

Pattern Recognition for Neuroimaging Toolbox

Pascal2 Meeting
Cumberland Lodge
29 March 2012

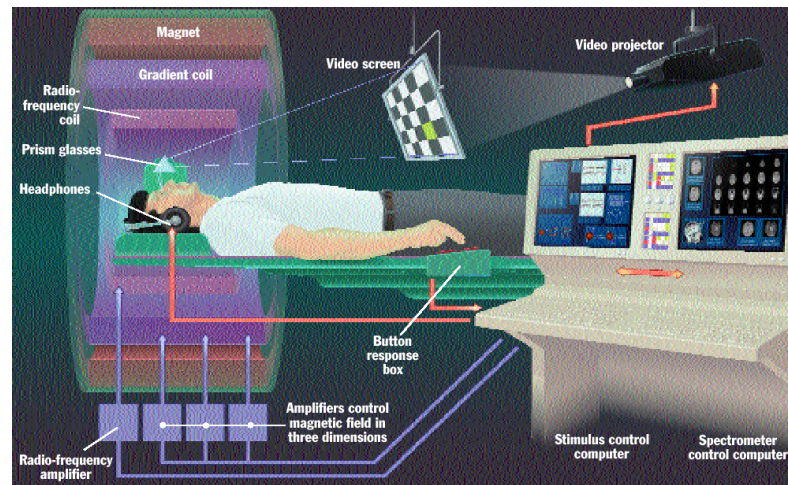
Janaina Mourao-Miranda,
Machine Learning and Neuroimaging Lab,
Computer Science Department,
University College London, UK

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?

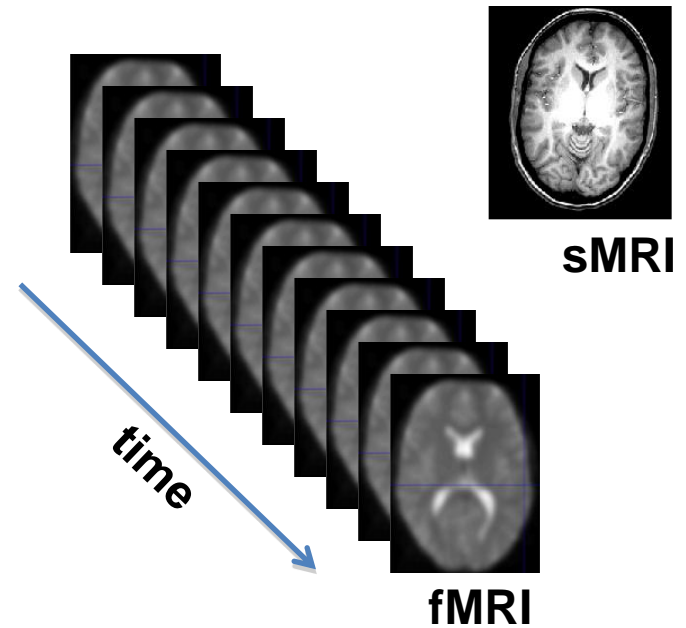
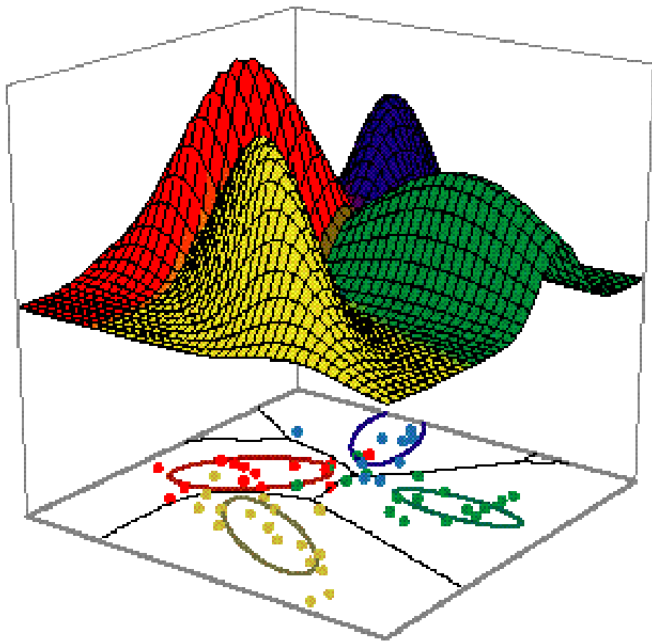


PRoNTTo

Machine Learning
community



Neuroscience and
Clinical Neuroscience
communities



Pascal Harvest Project

- Increase the impact of PASCAL on society and the economy.
 - Piece of software as their main objective.
 - Training component.
 - International team.
-

PRoNTo

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)

Dr. Andre Marquand (Department of Neuroimaging, KCL)

Dr. Maria Joao Rosa (Wellcome Trust Centre for Neuroimaging, UCL)

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>)
- **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/>).
- **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”

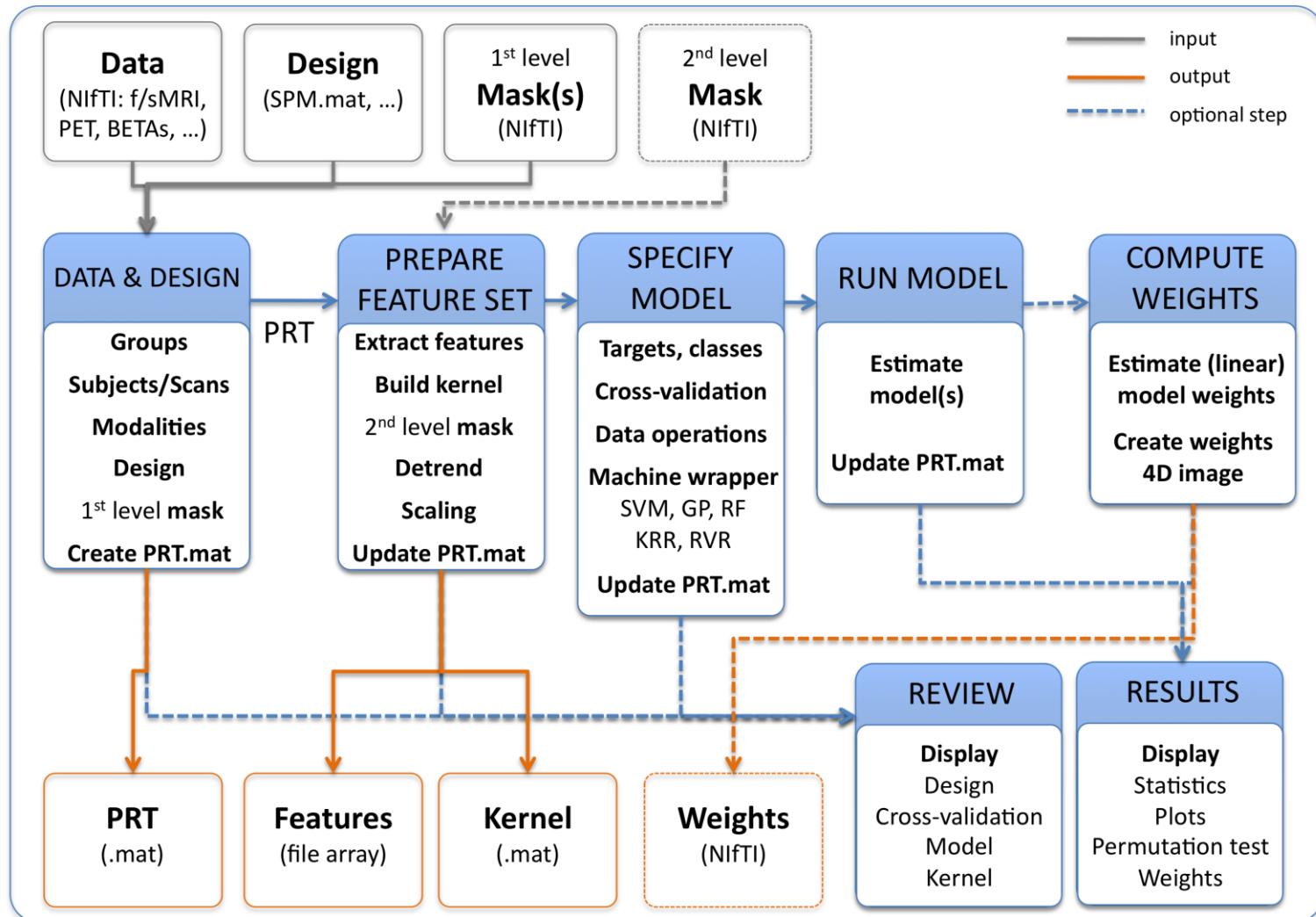
BUT

“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

PRoNTo

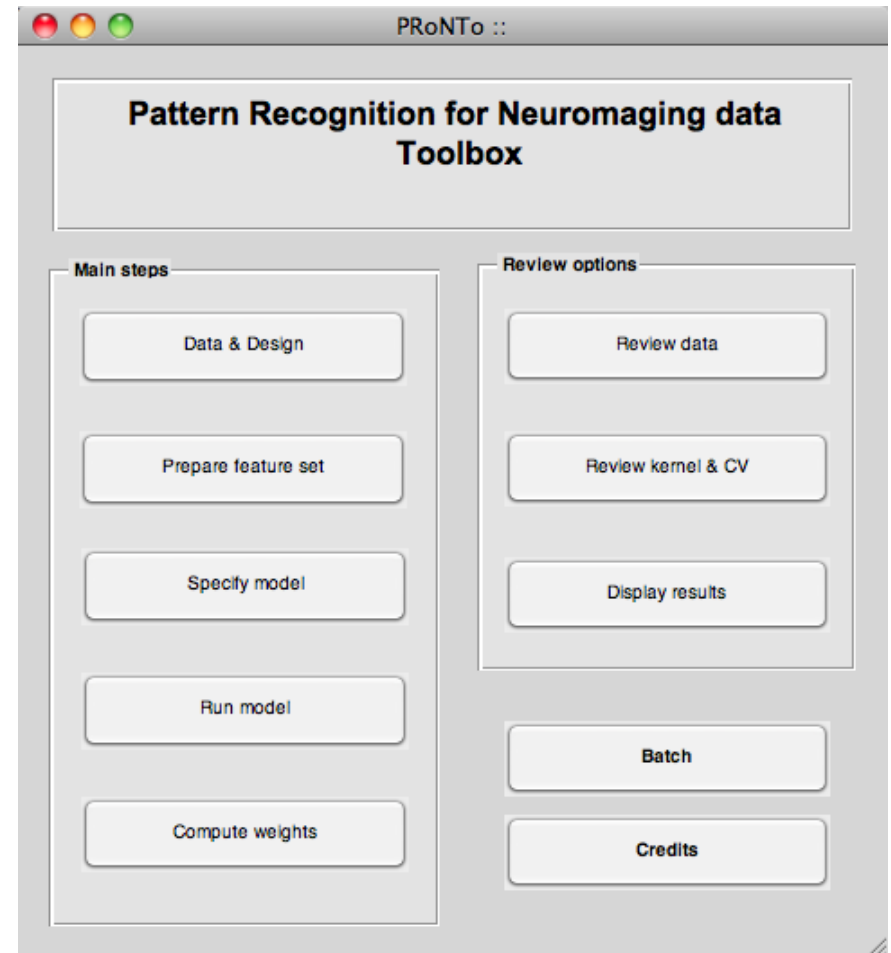
PRoNTo FRAMEWORK



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

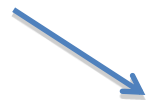


Structure containing:

- Predictions
- Coefficients/Weights
- etc

Structure containing:

- Function name (machine)
- Arguments

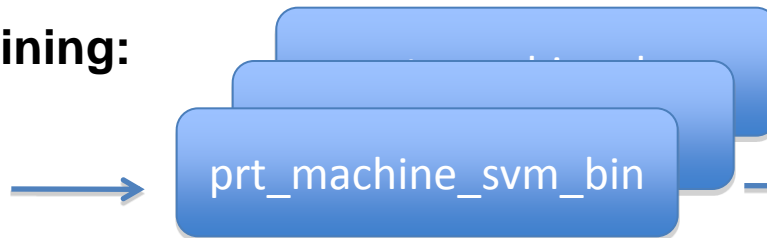


Machine Library

(classification and regression models)

Structure containing:

- Data/Kernel
- Labels
- Etc



Structure containing:

- Predictions
- Coefficients/Weights

PRoNTo

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



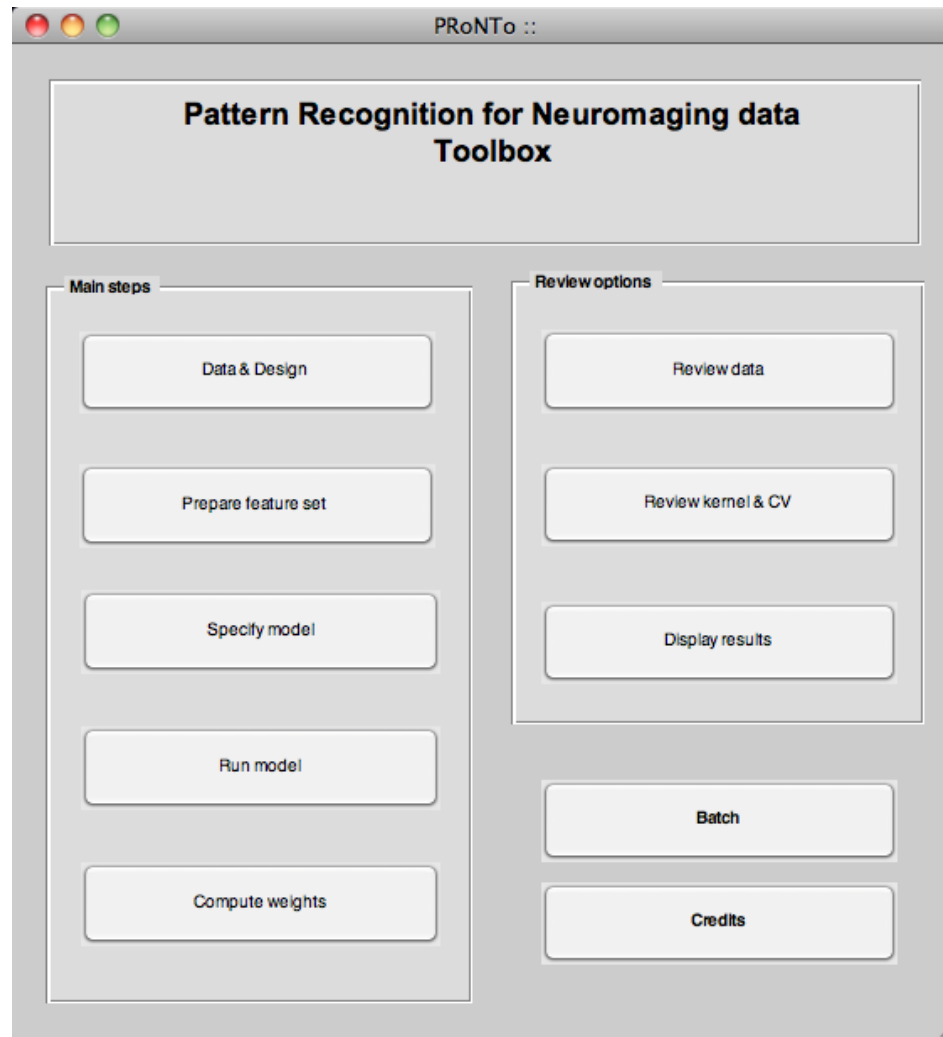
Unpleasant



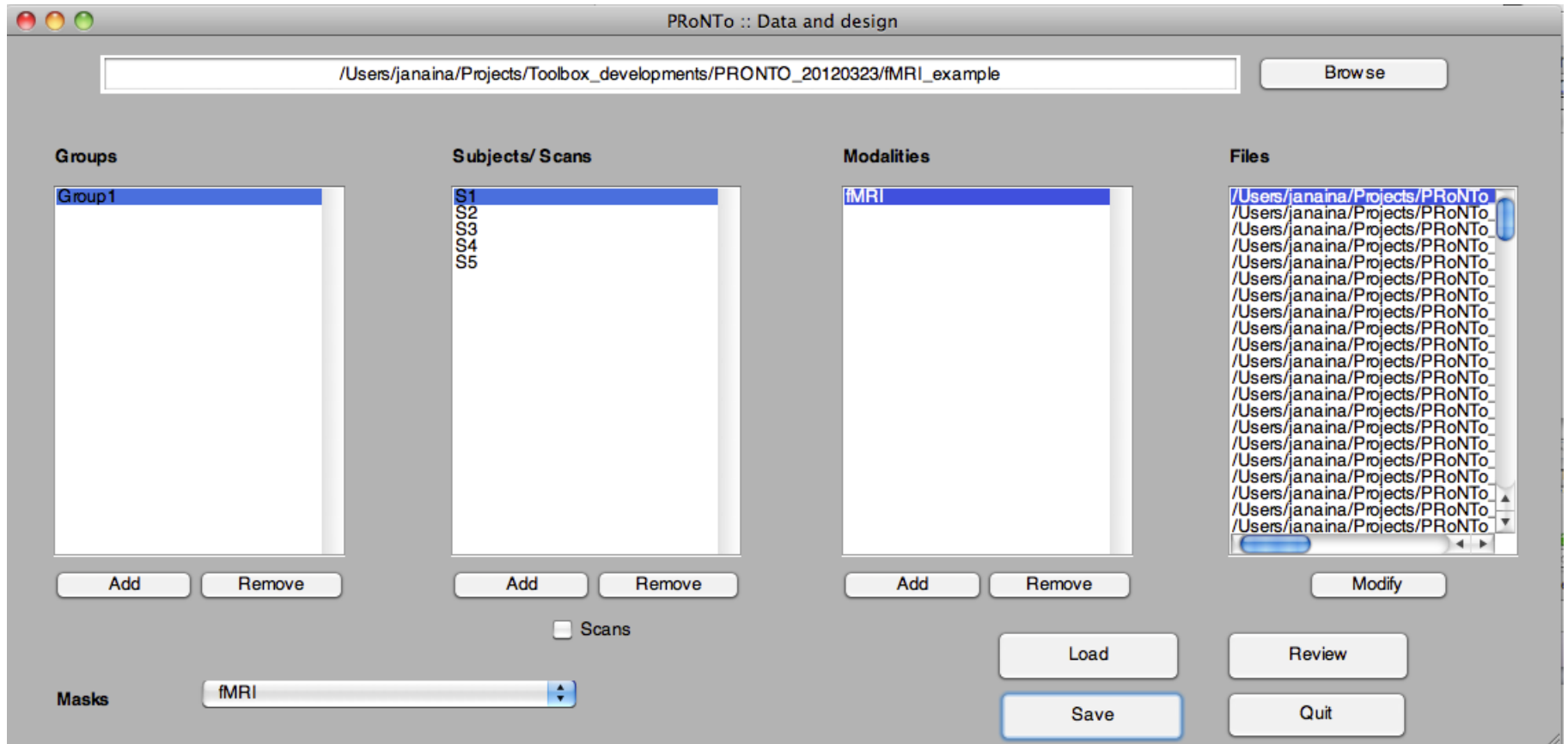
Neutral



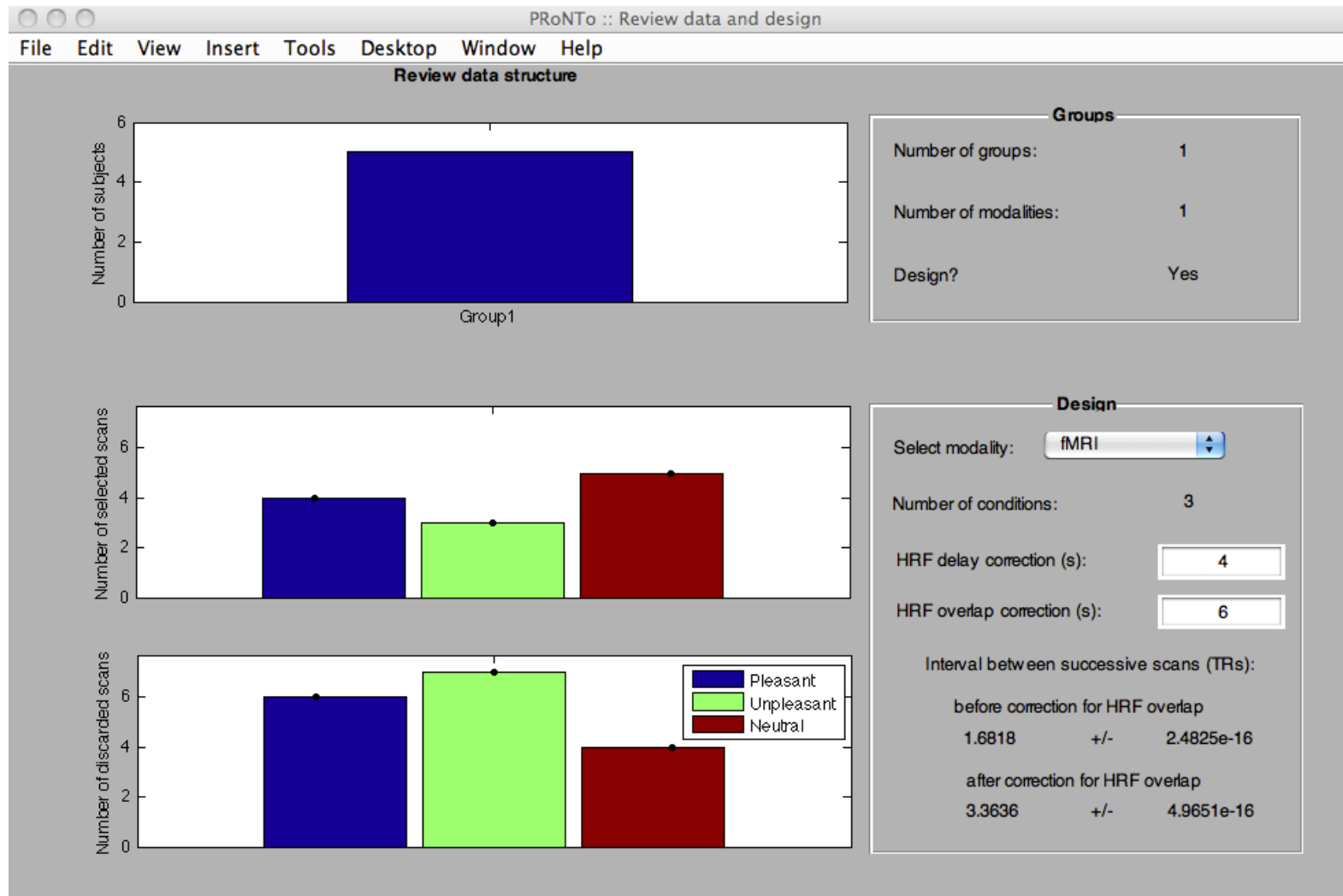
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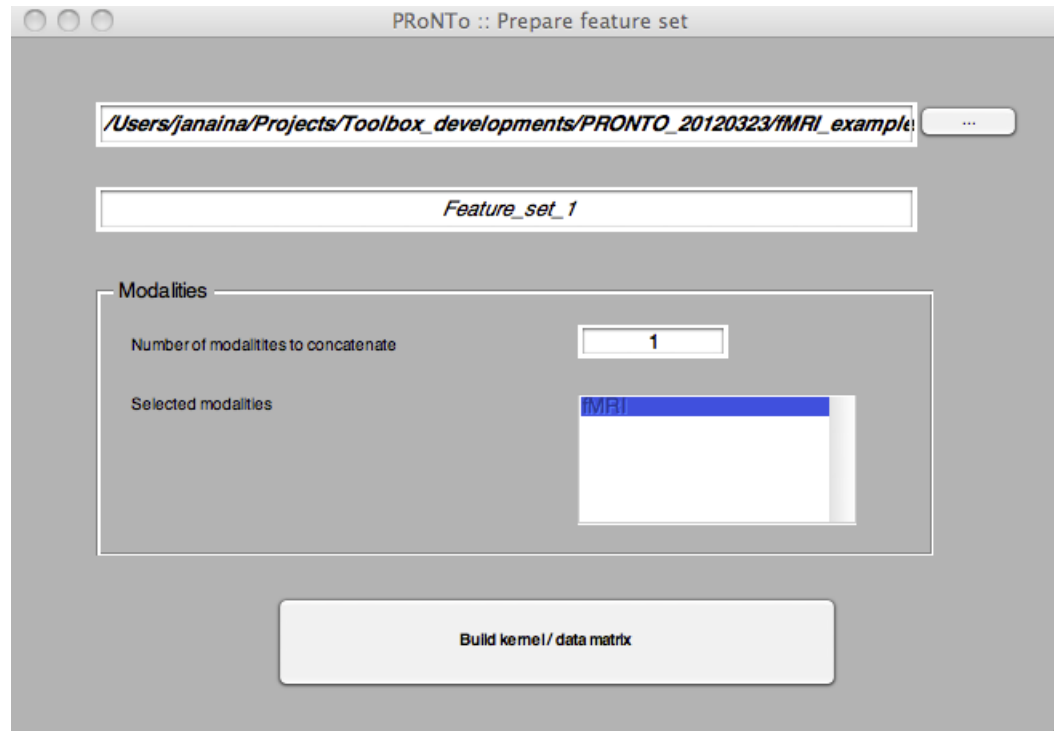
PRoNTo



PRoNTo



PRoNTo



PRoNTo

PRoNTo :: Specify model

/Users/janaina/Projects/Toolbox_developments/PRoNTO_20120323/fMRI_example/PRT.m ...

Model1_SVM

Features

Feature set: Feature_set_1

Use kernels: Yes

Model

Model type: Classification

Machine: Binary support vector machine

Cross-Validation

Cross-Validation Scheme: Leave One Subject Out

Data operations

- Temporal Compression
- Sample averaging
- Divide data vectors by their norm
- Perform a GLM (fMRI only)

Selected data operations

- Mean centre features over subject

Specify model Specify and run model

PRoNTo

PRoNTo :: Specify classes

Number of classes

Class Class name

Groups in data set

- Group 1

Subjects in group

- S1
- S2
- S3
- S4
- S5

Conditions in modality

- Neutral
- Pleasant
- Unpleasant

Select all

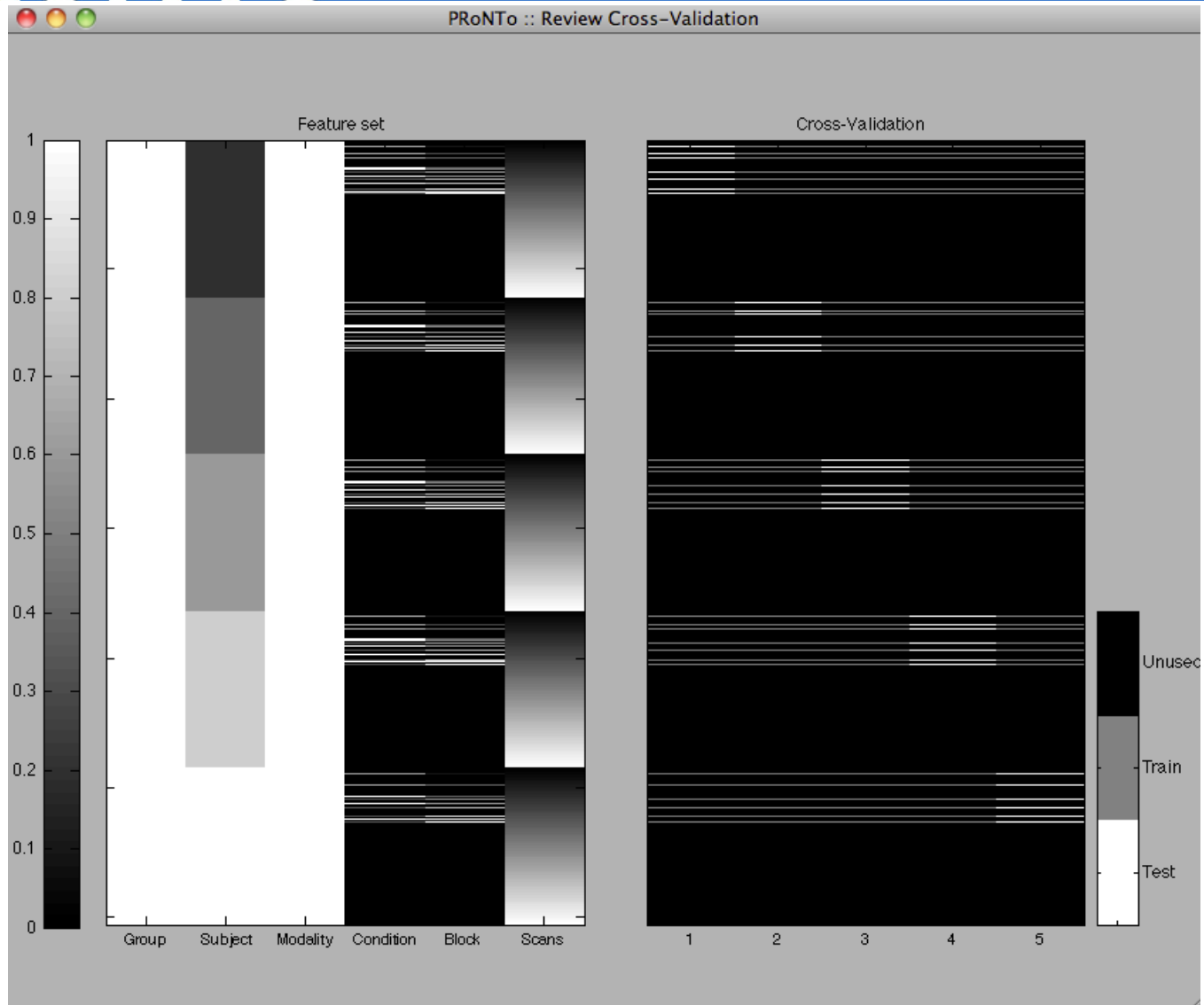
Select all

Selected subject(s)

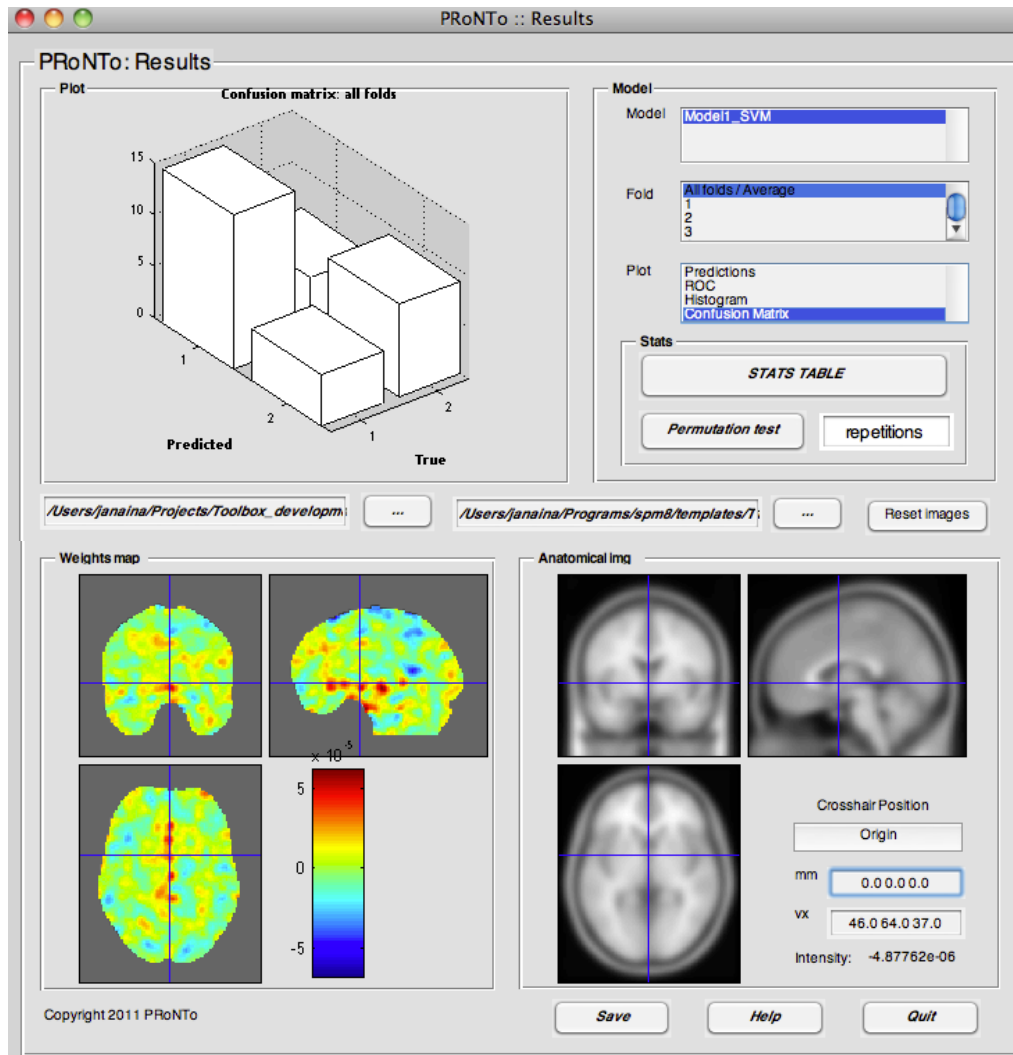
Selected condition(s)

Done

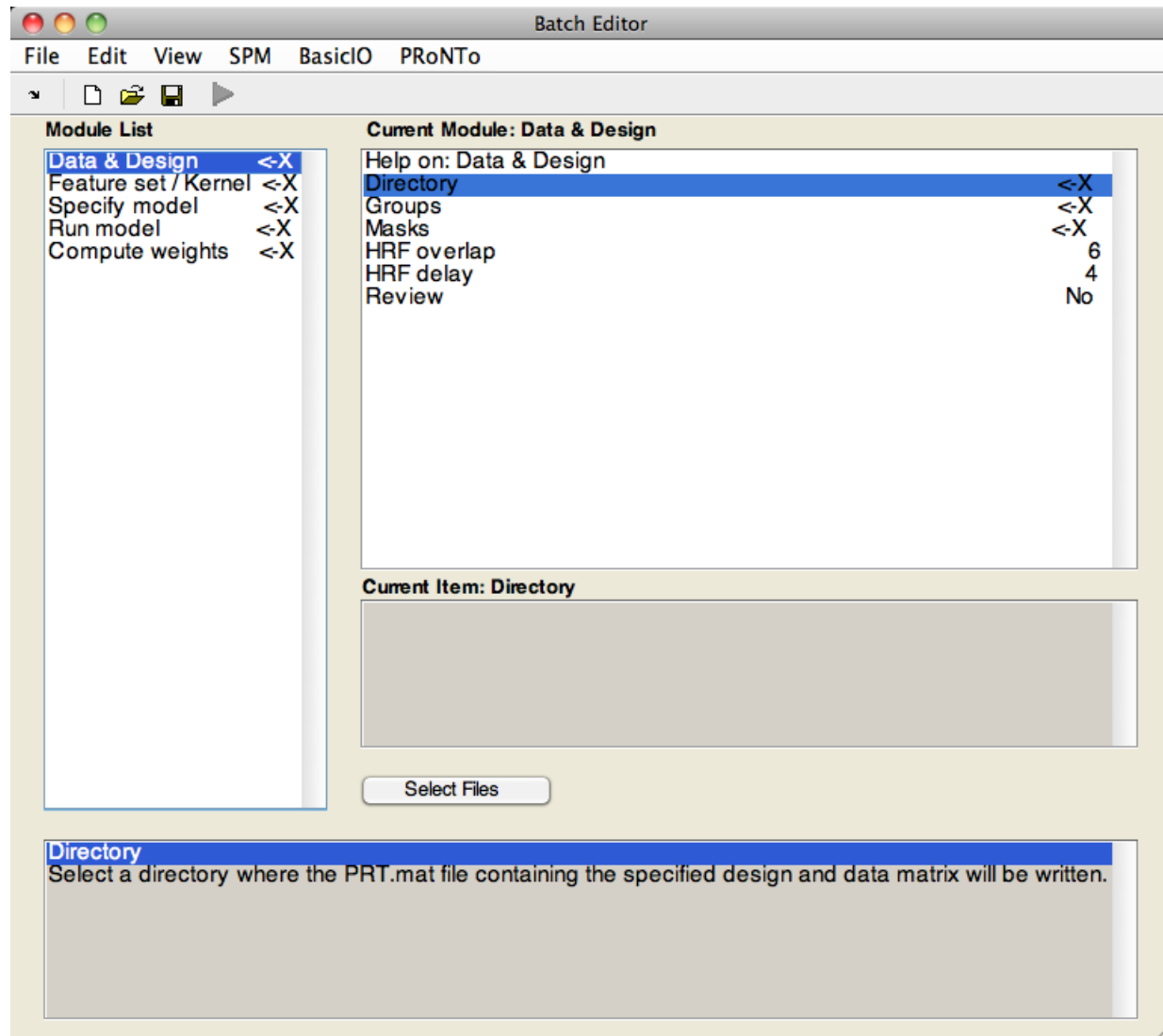
PRoNTo



PRoNTo



PRoNTo



Ongoing work since November 2011

Documentation: Manual and paper

Website: <http://www.mlnl.cs.ucl.ac.uk/pronto/>

PRoNTo small tutorial sessions were given at different institutions:

- ABC University (Sao-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 (21st 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.mnl.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:

- PASCAL Harvest Programme
(<http://www.pascal-network.org/>)
- the Department of Computer Science, University College London
(<http://www.cs.ucl.ac.uk>);
- the Wellcome Trust;
- PASCAL2 (<http://www.pascal-network.org/>);
- the Fonds de la Recherche Scientifique-FNRS, Belgium
(<http://www.fnrs.be>);
- The Foundation for Science and Technology, Portugal
(<http://www.fct.pt>);
- Swiss National Science Foundation (PP00P2-123438) and Center for Biomedical Imaging (CIBM) of the EPFL and Universities and Hospitals of Lausanne and Geneva.

PRoNTo

PRT group(s) subject(s), modality(m)

design, fcnlds(r) orsch, durations, rt_trial, ntrng

→ SI mod, nt-subj

[PRT_group(s), subject(s), modality(m), ...]

PRT mask(m)
 fac name
 PRT fcs(m) .hdr

PRT fcs(m)
 .detrend
 .param-idx
 .mod-name
 .fcs_name (string) "all features"

PRT fcs(m)
 .fcs
 .K_Plc(m) (string - relative path filename) "Ph."
 .id.mat
 .id_col_names
 .mod a liby (m) default fcs
 .normalise
 .COV

PRT model
 model_name
 input_type "classification" / "regression"
 .wts
 .machine
 .args
 # Sources
 .fcs, fcs_name = all (K x 1)
 .ts, sample_rate = vector (n x 1) men
 .kernel
 .input_weights, w_name
 .output_fold(k)
 .predictions
 .classification_out
 .type "classifier" "regression"
 .stats, sm.mat
 .acc
 .b-acc
 .c-acc
 .b-pr

PRT kernel(k)
 .name
 .ids → id.mat
 .fcs → mod
 .fcs
 .subj
 .modality (m) mod_name
 .kernel_idx
 .param_idx
 .features

TO DO LIST

- Multi-subject (Probed)
- Betas
- SPM mat
- SMRI

classif/regression

$V = \text{spm_vol}(\text{fname})$
 $\text{vols} = \text{spm_read_vols}(V)$
 $V_{\text{new}} = V$
 $V_{\text{new}} = \text{new_name}$
 $V_{\text{new_data}}(C_i) = \text{matrix}(\text{wts})$

TO DO LIST

$G = (E, V, P)$
 $P_i \rightarrow \text{vec}(e) = ()$
 $\|g-b\|_1$
 $\|g-b\|_0$

SPM mat

SMRI

file arrays(m)
 .maximal
 .detrend
 .param-idx
 .header
 .y
 .z

SPM mat

SMRI