Pattern Recognition for Neuroimaging Toolbox (PRoNTo)

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Questions investigated with neuroimaging

- Can we decode from the brain scans information about the stimuli?
- Can we use brain scans to diagnosis psychiatric or neurological disorders?
- Which brain areas are involved in processing specific stimuli/cognitive task?
- Which brain areas are affected in specific disorders?
PRoNTo

Machine Learning community

PRoNTo

Neuroscience and Clinical Neuroscience communities

sMRI

fMRI

time
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)
  Dr. John Ashburner (Wellcome Trust Centre for Neuroimaging, UCL)
  Dr. Jane Rondina (Department of Neuroimaging, KCL)
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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 (free) software

- **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)

**PRoNTo:** “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 (Pattern Recognition for Neuroimaging Toolbox) is a software toolbox based on pattern recognition techniques for the analysis of neuroimaging data. Statistical pattern recognition is a field within the area of machine learning which is concerned with automatic discovery of regularities in data through the use of computer algorithms, and with the use of these regularities to take actions such as classifying the data into different categories. In PRoNTo, brain scans are treated as spatial patterns and statistical learning models are used to identify statistical properties of the data that can be used to discriminate between experimental conditions or groups of subjects (classification models) or to predict a continuous measure (regression models).

PRoNTo aims to facilitate the interaction between machine learning and neuroimaging communities. On one hand, the machine learning community can contribute to the toolbox with novel machine learning models. On the other hand, the toolbox provides a variety of tools for the neuroscience and clinical neuroscience communities, enabling them to ask new questions that cannot be easily investigated using existing software and analysis tools.

PRoNTo is distributed for free as copyright software under the terms of the GNU General Public License as published by the Free Software Foundation. The development of the toolbox has been supported by the PASCAL Harvest framework and The Wellcome Trust.

Latest news

http://www.mlnl.cs.ucl.ac.uk/pronto/
PRoNTo FRAMEWORK

Data
(Nifti: f/sMRI, PET, BETAs, ...)

Design
(SPM.mat, ...)

1st level Mask(s)
(Nifti)

2nd level Mask
(Nifti)

DATA & DESIGN
Groups
Subjects/Scans
Modalities
Design
1st level mask
Create PRT.mat

PREPARE FEATURE SET
Extract features
Build kernel
2nd level mask
Detrend
Scaling
Update PRT.mat

SPECIFY MODEL
Targets, classes
Cross-validation
Data operations
Machine wrapper
SVM, GP, RF
KRR, RVR
Update PRT.mat

RUN MODEL
Estimate model(s)
Update PRT.mat

COMPUTE WEIGHTS
Estimate (linear) model weights
Create weights 4D image

REVIEW
Display
Design
Cross-validation
Model
Kernel

RESULTS
Display
Statistics
Plots
Permutation test
Weights

PRT (.mat)
Features (file array)
Kernel (.mat)
Weights (Nifti)
User point of view

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

+ some reviewing & displaying functions.
Code organisation

User Interface
- Specific GUI
- Batch system
- Script

Machine learning
- Features
- Kernel
- Model
- Training
- Validation

Machines
- Classification (SVM, GPC, RF)
- Regression (KRR, RVR)

Wrapper
Developer point of view

Structure containing:
- Data/Kernel
- Labels
- Function name (machine)
- Arguments

Structure containing:
- Predictions
- Coefficients/Weights
- etc

Machine Library
(classification and regression models)

Input:
- Data
- Labels
- Options

Output:
- Predictions
- Coefficients/Weights
Future developments: contributions welcome

- feature selection (GP based, RFE,...)
- improved fMRI data handling (detrending & hrf estimation)
- bootstrap, multi-kernel, ensemble learning, testing & predicting...
- more machines (provided by Machine Learning community)
Live demo...
Generative embedding for neuroimaging

Generative model
(e.g. dynamic causal models, MAR models, Riccican mixtures)

Generative embedding:
(e.g. Fisher kernels, free energy scores, TOP kernel)

Generative based kernel
(e.g. linear kernel, RBF kernel, information theoretic kernels)

Advantages:
• Better interpretability of classification/regression results
• Classification/Regression based on hidden (ideally physiological) quantities
• More biologically meaningful (model based) feature selection

Supervised learning
(Classification (e.g. SVM) / Regression (e.g. KRR))
for clinical neuroimaging data application