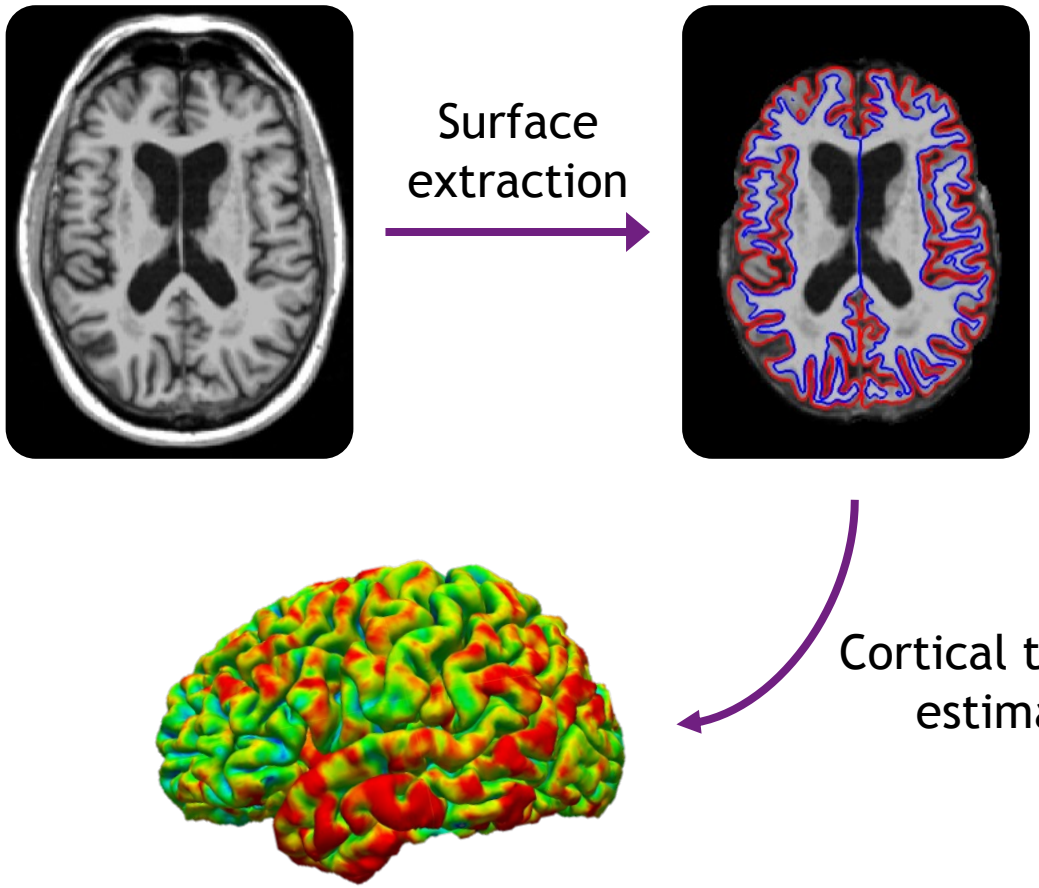
The development of Clinica was initiated by the ARAMIS Lab at the Paris Brain Institute.

QUICK START

Software platform for neuroimaging studies



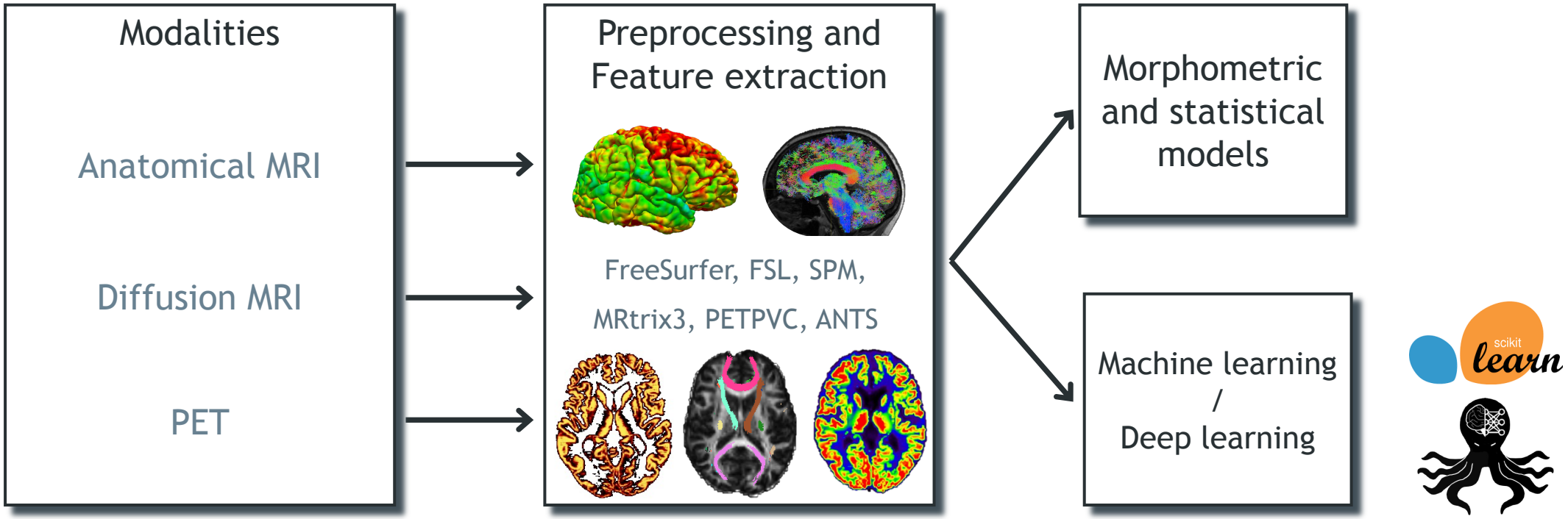
```
➜  clinica run t1-freesurfer BIDS_Dataset CAPS_Dataset
```



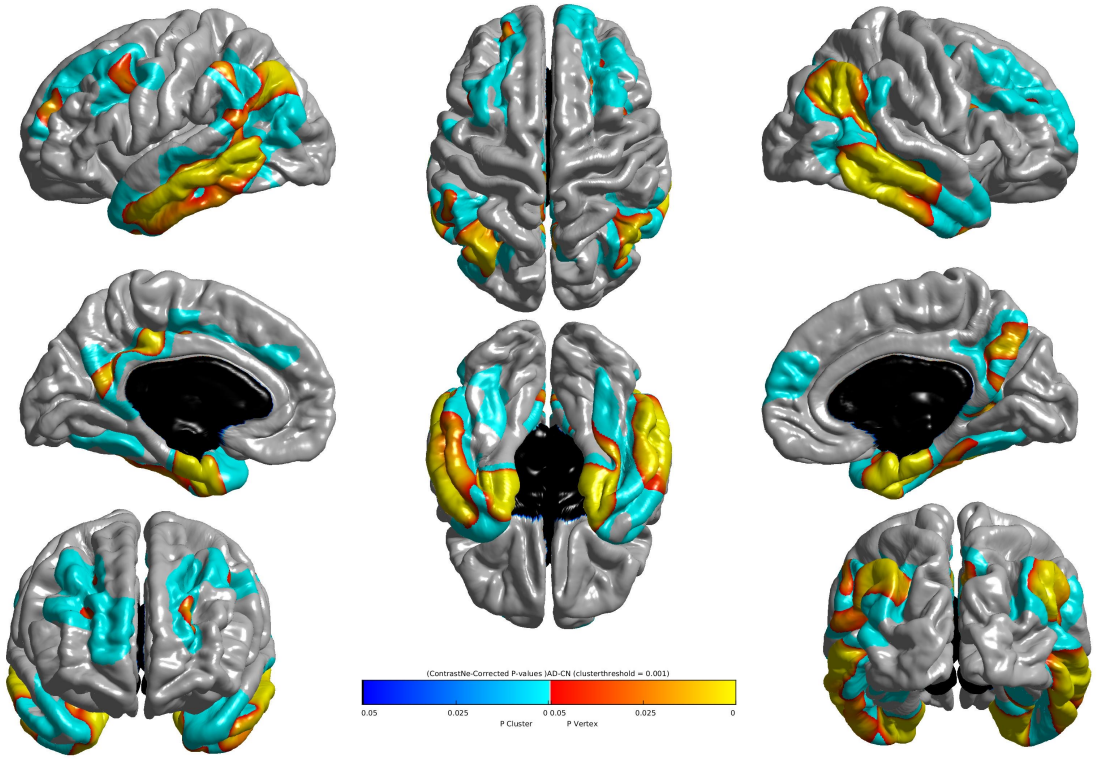
FreeSurfer

https://surfer.nmr.mgh.harvard.edu

Software platform for neuroimaging studies



```
➜ clinica run statistics-surface CAPS_Dataset ADvsHC ADvsHC_participants.tsv
   <analysis_parameter>
```

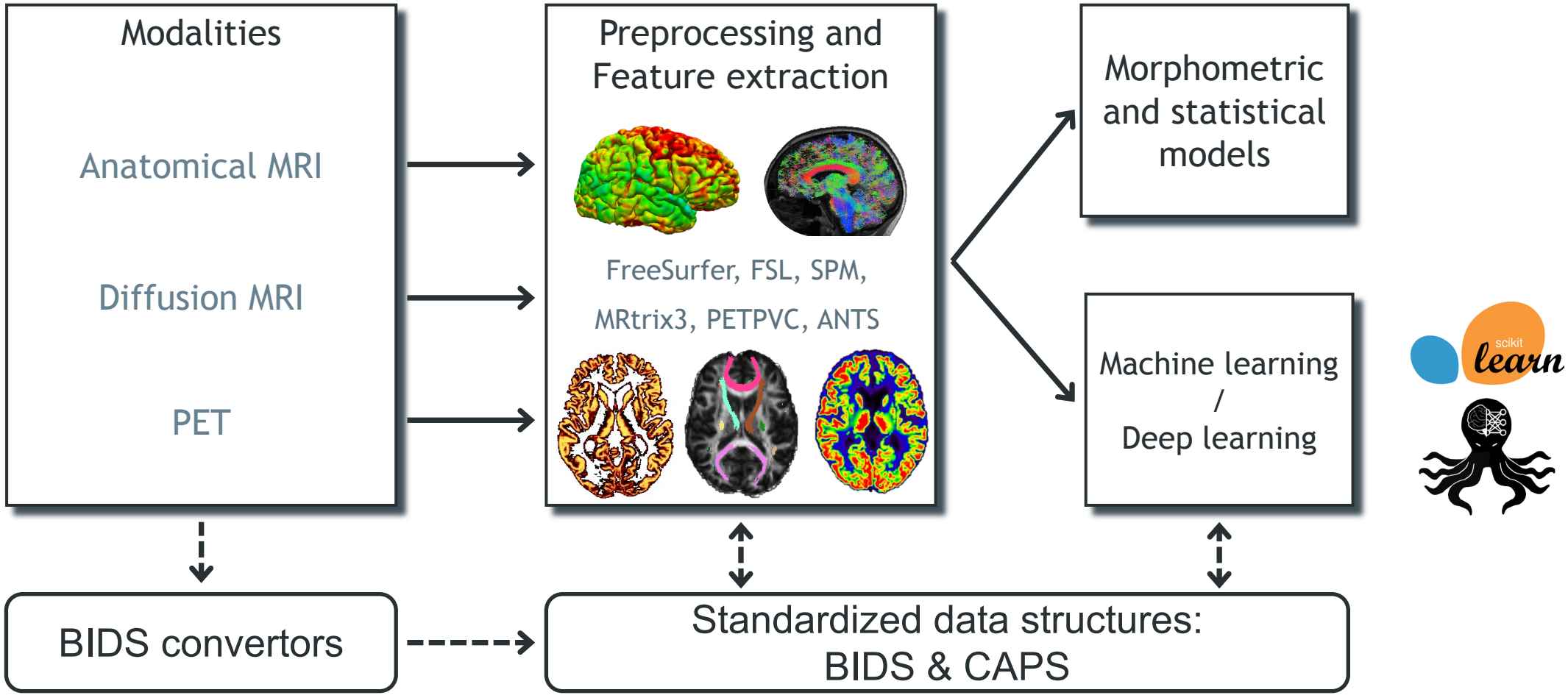


Areas of significantly reduced cortical thickness in Alzheimer's disease patients compared with healthy controls

SurfStat

https://www.math.mcgill.ca/keith/surfstat

Software platform for neuroimaging studies



```
→  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
|  …
|  |— MT1__GradWarp__N3m
|  |— Sag_IR-SPGR
|  |  |— 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
|— 094_S_4162
|— …
```

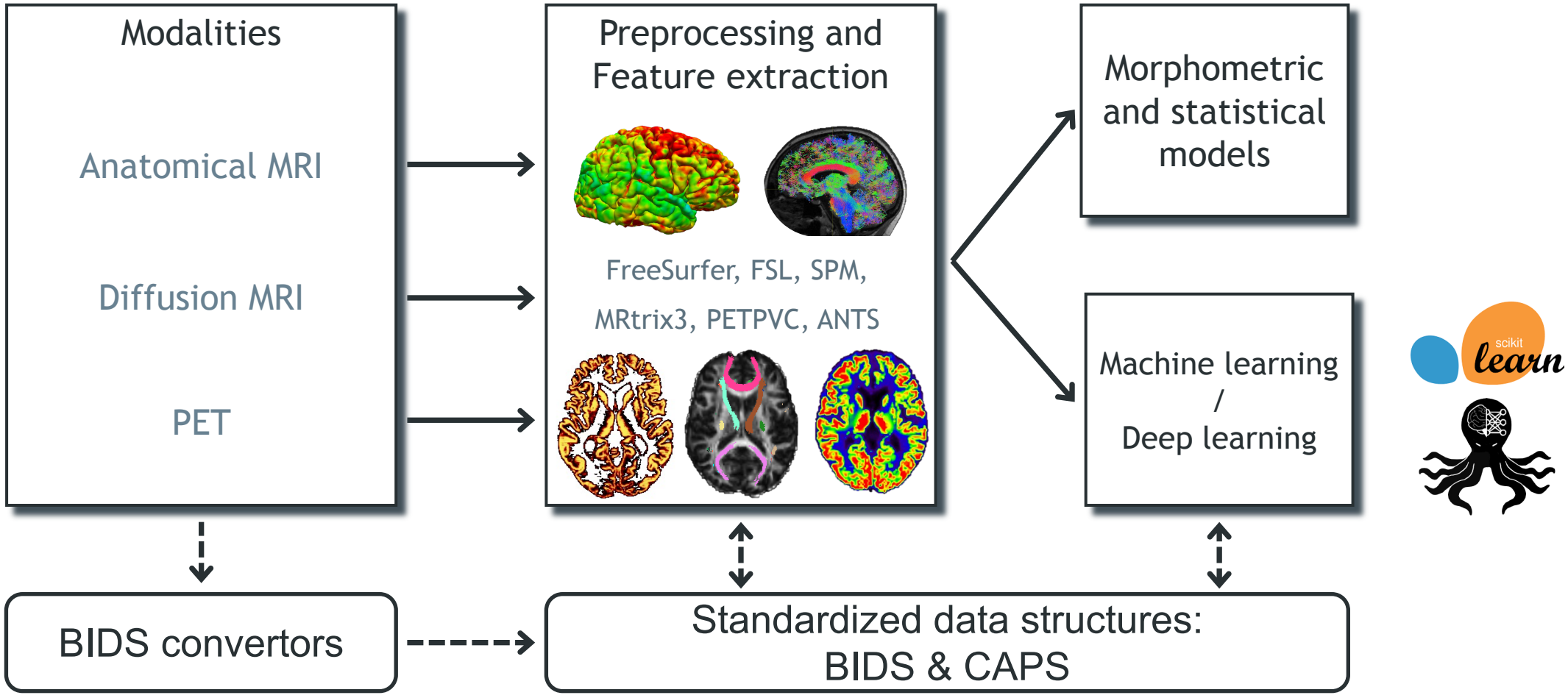
ADNI_BIDS

```
|— 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_trc-av45_pet.nii.gz
|  |  |  └— sub-ADNI094S4089_ses-M00_trc-fdg_pet.nii.gz
|  |  └— sub-ADNI094S4089_ses-M00_scans.tsv
|  |— ses-M03
|  |— ses-M12
|  └— ses-M24
|— sub-ADNI094S4162
|— …
```

BIDS BRAIN IMAGING DATA STRUCTURE

Gorgolewski et al., Nature Scientific Data, 2016 | http://bids.neuroimaging.io

Software platform for neuroimaging studies



Clinica

BIDS Converters

```
clinica convert <dataset>-to-bids \
    dataset_dir clinical_data_dir bids_dir
```

Conversion of datasets to the BIDS format:

ADNI · HARVARD AGING BRAIN · GENFI GENETIC FTD INITIATIVE · aibl · UCSF MEMORY AND AGING CENTER The Frontotemporal Lobar Degeneration Neuroimaging Initiative · biobank uk Enabling scientific discoveries that improve human health · OASIS OPEN ACCESS SERIES OF IMAGING STUDIES

\+

I/O Tools

```
clinica iotools create-subjects-visits ...
               merge-tsv ...
               check-missing-modalities ...
```

\+

Main Third-Party Dependencies

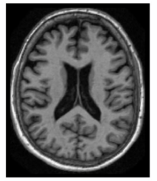
Advanced Normalization Tools (ANTs) · FreeSurfer · SPM · FSL · MRTrix

Preprocessing and features extraction: clinica run pipeline [BIDS dataset] [CAPS dataset] [options]

Anatomical MRI

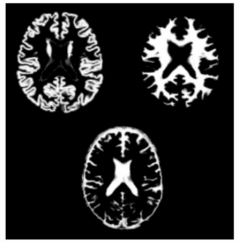
{t1|flair}-linear

Bias field correction, affine registration to standard space (MNI) and cropping (ANTs)



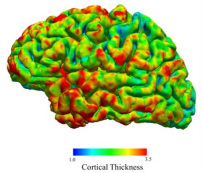
t1-volume*

Tissue segmentation (GM, WM, CSF), normalization to standard space (MNI) (SPM, CAT12)



t1-freesurfer*

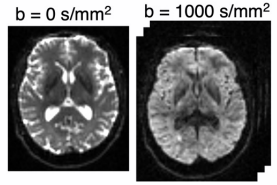
Cortical surface extraction, segmentation of subcortical structures, cortical thickness estimation, spatial normalization to standard space (FreeSurfer)



Diffusion MRI

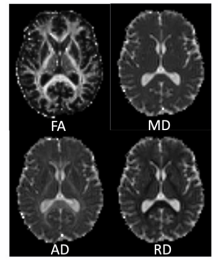
dwi-preprocessing

Correction of raw DWI data (FSL, ANTs, MRtrix3)



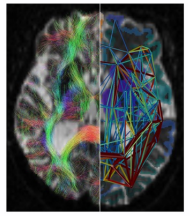
dwi-dti

Extraction of DTI-based measures, normalization to standard space (MNI) (FSL, MRTrix3, ANTs)



dwi-connectome

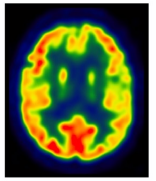
Tractography & connectome (FSL, FreeSurfer, MRTrix3)



PET

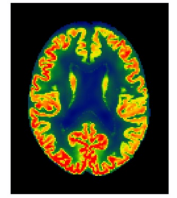
pet-linear

Affine registration to standard space (MNI) via T1 MRI, intensity normalization and cropping (ANTs)



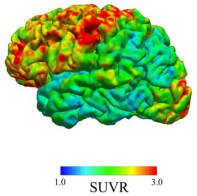
pet-volume

Registration to T1 MRI, partial volume correction, intensity normalization, spatial normalization to standard space (MNI) (SPM, PETPVC, CAT12)



pet-surface*

Projection of PET signal onto surfaces of the cortex (FreeSurfer, FSL, SPM, PETPVC)



Standardized data structures

BIDS & CAPS

Machine Learning

SVM, logistic regression, random forest

scikit learn

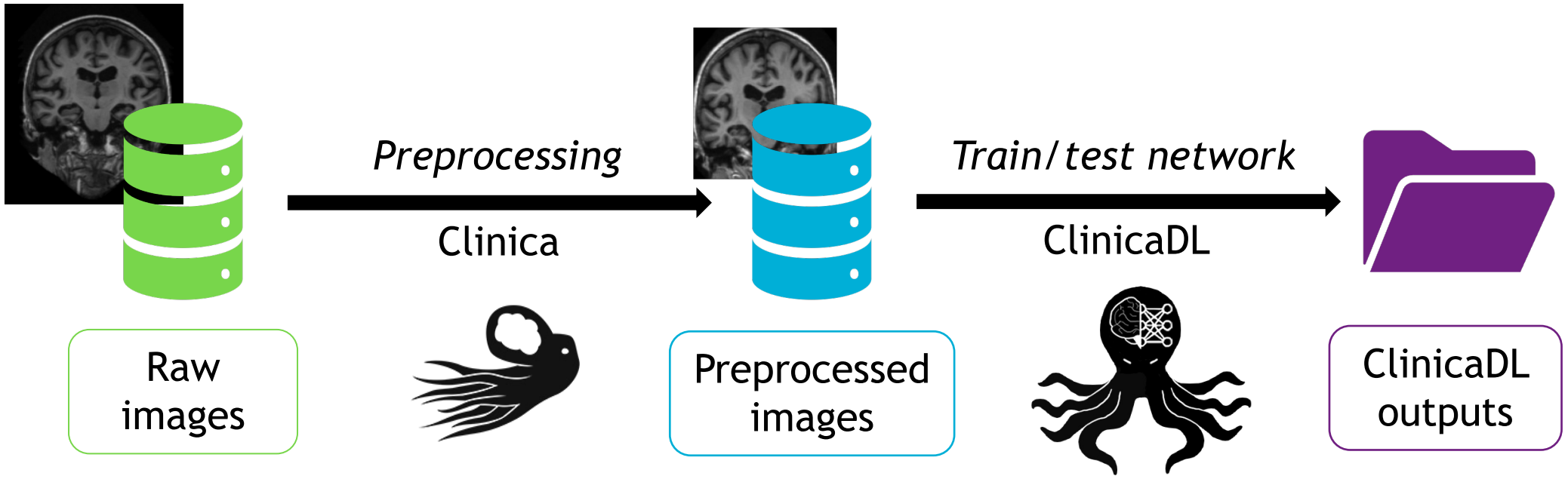
(Repeated) K-fold cross validation, repeated hold-out validation

Statistical models

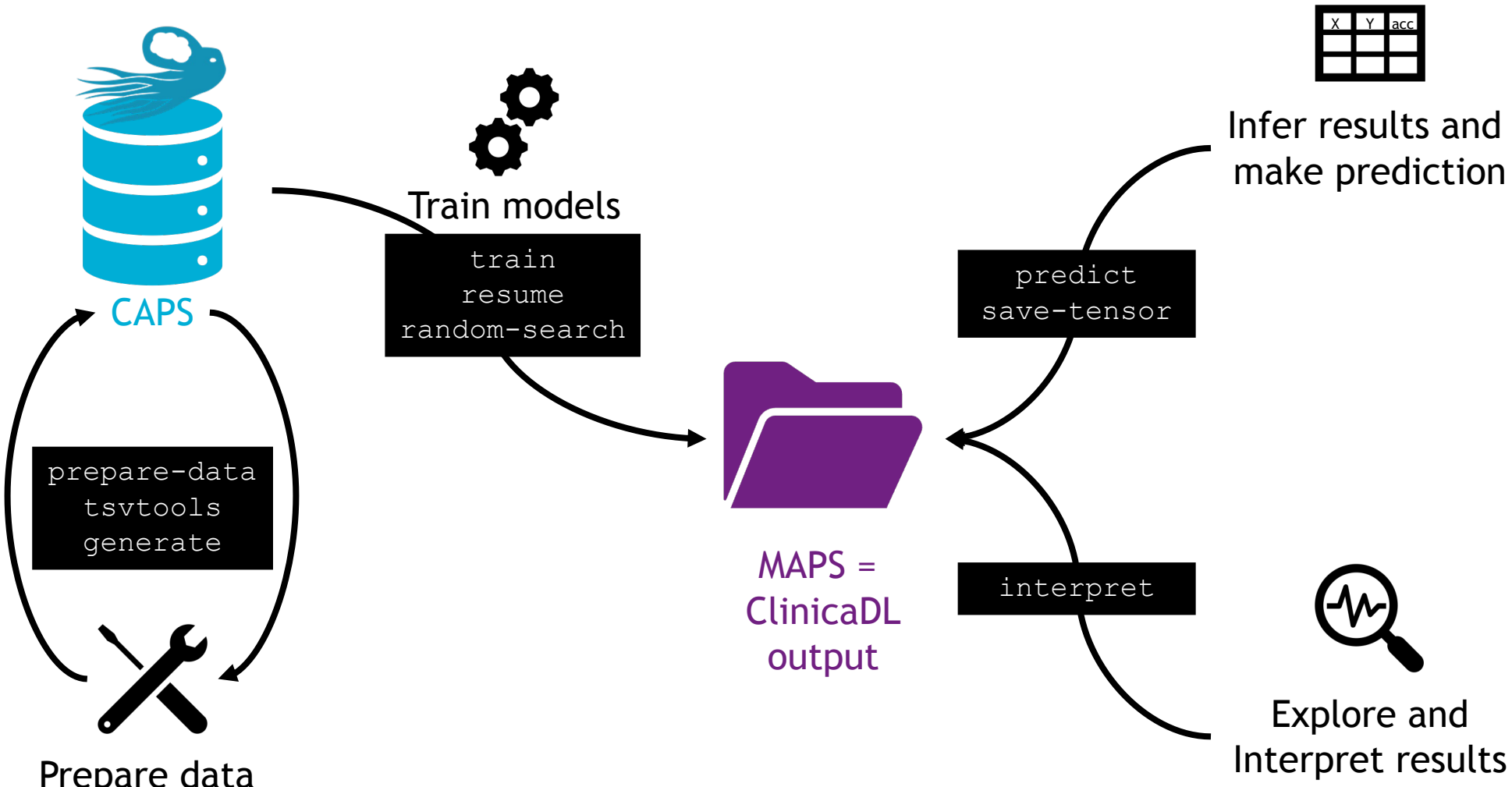
Surface-based analysis (statistics-surface):

- Group comparison
- Correlation

Clinica & ClinicaDL



Open-source software for reproducible DL in neuroimaging



github.com/aramis-lab/clinicadl

Clinica's environment

GitHub

python™

DVC

BIDS
BRAIN IMAGING DATA STRUCTURE

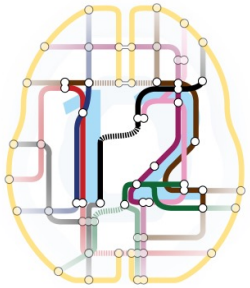
Nipype

Pydra

Advanced Normalization Tools

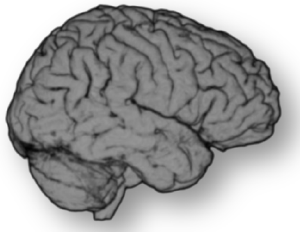
ANTs

FreeSurfer



SPM

FSL



MRTrix

Who develops Clinica

Simona Bottani

Jérémy Guillon

Stanley Durrleman

You?

Tristan Moreau

Thomas Jacquemont

Ghislain Vaillant

Omar El Rifai

Arnaud Marcoux

Ninon Burgos

Nicolas Gensollen

Olivier Colliot

Alexandre Routier

Alexis Guyot

Pascal Lu

Jorge Samper-Gonzalez

Elina Thibeau--Sutre

Matthieu Joulot

Ravi Hassanaly

Sabrina Fontanella

Junhao Wen

Adam Wild

Mauricio Diaz

Michael Bacci

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Clinica's environment

GitHub

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DVC

BIDS
BRAIN IMAGING DATA STRUCTURE

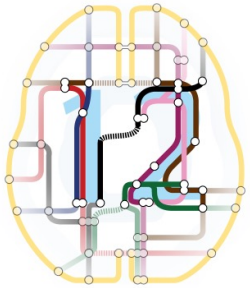
Nipype

Pydra

Advanced Normalization Tools

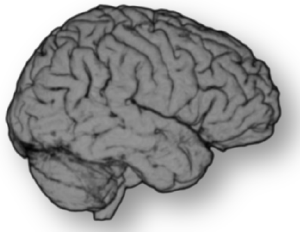
ANTs

FreeSurfer



SPM

FSL



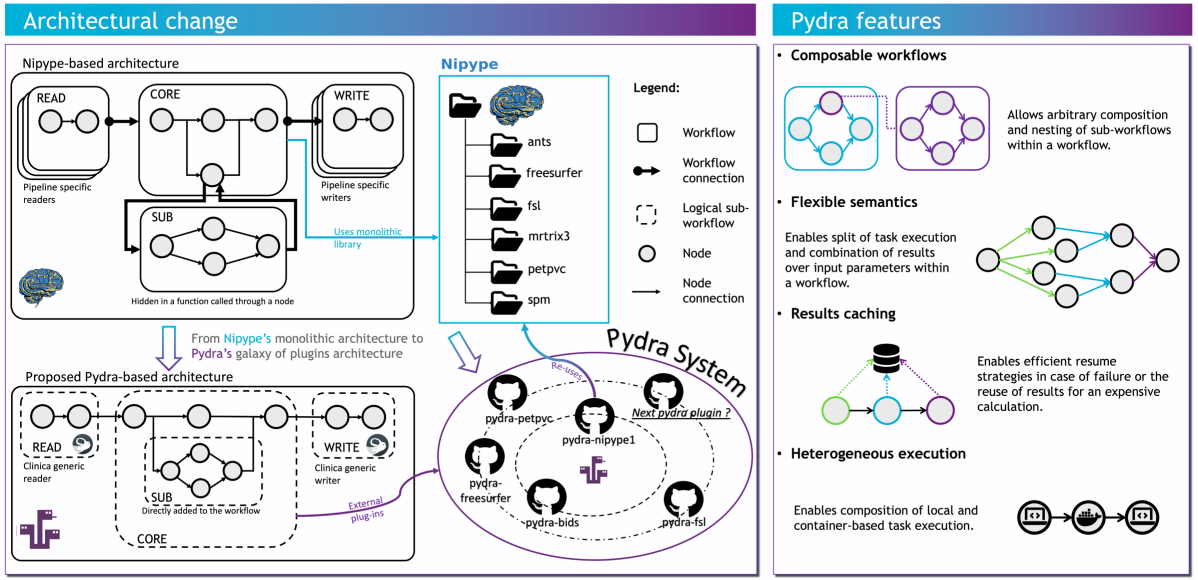
MRTrix

Involvement of Clinica in community efforts

BIDS

- BIDS Extension Proposal 009: Positron Emission Tomography → v1.6.0
- BIDS Extension Proposal 028: Provenance

Pydra (aka the new Nipype)



Was it worth making Clinica open?

A few numbers

- 84 citations of Routier et al., Frontiers in Neuroinformatics, 2021
  - ➢ 60+ actually use the software, 30+ outside the ICM

- ~200 stars on GitHub, ~60 forks, ~200 issues opened (~65 by external users), ~170 Google Group conversations

What cannot be counted

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www.clinica.run

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Software platform for neuroimaging studies

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