

# Neuroimaging Analysis Kit - Overview

NIAK development team

[niak.simexp-lab.org](http://niak.simexp-lab.org)

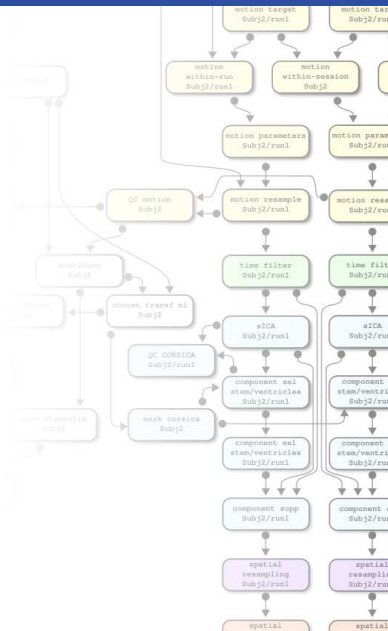
Département d'informatique et de recherche opérationnelle, Université de Montréal



# What's NIAK

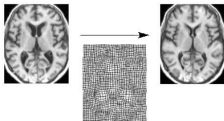
The Neuroimaging Analysis Kit (NIAK):  
a software package for connectivity analysis  
in large fMRI datasets.

- ▶ A catalogue of **complete workflows**.
- ▶ **Scales** for large datasets / analyses.
- ▶ **Reproducible** deployment.
- ▶ **Well tested** workflows.
- ▶ Web-based **notebook** interface.
- ▶ Interactive **dashboard** reports.
- ▶ Free and **open-source** (MIT).



# Available pipelines

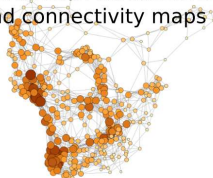
## fMRI preprocessing



## Functional brain parcellation



## Generation of connectomes and connectivity maps

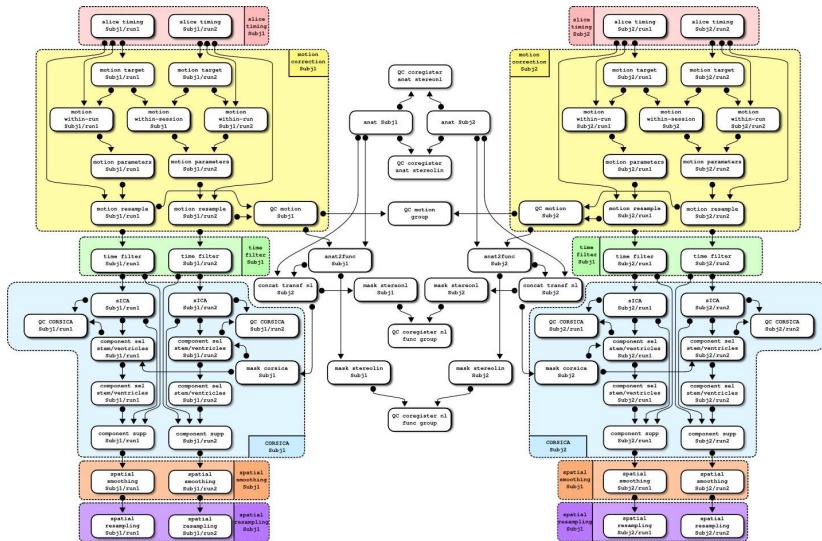


Check <http://niak.simexp-lab.org> for more info.

# Main dependencies

- ▶ **Ubuntu:** An operating system based on mostly GNU tools as well as the linux kernel. Free software (mixed licenses).  
<https://www.ubuntu.com/>
- ▶ **Octave:** A high-level scientific programming language, largely identical to Matlab. Octave is Free Software (GNU license).  
<https://www.gnu.org/software/octave/>
- ▶ **The MINC toolkit:** A set of command line tools for brain registration, segmentation and basic image processing operation. Underlying code is mostly C and PERL. Free software (MIT like custom license). <http://bic-mni.github.io/>
- ▶ **The brain connectivity toolbox:** A toolbox to generate properties of brain networks. <https://sites.google.com/site/bctnet/>.

# One pipeline, many jobs...



Jobs and dependencies for fMRI preprocessing of two subjects with two functional runs each.

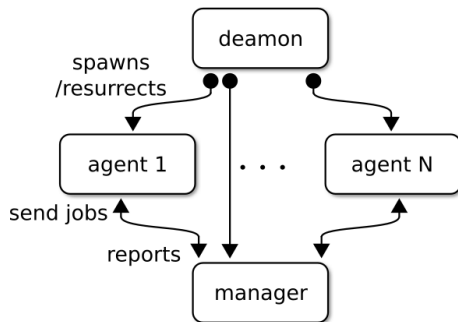
# The pipeline system for Octave and Matlab

NIAK is powered by PSOM, an open-source library for scripting pipelines using Octave or Matlab (Bellec et al., Frontiers in Neuroinformatics, 2012).

- ▶ **Parallel computing:** Detection and execution of parallel components in the pipeline. The same code can run in a variety of execution environments (local, multi-core, cluster).
- ▶ **Provenance tracking:** Generation of a comprehensive record of the pipeline stages and the history of execution.
- ▶ **Fault tolerance:** Multiple attempts will be made to run each job before it is considered as failed. Failed jobs can be automatically re-started.
- ▶ **Smart updates:** When an analysis is started multiple times, only the parts of the pipeline that need to be reprocessed are executed.

<http://psom.simexp-lab.org>

# PSOM architecture



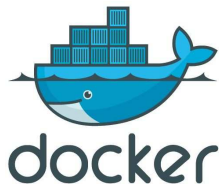
PSOM features an agent-based execution model.

# Benchmark PSOM 2.0

- ▶ Dataset Human Connectome Project, 875 subjects with T1 + 7 multiband fMRI task runs.
- ▶ 123k jobs / 3.4 T raw input / 3.8 T output / 173k unique input/output files.
- ▶ guillimin: supercomputer (Xeon, 20k+ cores on 2016), infiniband parallel file system.
- ▶ Up to 300 concurrent processes allowed.
- ▶ Serial time: 17.9k hours / 746.87 days. Parallel time: 70 hrs. Parallelization efficiency: 85%
- ▶ deviation from 100% efficiency mostly attributable to queuing delays in order to access resources.




# NIAK deployment using Docker and Singularity

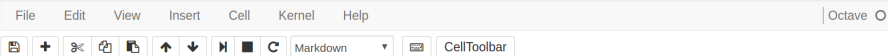


- ▶ The NIAK now as a docker container, available in docker hub <https://hub.docker.com/>, as well as singularity <http://singularity.lbl.gov/>, designed for high-performance computing infrastructures.
- ▶ The container includes all dependencies (MINC-toolkit, Octave, PSOM, NIAK, Brain Connectivity Toolbox, Jupyter).
- ▶ This facilitates installation and increases reproducibility on all platforms, Linux, Mac, Windows  
[http://niak.simexp-lab.org/niak\\_installation.html](http://niak.simexp-lab.org/niak_installation.html)

# How does it work?

Octave (similar to matlab) runs in a jupyter notebook.

 **jupyter** niak\_tutorial\_fmri\_preprocessing Last Checkpoint: 4 hours ago (autosaved)



## fMRI preprocessing

This tutorial shows how to run the NIAK fMRI preprocessing pipeline, using a limited set of options. See the [documentation](#) of the pipeline for a more comprehensive list of options. Download the tutorial as a notebook [here](#) and a matlab script [here](#). We recommend to use [jupyter](#) from a niak docker container, as described in the [NIAK installation page](#).

## Preparing files

First download a small fMRI dataset, with a structural scan. Be aware that all raw and derivatives data will be generated in the current folder. Note that you will need to manually remove the `data_test_niak_mnc1` and `fmri_preprocess` folders to restart this tutorial from scratch.

```
In [1]: clear  
niak_wget('data_test_niak_mnc1');  
  
--2016-10-15 18:36:07-- http://www.nitrc.org/frs/download.php/7241/data\_test\_niak\_mnc1.zip  
Resolving www.nitrc.org (www.nitrc.org)... 132.239.16.23
```

# Testing pipelines...



Numerical instabilities creep up in a complex pipeline.

Effective numerical stabilization strategies are required to extract reliable measures.

An engineering problem surprisingly little studied in the fMRI field.



# Continuous integration tests

NIAK continuous integration tests running on  
<https://circleci.com/gh/SIMEXP/niak>

The screenshot displays the CircleCI interface for a build. At the top, the breadcrumb navigation shows 'Builds » SIMEXP » niak » master » build 89'. To the right are buttons for 'Rebuild' and 'Project Settings'. The build status is 'SUCCESS', with a green checkmark icon. Below this, the build details are listed: 'Finished: 2 days ago (25:03)', 'Previous: 88', 'Parallelism: 1x out of 4x', and 'Queued: 00:48 waiting + 00:00 in queue'. The 'Triggered by' section shows 'P-O Quirion (pushed 671a0ab)'. A section titled 'COMMITTS (1)' lists the commit 'Pierre-Olivier Quirion' with the hash '671a0ab' and the message 'can run jupyter non root'. Below this is a table with tabs for 'Test Summary', 'Queue (00:48)', 'Debug via SSH', 'Artifacts', 'circle.yml', and 'Build Timing'. The 'Test Summary' tab is active, showing a tree view of the build steps: 'Container 0' (expanded), 'home/' (expanded), 'ubuntu/' (expanded), 'niak/' (expanded), 'result/' (expanded), and a list of test steps: 'demoniak\_connectome/', 'demoniak\_glm\_connectome/', 'demoniak\_glm\_fir/', 'demoniak\_region\_growing/', 'demoniak\_scores/', 'demoniak\_stability\_fir/', 'demoniak\_stability\_rest/', 'glm\_connectome\_unit/', and 'logs/'. Below these steps are three links to CSV reports: 'report\_test\_regression\_connectome\_demoniak.csv', 'report\_test\_regression\_fmripredproc\_demoniak.csv', and 'report\_test\_regression\_glm\_connectome\_demoniak.csv'. A dark circular button with a white question mark is located in the bottom right corner of the interface.

Builds » SIMEXP » niak » master » build 89

Rebuild Project Settings

**SUCCESS** Finished: 2 days ago (25:03) Previous: 88 Parallelism: 1x out of 4x Queued: 00:48 waiting + 00:00 in queue Triggered by: P-O Quirion (pushed 671a0ab)

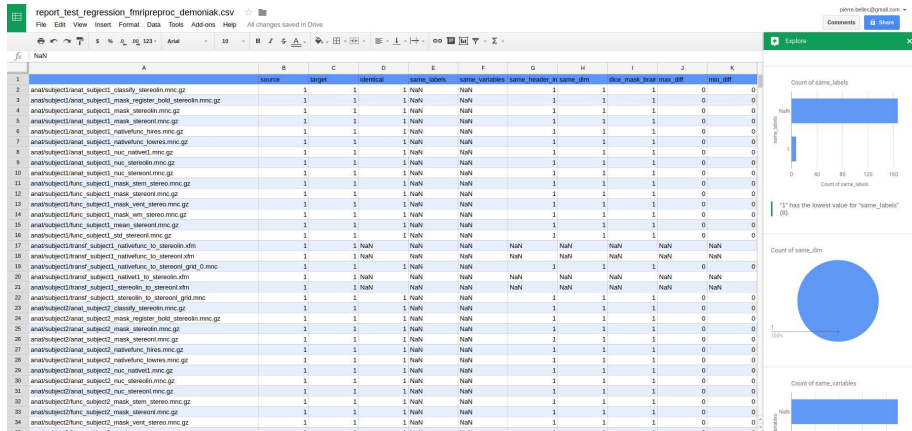
COMMITTS (1)

Pierre-Olivier Quirion 671a0ab can run jupyter non root

Test Summary	Queue (00:48)	Debug via SSH	Artifacts	circle.yml	Build Timing
<div>Container 0<ul style="list-style-type: none"><li>home/<ul style="list-style-type: none"><li>ubuntu/<ul style="list-style-type: none"><li>niak/<ul style="list-style-type: none"><li>result/<ul style="list-style-type: none"><li>demoniak_connectome/</li><li>demoniak_glm_connectome/</li><li>demoniak_glm_fir/</li><li>demoniak_region_growing/</li><li>demoniak_scores/</li><li>demoniak_stability_fir/</li><li>demoniak_stability_rest/</li><li>glm_connectome_unit/</li><li>logs/</li></ul></li></ul></li></ul></li></ul></li></ul><ul style="list-style-type: none"><li>report_test_regression_connectome_demoniak.csv</li><li>report_test_regression_fmripredproc_demoniak.csv</li><li>report_test_regression_glm_connectome_demoniak.csv</li></ul></div>					

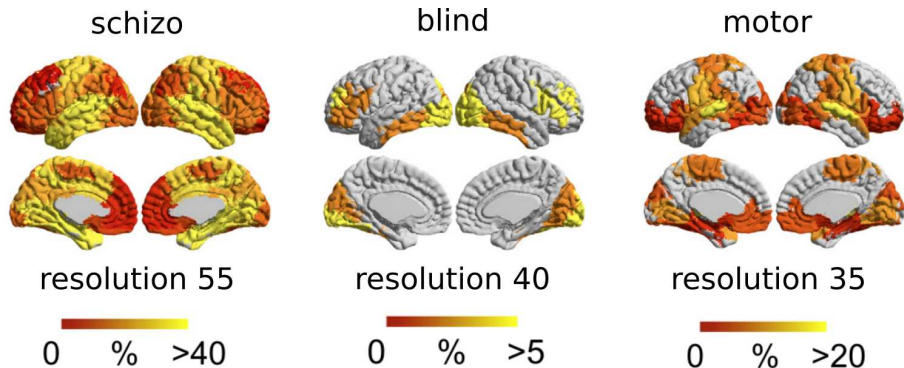
## Continuous integration tests

Each change in NIAK triggers a comparison between current results and a fixed, target version, across all available pipelines. Quantitative reports show which stage of the pipeline has changed, and by how much.



# Large-scale validation at release

Future NIAK releases will systematically replicate a number of key large-scale validation experiments and compare results across versions.



Between-group comparisons in resting-state connectivity across three populations. See Bellec et al., Orban, Neuroimage 2015.

# Acknowledgements

- ▶ **Funding:** Brain Canada CBRAIN, UdM, UNF/CRIUGM, CCNA (CIHR), Courtois foundation, Lemaire foundation.
- ▶ **QC@NIAK:** **Yassine Benhajali**, Sebastian Urchs, AmanPreet Badhwar, Perrine Ferré, Angela Tam, Christian Dansereau.
- ▶ **validation@NIAK:** **Pierre Orban**, Yassine Benhajali, Felix Carbonell, Christian Dansereau, Geneviève Albouy, Maxime Pelland, Cameron Craddock, Olivier Collignon, Julien Doyon, Emmanuel Stip.
- ▶ **NIAK:** Pierre-Olivier Quirion, Angela Tam, Sebastian Urchs, Yassine Benhajali, Christian Dansereau, Felix Carbonell, Jussi Tohka. Many indirect contributions

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