

New longitudinal and deep learning pipelines in the Clinica software platform




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Overview of Clinica

BIDS converters

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

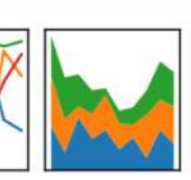
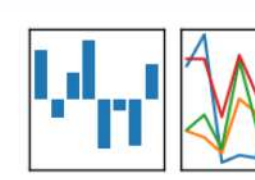
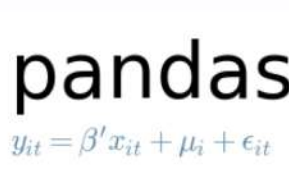


Standardized data structures


CAPS
Clinica Processed Structure


I/O tools

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




Preprocessing and image-derived feature extraction:

```
clinica run pipeline [BIDS_Datasets] CAPS_Dataset ...
```

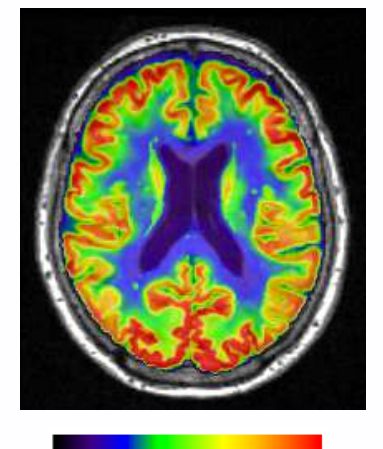


where pipeline can be:

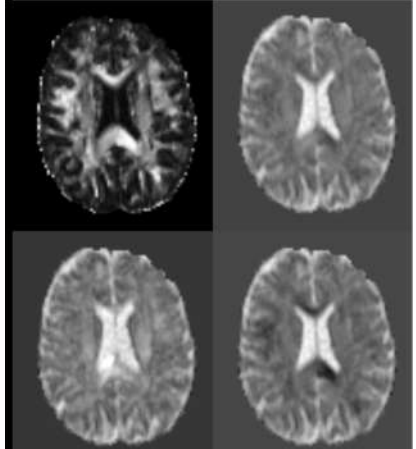
t1-volume


Dependencies: SPM, CAT12

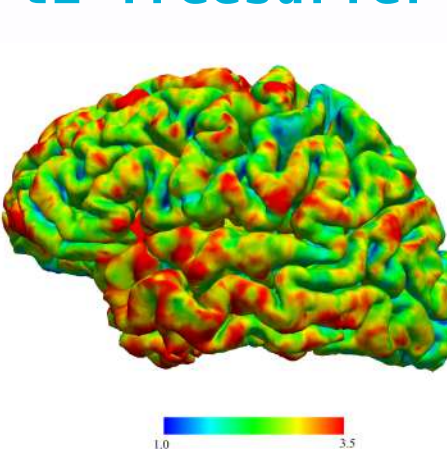
pet-volume


Dependencies: SPM, CAT12

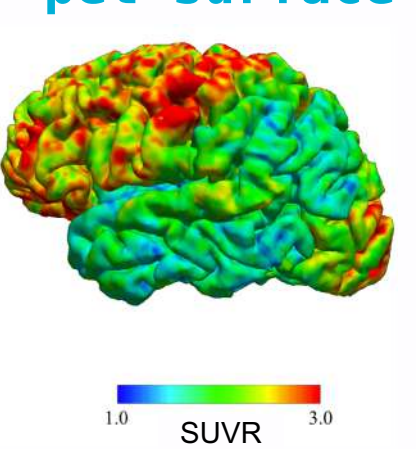
dwi-dti


Dependencies: FSL, ANTs, MRtrix3

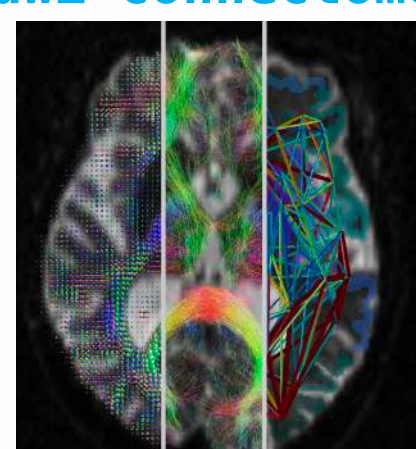
t1-freesurfer


Dependencies: FreeSurfer


pet-surface


Dependencies: FreeSurfer, FSL, SPM, CAT12, PETPVC

dwi-connectome


Dependencies: FreeSurfer, FSL, MRtrix

Machine learning


PyTorch

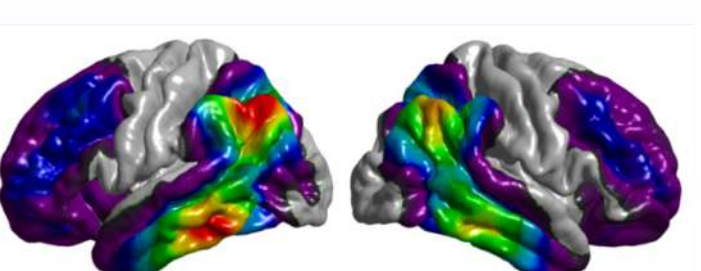
Classifiers:

- SVM
- l2 logistic regression
- Random forest

Cross-validations:

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

Statistical models


Surface-based analyses (statistics-surface):

- Group comparison
- Correlation

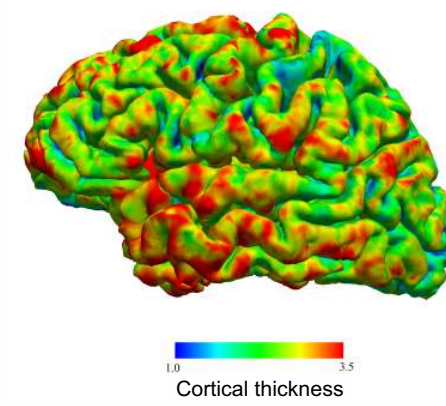
New longitudinal pipelines

t1-freesurfer-longitudinal (Reuter et al., 2012)

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

Dependencies: FreeSurfer

- Surface-based features (cortical thickness)
- Regional features (average cortical thickness) using atlases (Desikan, Destrieux)

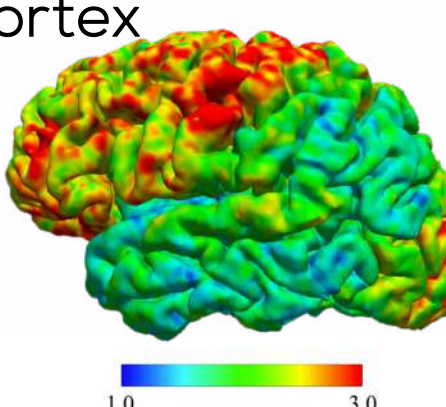


pet-surface-longitudinal (Marcoux et al., 2018)

Projection of PET uptake onto the surface of the cortex

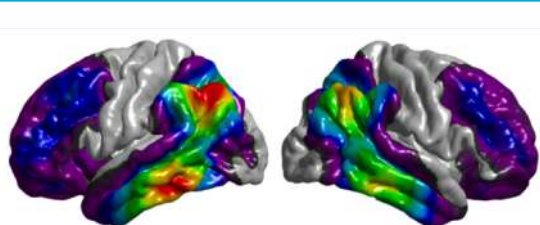
Dependencies: FreeSurfer, FSL, SPM, PETPVC

- Surface-based features (FDG uptake, amyloid uptake)
- Regional features (average FDG, amyloid uptake) using atlases (Desikan, Destrieux)



statistics-surface

- Now handles longitudinal inputs



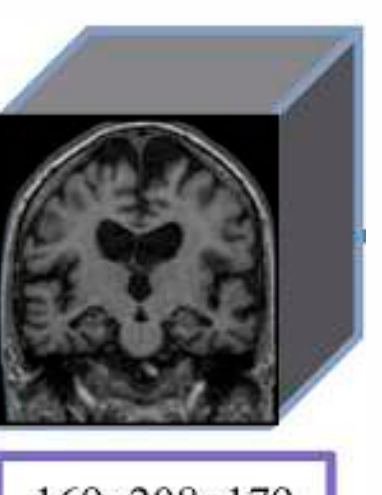
New deep learning pipelines

t1-linear

Bias field correction, affine registration and cropping

Dependencies: ANTs

- T1 MRI on ICBM 2009c nonlinear symmetric template
- Used as input for deeplearning-prepare-data

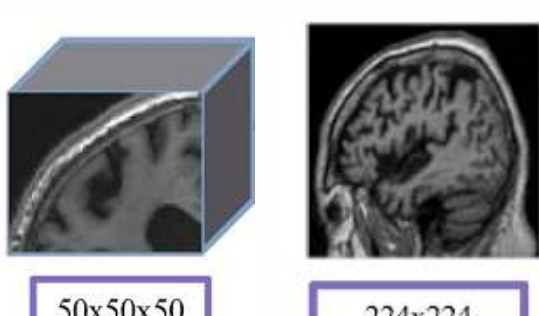


deeplearning-prepare-data

Convert features extracted by Clinica to PyTorch tensors

Dependencies: None

- 3D images, 3D patches or 2D slices from t1-linear
- Tensors for PyTorch

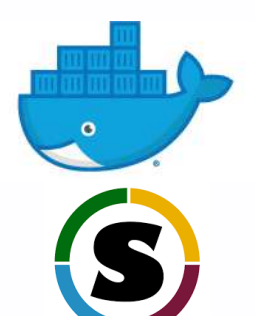
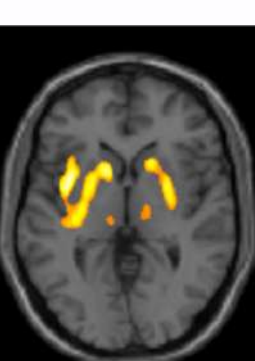
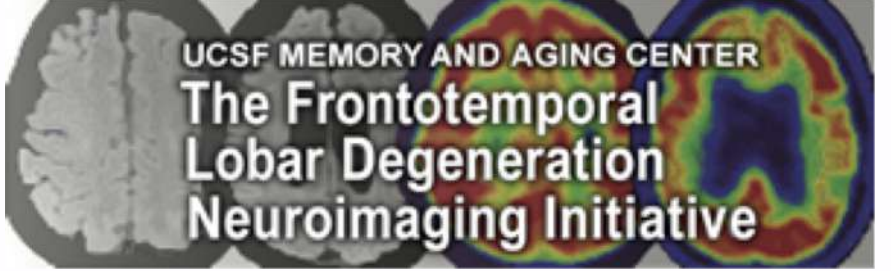


ClinicaDL (Wen, Thibeau-Sutre et al., 2020)

Framework for the reproducible classification of Alzheimer's disease using deep learning: <https://github.com/aramis-lab/AD-DL>

And more

- New nifd-2-bids converter
- Update of the adni-2-bids converter
 - ADNI3,
 - fMRI,
 - PET tracers
- New statistics-volume pipeline
 - Voxel-based features from t1-volume or pet-volume
 - Group comparison using GLM
- Update of the dwi-preprocessing pipeline
 - FSL eddy tool (Andersson et al., 2016)
- (Beta-test) Docker & Singularity https://github.com/aramis-lab/clinica_docker



Example: group comparison of cortical FDG-PET projection between patients and healthy controls

```
# Step 1 - Run FreeSurfer in order to extract cortical surfaces:
clinica run t1-freesurfer 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 Alzheimer's disease (AD group)
# and healthy controls (HC group). ADvsHC will define the group label:
clinica run statistics-surface CAPS_Dataset ADvsHC ADvsHC_participants.tsv <analysis_parameter>
```

BIDS_Dataset

participants.tsv

sub-CLNC01

ses-M0

anat

sub-CLNC01_ses-M0_T1w.json

sub-CLNC01_ses-M0_T1w.nii.gz

pet

sub-CLNC01_ses-M0_task-rest_acq-FDG_pet.json

sub-CLNC01_ses-M0_task-rest_acq-FDG_pet.nii.gz

sub-CLNC01_ses-M0_scans.tsv

ses-M18

anat

sub-CLNC01_ses-M18_T1w.json

sub-CLNC01_ses-M18_T1w.nii.gz

pet

sub-CLNC01_ses-M18_task-rest_acq-FDG_pet.json

sub-CLNC01_ses-M18_task-rest_acq-FDG_pet.nii.gz

sub-CLNC01_ses-M0_scans.tsv

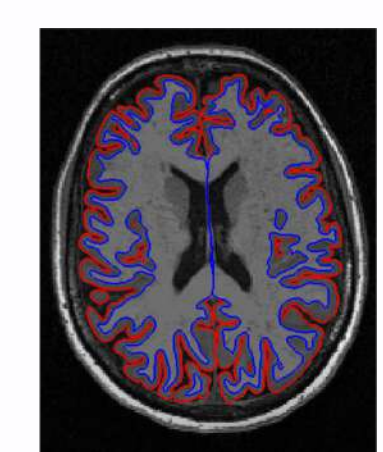
sub-CLNC01_sessions.tsv

sub-CLNC02

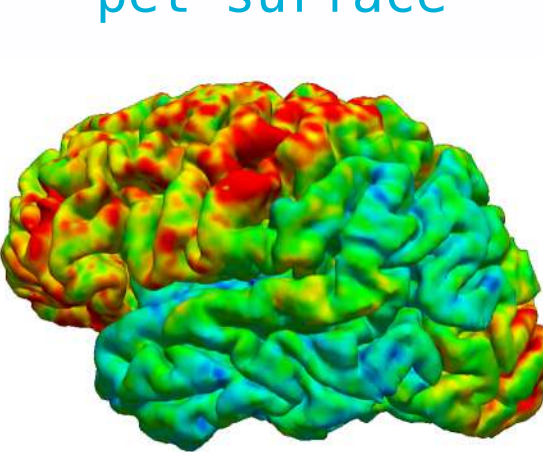
sub-CLNC03

...

t1-freesurfer



pet-surface



CAPS_Datasets

subjects

sub-CLNC01

ses-M0

pet

surface

t1

freesurfer_cross_sectional

ses-M18

pet

surface

t1

freesurfer_cross_sectional

sub-CLNC02

...

groups

group-ADvsHC

statistics

participant.tsv

surfstat_group_comparison

group-ADvsHC_glm.json

group-ADvsHC_AD-lt-HC_measure-fdg_fwhm-20_FDR.jpg

group-ADvsHC_AD-lt-HC_measure-fdg_fwhm-20_FDR.mat

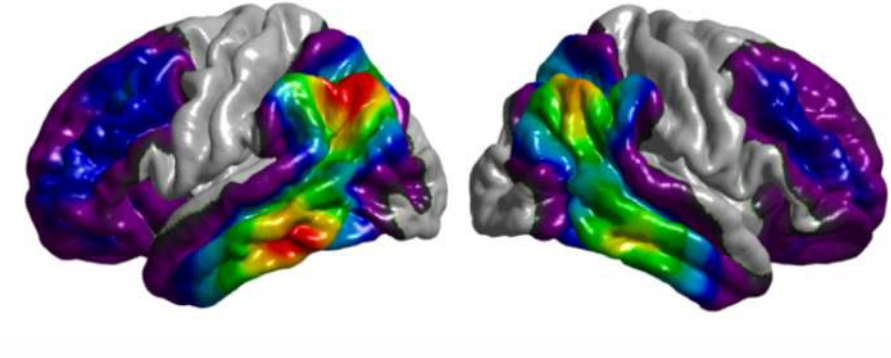
group-ADvsHC_AD-lt-HC_measure-fdg_fwhm-20_TStatistics.jpg

group-ADvsHC_AD-lt-HC_measure-fdg_fwhm-20_TStatistics.mat

group-ADvsHC_AD-lt-HC_measure-fdg_fwhm-20_correctedPValue.jpg

group-ADvsHC_AD-lt-HC_measure-fdg_fwhm-20_correctedPValue.mat

statistics-surface



Conclusion

Clinica is an **open-source software** platform for clinical neuroscience. We hope that it will help researchers to **spend less time** on data management and processing, **easily share** data and results, make their research more **reproducible** and contribute to **Open Science**.

Target audience of Clinica

- Neuroscientists** or **clinicians** conducting clinical neuroscience studies involving multimodal imaging
- Researchers** developing advanced **machine learning** algorithms