NILab
Premise

Center for Information Technology
Fondazione Bruno Kessler
www.fbk.eu

Center for Mind/Brain Sciences
Università degli Studi di Trento
www.cimec.unitn.it
Outline

Computational Methods
Machine learning for data analysis

Neuroscience Laboratories
Heterogeneous sources of data

Software Tools
Open source projects based on Python
Outline

Software Tools

PyMVPA
Multivariate Pattern Analysis in Python
pymvpa.org

DiPy
Diffusion Imaging in Python
nipy.sourceforge.net/dipy
Neuroscience Labs

- functional MRI
- diffusion MRI
- EEG
- MEG

4T Bruker MedSpec MRI

Elekta Neuromag 306 Channels
ML Methods

- **Brain Decoding**
  Prediction of mental state

- **Brain Mapping**
  Task-related brain segmentation

- **Brain Connectivity**
  Analysis of structural connectivity
Non invasive technologies, like fMRI and MEG, allow to record the brain activity when a subject is accomplishing a cognitive task. The challenge is to interpret the brain recordings in order to infer the corresponding mental task.
Supervised Learning of Mental State

Gaussian Processes and Recurrent Neural Networks to decode non-conventional protocol of stimuli without any assumption on haemodynamic model.

**KEYWORD**
Gaussian Processes Regression, Recurrent Neural Networks

**AWARD**
1st Prize PBAIC-2006

**DATASET**

**PARTNER**
CIMeC

**REFERENCE**
Real-time fMRI Brain Decoding

The challenge is twofold: on one hand to compute just in time the mental state, on the other hand to deal with dataset shift which occurs between different fMRI recordings or between different subjects.

**KEYWORD**
Dataset Shift, Domain Adaptation, Functional Alignment

**DATASET**
[fMRI] Neuroeconomics Trust Game, 2010

**PARTNER**
CNRS, Lyon, France

**REFERENCE**
(ongoing work)
Tensorial Kernel for Brain Data

A kernel-based model designed to deal with tensorial encoding of multidimensional brain data for increasing learning performance when few data are available.

**KEYWORD**
Multilinear Ranks, Tensorial Kernel, Cumulants Kernel

**DATASET**
[MEG] ICANN Contest, 2011
[MEG] Biomag Contest, 2010

**PARTNER**
Katholieke Universiteit Leuven

**REFERENCE**
(ongoing work)
Unbiased Error Estimate
To prevent circular analysis in computing error estimate which might invalidate the conclusion of the neuroscientific investigation.

**KEYWORD**
Error Estimation, Double Dipping

**DATASET**
[MEG] Biomag Contest, 2010

**PARTNER**
CiMeC

**REFERENCE**
Hypothesis Testing

Is there information about the stimulus given to the subject within brain data?

DATASET

-[fMRI] Knops et al., Science 324 (5934), 2009
-[MEG] Biomag Contest, 2010

PARTNER

Thomson Reuters, USA
GfK, Warszawa, Poland

REFERENCE

E. Olivetti, S. Veeramachaneni, E. Nowakowska, Bayesian Hypothesis Testing for Brain Decoding, Pattern Recognition. 2010. (under review)
Brain Mapping

A protocol of stimuli induces a mental state in a subject. The challenge is to identify the region of the brain related to the mental process.
Random Subsampling Methods

Dealing with the curse of dimensionality by reducing the ratio between features and examples. To perform the relevance voxel assessment by preserving the redundancy.

**KEYWORDS**
Feature Selection, Ensemble Methods

**DATASET**
[fMRI] MVPA Testbed recorded at CIMeC 2009.

**PARTNER**
CIMeC

**REFERENCE**
D. Sona, P. Avesani, Multivariate Brain Mapping by Random Subsampling, ICPR. 2010
Supervised Learning Haemodynamic Response
Given the protocol of stimuli to predict the BOLD response of a given voxel. Working hypothesis: relevant voxels should allow for accurate BOLD prediction.

KEYWORDS
Liquid State Machine, Reservoir Computing

DATASET
[fMRI] MVPA Testbed recorded at CIMeC 2009.

PARTNER
University of Haifa

REFERENCE
Longitudinal Studies

To detect the portion of the brain affected by a rehabilitation therapy interleaving two subsequent sessions of fMRI recordings. Untangling neuroplasticity recovery from systemic variance of data sampling.

DATASET
[fMRI] Language Rehabilitation 2010

PARTNER
CERIN

REFERENCE
Brain Connectivity

Recent diffusion MRI techniques allow to reconstruct the structure of nearly 300,000 fibers in the brain. Specific bundles of reconstructed fibers can be identified for their role in connecting related brain areas.
Joint Functional-Structural Data Analysis
To investigate brain connectivity by combining functional and diffusion MRI data. Setting an homogeneous pairwise encoding both for voxel timecourses and tractography streamlines.

**DATASET**
[fMRI, DSI] Pittsburgh Brain Connectivity Contest 2009

**PARTNER**
CIMeC

**REFERENCE**
E. Olivetti, Sriharsha Veeramachaneni, Susanne Greiner, Paolo Avesani, Brain Connectivity Analysis by Reduction to Pair Classification, Cognitive Information Processing. 2010.
Supervised Fiber Tract Segmentation

Learning from a tract of a source subject manually annotated by a human expert to segment the same kind of tract from a subsample of tractography of a target subject.

**AWARD**
Honorable Mention PBC-2009

**DATASET**
[DSI] Pittsburgh Brain Connectivity Contest 2009

**PARTNER**
University of Cambridge

**REFERENCE**