The Multi-Voxel Pattern Analysis (MVPA) toolbox

Greg J Detre[1], Sean M Polyn[3], Christopher D Moore[1], Vaidehi S Natu[1], Benjamin D Singer[2], Jonathan D Cohen[1,2], James V Haxby[1], and Kenneth A Norman[1]

1 Department of Psychology, Princeton University, Princeton, NJ
2 Center for the Study of Brain, Mind, and Behavior, Princeton University, Princeton, NJ
3 Department of Psychology, University of Pennsylvania, Philadelphia, PA

Introduction

We describe the open source Multi-Voxel Pattern Analysis (MVPA) toolbox, first introduced by Polyn et al (2005a). Written in Matlab (Mathworks, Natick, MA), it provides functionality for various kinds of multivariate analyses of fMRI data, especially those employing pattern classification methods (Duda, Hart & Stork, 2001), and more recently, regression.

Tools and design

The MVPA toolbox defines a set of data structures, functions and interfaces for classification and regression analyses that can be broken down into the following categories:

Import, export and visualization

The toolbox's import and export support is most robust for AFNI, through which it can read and write almost all major imaging formats, including DICOM, ANALYZE, BRIK, BrainVoyager and NiFTI. The toolbox also has basic native support for reading in BrainVoyager files, and can easily deal with any data already in Matlab matrices.

Once the data has been imported, the latest toolbox will interface with Keith Schneider's montage scripts for basic visualization of anatomicals/functionals within Matlab.

Preprocessing and feature selection

The toolbox provides or interfaces with preprocessing tools, e.g. for z-scoring voxel timecourses, convolution of regressors (requiring AFNI's 'waver' command), averaging blocks of timepoints together and temporal smoothing (using Matlab's 'filter').

Feature selection (i.e. masking of voxels) has been shown to play an important role in various kinds of MVPA analyses. The next release of the toolbox should include a wider variety of mass univariate feature selection approaches, including ANOVA and correlational approaches and an implementation of Mitchell's t-test against baseline method (Mitchell et al., 2004).

The toolbox will soon provide an interface for dimensionality reduction algorithms, such as PCA and MDS.

Classification

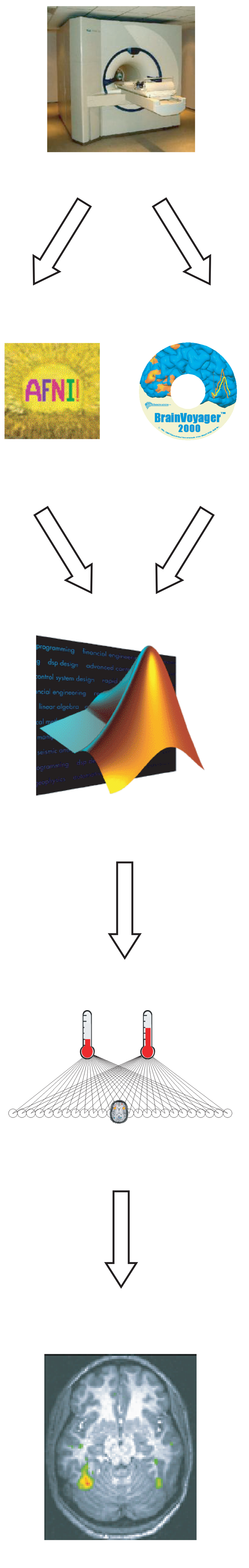
The toolbox provides a flexible framework for conducting leave-one-out cross-validation pattern classification analyses. This is particularly helpful for ensuring that only the timepoints designated for training are employed during preprocessing, feature selection and classifier training, to avoid 'peeking' at the testing timepoints. The toolbox provides interfaces for algorithms such as backpropagation, linear correlation, boosting and support vector machines

Regression

Much of the infrastructure for cross-validation classification adapts easily to regression/real-valued prediction problems, such as that of the EBC competition. Currently, ridge regression is the only algorithm to have a built-in interface, though it would be easy to interface with other regression algorithms.

The MVPA toolbox is freely available for download from:
http://www.csbmb.princeton.edu/mvpa/

For a downloadable version of this poster, please visit:
http://compmem.princeton.edu/publications.html



Data is imported from AFNI or other software into Matlab, pre-processed and fed into the classifier, before being exported back again.

Tutorials, documentation and sample data

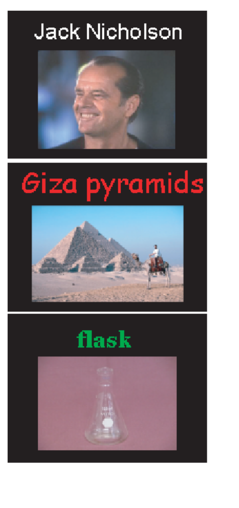
Step-by-step tutorials walk the user through a variety of standard multi-voxel analysis paths, and discuss common issues, using fMRI data from the Haxby et al (2001) visual object-category experiment as a sample data set. The source code is carefully commented, and the download includes a manual, glossary and setup instructions.

More recently, a tutorial has been provided for regression analyses using the EBC dataset (see below). This takes the user through a complete ridge regression analysis, based on Chigirev, Stephens et al.'s (2006) EBC entry.

Case studies

EBC competition - the aim was to predict real-valued ratings of subjects' experience along 13 dimensions such as arousal, amusement, presence of a face, and music (W. Schneider et al., 2006; Chigirev, Stephens et al., 2006).

The next release of the toolbox will include EBC-specific tutorials and scripts to create separate masks for each feature rating, cross-validate predictions across movies, perform ridge regression, and calculate an overall correlation score.



Free recall - tracked the reinstatement of context on a second-by-second basis during a free recall experiment (Polyn et al, 2005b).

Included sample data set (Haxby et al., 2001) - classified brain patterns into 8 categories (e.g. face, house, shoe, bottle, cat).

Future directions

By releasing a set of functions, interfaces and standardized data structures in a widely used scripting language to the community, we hope to facilitate exploration of multi-voxel pattern analysis techniques and to reduce the 'startup costs' for knowledgeable users eager to apply pattern classification and regression techniques to their imaging data.

Development will continue over the coming year, and new contributors are welcomed. All MVPA toolbox code has been released under the open source General Public License (GPL).

References and acknowledgements

Many thanks to David Weiss for his work on the EBC-specific functionality, and also to Denis Chigirev, Greg Stephens and the whole Princeton EBC team.

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