BrainVISA: an extensible software environment for neuroimaging data processing

Introduction

BrainVISA is a modular and customizable software platform built to host heterogeneous tools dedicated to neuroimaging research. As it is extensible, it allows neuroimaging methodologists to share their data and processing tools. Several toolboxes have already been developed in various domains.

BrainVISA is developped by french governement founded research organizations (mainly CEA, INSERM, INRIA, CNRS) grouped in a federative research institute: IFR 49. It is a free and open-source software and can be downloaded from: **http://brainvisa.info.**

Methods

BrainVISA Main features include:

- Harmonization of communications between different software.
- Ontology based data organization allowing databases sharing and automation of mass of data analysis.
- Interactive visualization of multimodal data using Anatomist, a software for 3D visualization and manipulation of structured objects.
- Automatic generation of graphical user interfaces.
- Workflow monitoring and easy data quality checking.
- Extensible and customizable.
- Runs on Linux, Mac and Windows.

Adding new functionalities to BrainVISA is a matter of writing small scripts in Python. BrainVISA processes may use any processing software, and can combine home-made algorithms, software contained within the core BrainVISA package, or third-party software (some toolboxes use FSL, SPM, nipy, R-project, etc.). Custom processes may be used either for quick and convenient developing and testing purposes, or for creating complete toolboxes. Recent developements in BrainVISA infrastructure have focused on modularity: a toolbox can now be a separate package which includes a set of processes, a data organization extension, documentation, and any needed software and data. Toolboxes may be distributed as separate add-on packages.

Results

BrainVISA infrastructure advantages have encouraged several teams to develop their own toolboxes.

Some toolboxes are included in BrainVISA package:

- **T1 MRI**: automatic segmentation of brain hemispheres and sulci from T1 MR images.

- **Sulci**: automatic sulci identification and object-based morphometry (Cachia, 2008).

- **Cortical Surface**: analysis of the cortical surface geometry and of functional data projected on this surface (Operto, 2008).

- **Connectomist**: Diffusion MR images analysis (DTI and Qball models) and fiber tracking.

- **BrainRat**: automated processing of histological and autoradiographic sections (A. Dubois, 2008).

Other toolboxes are external:

- **fMRI**: individual and group analysis of fMRI data.

- **MEEG**: visualization and analysis of MEG and EEG data (Barbot, 2005).

- **nuclear imaging:** PET images segmentation and analysis

- **RIC**: cortical measurements such as gyrification index or cortical thickness (Kochunov, 2005).

- **Odyssee-BrainVISA add-ons:** Inria tools for visualization and analysis of diffusion MRI data (Delmaire, 2009)

- **SACHA:** automatic segmentaton of hyppocampus

Conclusion

BrainVISA has now 8 years of maturity. It has been successfully used by various research groups and contributed achieving novel neuroscience results. Some studies use built-in functionalities: morphometry in psychiatry (Cachia, 2008), tractography in psychiatry (Houenou, 2007), pediatrics (J. Dubois, 2008), clinical and neurosurgical applications (Besson, 2008). Other applications use dedicated add-ons: diffusion in clinical applications (Delmaire, 2009), nuclear imaging (Kas, 2007), aging studies (Kochunov, 2005). See http://brainvisa.info/biblio/en/index.html for a list of publications relying on BrainVISA processings.

BrainVISA teams are now working to widen the fields of applications by encouraging the development of new independent toolboxes.

References

1. Houenou, J., Wessa, M., Douaud, G., Leboyer, M., Chanraud, S., Perrin, M., Poupon, C., Martinot, J.-L. & Paillère-Martinot, M.-L. (2007), Increased white matter connectivity in euthymic bipolar patients: diffusion tensor tractography between the subgenual cingulate and the amygdalo-hippocampal complex. *Mol Psychiatry*, vol. 12, no. 11, pp. 1001-1010.
2. Operto, G., Bulot, R., Anton, J.-L. & Coulon, O. (2008), Projection of fMRI data onto the cortical surface using anatomically-informed convolution kernels. *Neuroimage*, vol. 39, pp. 127-135.
3. Barbot, A., Schwartz, D. P., N'Diaye, K., Bellio, A., Mattout, J., Pélégrini, M., Cointepas, Y., Rivière, D. & Ducorps, A. (2005), A MEG/EEG analysis toolbox for BrainVISA. *In Human Brain Mapping, Florence*
4. Kochunov, P., Mangin, J.-F., Coyle, T., Lancaster, J., Thompson, P., Rivière, D., Cointepas, Y., Régis, J., Schlosser, A., Royall, D.R., Zilles, K., Mazziotta, J., Toga, A. & Fox, P. T. (2005), Age-related morphology trends of cortical sulci. *Human Brain Mapping*, vol. 26, no. 3, pp. 210-220.
5. Dubois, A., Dauguet, J., Souedet, N., Hérard, A. S., Rivière, D., Cointepas, Y., Bonvento, G., Hantraye, P. & Delzescaux, T. (2008), BrainRAT: Brain Reconstruction and Analysis Toolbox. a freely available toolbox for the 3D reconstruction of anatomo-functional brain sections in rodents. *In 38th annual meeting of the Society for Neuroscience, Washington*.
6. Cachia, A., Paillère-Martinot, M.-L., Galinowski, A., Januel, D., De Beaurepaire, R., Bellivier, F., Artiges, E., Gallarda, T., Andoh, J., Bartrés-Faz, D., Duchesnay, E., Rivière, D., Cointepas, Y., Plaze, M., Mangin, J.-F. & Martinot, J.-L. (2008), Cortical folding abnormalities in schizophrenia patients with resistant auditory hallucinations. *Neuroimage*, vol. 39, no. 3, pp. 927-935.
7. Dubois, J., Dehaene-Lambertz, G., Soarès, C., Cointepas, Y., Le Bihan, D. & Hertz-Pannier,

L. (2008), Microstructural correlates of infant functional development: example of the visual pathways. *Journal of Neuroscience*, vol. 28, no. 8, pp. 1943-1948.

8. Besson, P., Andermann, F., Dubeau, F. & Bernasconi, A. (2008), Small focal cortical dysplasia lesions are located at the bottom of a deep sulcus. *Brain*, vol. 131, no. 12, pp. 3246.
9. Delmaire, C., Vidailhet, M., Wassermann, D., Descoteaux, M., Valabregue, R., Bourdin, F., Lenglet, C., Sangla, S., Terrier, A., Deriche, R. & Lehéricy, S. (2009), Diffusion Abnormalities in the Primary Sensorimotor Pathways in Writer's Cramp. *Archives of Neurology*, in press.
10. Kas, A., Payoux, P., Habert, M. O., Malek, Z., Cointepas, Y., El Fakhri, G., Chaumet-Riffaud, P., Itti, E. & Remy, P. (2007), Validation of a standardized normalization template for statistical parametric mapping analysis of 123I-FP-CIT images. *Journal of Nuclear Medecine*, vol. 48, no. 9, pp. 1459-1467.

Figures