Pattern Recognition for Neuroimaging Toolbox

Pascal2 Meeting
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Outline

• Motivation
• Project’s Goals
• PRoNTo Framework
• Future Developments
Questions investigated with neuroimaging

• Which brain areas are activated by a specific stimuli or cognitive task?
• Which brain areas are affected in specific disorders?
• Can we use brain scans to diagnosis psychiatric or neurological disorders?
• Can we decode from the brain scans information about the stimuli being processed?
Pascal Harvest Project

- Increase the impact of PASCAL on society and the economy.

- Piece of software as their main objective.

- Training component.

- International team.
Title: PRoNTo (Pattern Recognition for Neuroimaging Toolbox)

Coordinator: Dr. Janaina Mourao-Miranda

Participants:
Dr. Christophe Phillips (Cyclotron Research Centre, University of Liège, Belgium)
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Dr. Jonas Richiardi (Ecole Polytechnique Fédérale de Lausanne, Switzerland)
Ms. Jessica Schrouff (Cyclotron Research Centre, University of Liège, Belgium)
Dr. Carton Chu (National Institute of Mental Health (NIMH), NIH, USA)

Hosting site:
UCL, Computer Science Department, London, UK

Project duration:
August 20th, 2011 – November 20th, 2011
Existing software

Freely available packages for machine learning modeling of neuroimaging data:

- **3dsvm** plugin for AFNI (LaConte et al., 2005)
- **the Matlab MVPA toolbox for fMRI data** (Detre et al., 2006)
- **PyMVPA** (Hanke et al., 2009)
- **PROBID** ([http://www.brainmap.co.uk/probid.htm](http://www.brainmap.co.uk/probid.htm))

**3dsvm**, the Matlab MVPA toolbox for fMRI data and PyMVPA require (advanced) programming skills and can not be directly integrated into the main neuroimaging analysis pipelines, such as those provided by **SPM** ([http://www.fil.ion.ucl.ac.uk/spm/](http://www.fil.ion.ucl.ac.uk/spm/)).

**PROBID** is optimized for groups’ classification (i.e. patients vs. healthy controls) and therefore does not easily enables single subject analysis or flexible cross-validation framework.
OUR GOAL

“develop a toolbox based on machine learning techniques for the analysis of neuroimaging data”

BUT

“free”, matlab based, compatible with SPM, easy to use (with GUI), multiple modalities (fMRI/sMRI/PET/betas), various machines, modular code, easy to contribute

⇒ PRoNTo
User point of view

- **Data & Design**
- **Prepare feature set**
- **Specify model**
- **Run model**
- **Compute weights**

+ some reviewing & displaying functions.
Developer point of view

Structure containing:
- Data/Kernel
- Labels
- Etc

Structure containing:
- Function name (machine)
- Arguments

Structure containing:
- Predictions
- Coefficients/Weights
- etc

Machine Library
(classification and regression models)

Structure containing:
- Data/Kernel
- Labels
- Etc

Structure containing:
- Predictions
- Coefficients/Weights
- etc
A practical example
Dataset

Functional magnetic resonance imaging (fMRI) data

Download: http://www.brainmap.co.uk/probid.htm

1 group - 5 subjects - 3 conditions

Pleasant  Unpleasant  Neutral
Pattern Recognition for Neuromaging data Toolbox

Main steps:
- Data & Design
- Prepare feature set
- Specify model
- Run model
- Compute weights

Review options:
- Review data
- Review kernel & CV
- Display results
- Batch
- Credits
PRoNTo :: Data and design

/Users/janaina/Projects/Toolbox_developments/PRONTO_20120323/fMRI_example

Groups
- Group 1

Subjects/Scans
- S1
- S2
- S3
- S4
- S5

Modalities
- fMRI

Files
- /Users/janaina/Projects/PRONTO
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Add  Remove  Add  Remove  Add  Remove
Scans

Masks
- fMRI

Load  Review  Save  Quit
PRoNTo

PRoNTo :: Prepare feature set

/Users/janaina/Projects/Toolbox_developments/PRONTO_20120323/MRI_example

Feature set 1

Modality
Number of modalities to concatenate: 1
Selected modalities: MRI

Build kernel/data matrix
PRoNTo :: Specify classes

Number of classes: 2

Class: Class 1

Class name: Class 1

Subjects in group:
- S1
- S2
- S3
- S4
- S5

Conditions in modality:
- Neutral
- Pleasant
- Unpleasant

Groups in data set:
- Group 1

Selected subject(s)

Selected condition(s)

Done
Current Module: Data & Design

Directory

Select a directory where the PRT.mat file containing the specified design and data matrix will be written.
Ongoing work since November 2011

Documentation: Manual and paper

Website: http://www.mlnil.cs.ucl.ac.uk/pronto/

PRoNTo small tutorial sessions were given at different institutions:
• ABC University (São-Paulo, Brazil)
• University College London (London, UK)
• King's College London (London, UK)
• University of Liège (Liège, Belgium)

People attending had different background, level of experience, etc. They are currently used it!

Software updates (e.g. including harmonization of the GUIs, increasing the number of checks and embedding the multiclass framework)
Future developments

New features:
• improved feature extraction strategies
• feature selection strategies (GP based, RFE,...)
• multi-class, bootstrap, nested-cross validation...
• more machines (provided by Machine Learning community)
Course Program (21\textsuperscript{st} May)

- **Theory**
  
  *Introduction & Motivation*
  
  *Neuroimaging for Machine learners*
  
  - Data representation (image modalities and pre-processing)
  - Validation and Inference (current neuroimaging analyses approaches)
  - Data resources

  *Coffee-break*
  
  *Machine learning for neuroimagers*
  
  - Pattern Recognition Methods
  - Validation and Inference
  - Software resource

- Lunch on your own
- **Tutorial** (2 examples)
- **Practical** (including Tea-break)
- **Questions & Answers**
Impact

• Dedicated website (http://www.mlnl.cs.ucl.ac.uk/pronto/)

• The toolbox will be presented in conferences and workshops (e.g. Human Brain Mapping 2012)

• Potential users:
  - SPM has 4,000 subscription in their mailing list
  - We also expect machine learning users

• To increase the visibility further we need to provide support and add further developments/updates -> more funds.
Credits

The development of PRoNTo was possible with the financial and logistic support of:

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