Applied NeuroDebian: Python in Neuroimaging

Yaroslav O. Halchenko

Dartmouth College, USA

Munich, Germany 2012
The Vision

We (society) have the software platform... 

- that works on all devices, operating systems, ...
- that is guaranteed to be available for as long as we want, wherever we want
- that we can freely share with anyone
- that makes manual maintenance trivial, or superfluous
- so all software is available in a single environment
- so we can share our experience with colleagues
- so we can share data processing workflows easily
- so developers can focus their scarce resources
How do we get there?

Role model **debian**

- Origin of most active software distributions
- Vast archive of **maintained** software (≈30000 binary packages) – proven procedures
- Self-governed, “do-ocracy”, no need to earn money, going strong for 20 years
## How do we get there?

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### We . . .

- Adopt standards and procedures
- Participate in the Debian project and integrate all research software
- Benefit from the work of thousands of *additional* developers
- Call it **NeuroDebian**, add fancy logo

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**NeuroDebian**

Munich, Germany 2012
NeuroDebian from a researcher’s perspective

Install simple editor

```
apt-get install gedit
```

Install complex MRI analysis package

```
apt-get install fsl
```

Install software collection for psycho-physics

```
apt-get install science-psychophysics
```

Keep the whole system up-to-date

```
apt-get upgrade
```
NeuroDebian ([http://neuro.debian.net](http://neuro.debian.net)) after X years and the contributions of many people:
PsychoPy

PsychoPy is an easy, precise, platform-independent package for stimulus presentation. Suitable for psychophysics, neuroimaging, and all areas of psychology.
- Huge variety of stimuli generated in real-time
- Cross-platform – run the same script on Linux, Win or OS X
- Flexible stimulus units (degrees, cm, or pixels)
- Coder interface for those that like to program
- Builder interface for those that don’t
- Input from keyboard, mouse, joystick or button boxes
- Multi-monitor support
- Automated monitor calibration (supported photometers)

OpenSesame

OpenSesame is a graphical experiment builder for the social sciences.
- A comprehensive and intuitive graphical user interface
- WYSIWYG drawing tools for creating visual stimuli
- Cross-platform
- Python scripting for complex tasks
- A plug-in framework
- Compatibility (through plug-ins) with commonly used devices: (e.g. Eyelink eye trackers, serial response boxes, Mantra object tracker)
- Compatibility with popular Python libraries: PsychoPy, PyGame, PyOpenGL, etc.

NiBabel

NiBabel provides read and write access to some common medical and neuroimaging file formats, including: ANALYZE (plain, SPM99, SPM2), GIFTI, NIFTI, MINC, as well as PAR/REC. NiBabel is the successor of PyNIfTI. The various image format classes give full or selective access to header (meta) information and access to the image data is made available via NumPy arrays.

BrainVISA

BrainVISA is an open-source, modular and customizable software platform built to host heterogeneous tools dedicated to neuroimaging research. It aims at helping researchers in developing new neuroimaging tools, sharing data and distributing their software.
- Databasing capabilities
- Massive computation facilities using Soma-workflow
- Open environment, with many toolboxes
- Specialized toolboxes for T1 MRI processing, sulci and gyri morphometry, diffusion imaging and fibers tracking, surfacic and structural analysis, 3D histology...
- Links with other software like SPM, FSL, FreeSurfer, or CIVET

Dipy

Dipy is an international FOSS project for diffusion magnetic resonance imaging analysis. Dipy is multiplatform and will run under any standard operating system such as Windows, Linux, Mac OS X. Some of our state-of-the-art applications are:
- Reconstruction algorithms e.g. GQI, DTI
- Tractography generation algorithms e.g. EuDX
- Intelligent downsampling of tracks
- Ultra fast tractography clustering
- Resampling datasets with anisotropic voxels to isotropic
- Visualizing multiple brains simultaneously
- Finding track correspondence between different brains
- Warping tractographies into another (e.g. MNI) space
- Support of various file formats e.g. Trackvis or NIfTI

Find the community @ http://www.nipy.org
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http://www.cogsci.nl/software/opensesame

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PsychoPy: Builder

http://www.psychopy.org

NavonTask.pyexp - PsychoPy Builder

0 1 2 3 4 5 6 7 8 t (sec)

fixate
stimulus
mask
resp

insertRoutine insertLoop

namespace

trial instrPractice instrMain feedback thanks
NiBabel (successor of PyNIfTI) provides read and write access to some common medical and neuroimaging formats:

- ANALYZE (plain, SPM99, SPM2)
- GIFTI
- NIfTI1
- MINC
- PAR/REC
- Freesurfer volume/surface/spec

The various image format classes give full or selective access to header (meta) information and access to the image data is made available via NumPy arrays.

Handy tools...
NiBabel: Handy tools

http://nipy.org/nibabel

nib-dicomfs:
FUSE filesystem on top of a directory with DICOMs

nib-ls:
ls for neuroimaging data files

```bash
$> nib-ls -s nibabel/tests/data/*
nibabel/tests/data/0.dcm failed
nibabel/tests/data/1.dcm failed
nibabel/tests/data/analyze.hdr uint8 [ 91, 109, 91, 1] 2.00x2.00x2.00x0.00 1.72e+03 error
nibabel/tests/data/example4d.nii.gz int16 [128, 96, 24, 2] 2.00x2.00x2.20x2000.00 2 exts: 2 sform [229725] 2:1.2e+03 error
nibabel/tests/data/niftii.hdr int16 [ 91, 109, 91] 2.00x2.00x2.00
nibabel/tests/data/test.mgz >f4 [ 3, 4, 5] 3.74x3.74x3.74
nibabel/tests/data/tiny.mnc uint8 [ 10, 20, 20] 2.00x2.00x2.00
nibabel/tests/data/tinyPET.v failed
```
NiPy

http://nipy.org/nipy

NIPY provides a rich suite of algorithms for pre-processing and analysis of neuroimaging data

- General linear model (GLM) statistical analysis
- Combined slice time correction and motion correction
- General image registration routines with flexible cost functions, optimizers and resampling schemes
- Image segmentation
- Basic visualization of results in 2D and 3D
- Basic time series diagnostics
- Clustering and activation pattern analysis across subjects
- Reproducibility analysis for group studies
Nipype allows you to

- interact with tools from different software packages (SPM, FSL, FreeSurfer, Camino, AFNI, Slicer)
- combine processing steps from different packages
- develop new workflows faster by reusing common steps from old ones
- process data faster by running in parallel
- make your research easily reproducible
- share your processing workflows with the community
Nipype

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Interfaces

Uniform Python API
- SPM Interface
- FSL Interface
- FreeSurfer Interface

Idiosyncratic, Heterogeneous APIs

Execution Plugins
- SGE
- MultiProc
- Linear
- PBS
- IPython
- SSH

Workflow Engine

(Map)Node Interface

- inputs/outputs setting
- graph transformations (e.g., iterable expansion)

.run()
PyMVPA eases statistical learning analyses (or otherwise called Multivariate pattern analysis, MVPA) of large datasets, with an accent on neuroimaging.

- Easy I/O to Neuroimaging data (via NiBabel)
- Variety of machine learning methods (e.g. SVM, SMLR, kNN)
- Uniform interfaces to other toolkits (e.g. MDP, Shogun, Scikit-learn)
- Flexible Searchlight-ing
- Uber-Fast GNB/M1NN Searchlight-ing
- Hyperalignment (Haxby et al 2011, Neuron)
PySurfer is a module for visualization and interaction with cortical surface representations of neuroimaging data from Freesurfer.
Python in NeuroImaging

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Data I/O

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Python in Electrophysiology

Find the community @ http://neuralensemble.org

Neuroshare Tools
http://g-node.org/neuroshare-tools

Neuroshare is a standardized API for accessing neurophysiology data stored in vendor-specific binary formats in a vendor-neutral way. The G-Node Neuroshare Tools provide libraries and utilities built on Neuroshare and Python to work with Neuroshare compatible files on various platforms.

- High-level Python library to access Neuroshare compatible data files
- Automatically detects file types and loads the corresponding vendor library
- Support for GNU/Linux, MacOS X, and Windows
- Neuroshare-WineProxy enables the use of vendor libraries for Windows under GNU/Linux and MacOS X
- Comes with a tool to convert any data file supported by Neuroshare to the HDF5 format

Data Archiving

Stimfit
http://www.stimfit.org

Visualise and quantify electrophysiological data.

- With a focus on patch-clamp recordings
- Supports most standard patch-clamp file types
- Embedded Python shell
- Measure action potential, EPSC and EPSP kinetics
- Extract spontaneous and evoked events
- Successfully used in many publications for >5 years

Closed-loop Frameworks


Brain Download:

iz completes.
Acknowledgements

Michael Hanke

FOSS developers of
Python, NumPy, SciPy,
Matplotlib, H5Py, Rpy,
Nipy, nibabel, ...
Inkscape, ...
Debian Community

James V. Haxby
Stephen J. Hanson
INCF

Dr. Yaroslav O. Halchenko
Dartmouth College, NH, USA
yoh@onerussian.com

about the slides:
should become available at
© 2012
snake-brain © 2010
slide style

http://neuro.debian.net
Yaroslav O. Halchenko & artwork authors,
Arno Klein
inspired by Stefano Zacchirol
CC BY-SA 3.0 — Creative Commons Attribution-ShareAlike 3.0
OS market share

Operating systems:
- GNU/Linux (L)
- Debian based
- Red Hat based
- Windows (W)
- Mac OS X (M)
- Other OS

Usage time:
- Always
- < 50%
- > 50%
- Never

A) Proportion of participants

B) Reported combinations

Open is not enough. Let’s take the next step: An integrated, community-driven computing platform for neuroscience

Yaroslav O. Halchenko¹, ², ³ and Michael Hanke³, ⁴, ⁵*

¹ Center for Cognitive Neuroscience, Dartmouth College, USA
² Department of Psychological and Brain Sciences, Dartmouth College, USA
³ Debian Project
⁴ Department of Experimental Psychology, Otto-von-Guericke-University, Germany
⁵ Center for Behavioral Brain Sciences, Germany

The last five years have seen dramatic improvements in the collaborative research infrastructure. A need for open research tools has been identified (Ince et al., 2012), and one solution has been clearing houses, such as the INCF Software Center[1], and the NITRC[2] portal, which facilitate efforts of peer-to-peer software and data sharing that were previously limited to only well-funded formal consortia (see Poline et al., 2012, for a recent summary of the status quo). However, collecting these resources into a centralized clearing-house addresses only one necessary aspect on the way to a sustainable software ecosystem for neuroscience – availability. Unfortunately it does not ensure ease of deployment, nor does it offer a sustainable model for long-term maintenance.

Statistical learning analysis in neuroscience: aiming for transparency
Michael Hanke, Yaroslav O Halchenko, James V Haxby and Stefan Pollmann

Neuroscience Runs on GNU/Linux
Michael Hanke and Yaroslav O Halchenko

Nipype: A Flexible, Lightweight and Extensible Neuroimaging Data Processing Framework in Python
Krzysztof Gorgolewski, Christopher D. Burns,