Cocaine Dependent Classification using Brain Magnetic Resonance Imaging

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Outline

Introduction

- Application of Machine Learning (ML) techniques for the computer aided diagnosis (CAD) of cocaine adicted subjects.
- Aim:
    - To obtain discriminant features from scalar measures of structural (T1) Magnetic Resonance Imaging (MRI) data.
    - To train and test classifiers able to discriminate cocaine dependent patients from healthy subjects.

Cocaine Adiction

- Cocaine is one of the most illegal consumed drugs.
- Its chronic abuse may cause: ischemic, hemorrhagic strokes, cerebral infarcts, depression and neuropsychological abnormalities.
- Selected regions in the brains of cocaine users show functional, neurochemical and structural abnormalities.
- These regions can be used to identify the differences between the brains of cocaine users and nonusers and then, to select an adecuate pharmacotherapy to treat this disorder.

T1 Magnetic Resonace Imaging

- MRI is a medical imaging technique used in radiology to visualize detailed internal structures.
- It provides good contrast between the different soft tissues of the body.

Database

- 30 male cocaine-dependent patients (34.41 ± 6.62).
- 35 matched controls ($33.38 \pm 7{,}87$).
- Exclusion criteria: neurological illness, prior head trauma, positive HIV status, diabetes, Hepatitis C or other medical illness and psychiatric disorders.
- Groups were matched on the basis of age and level of education.
- Patients were recruited from the Addiction Treatment Service of San Agustín in Castellón, Spain.

Outline

Preprocessing Steps

- Appropriate data preprocessing, ensuring anatomical correspondence of voxels intersubjects, is of paramount importance.
- Volumes were skull stripped and reoriented.
- Two registration phases:
  - Affine registered to MNI152 standard template.
  - Nonlinear diffeomorphic registration of affine registered data to MNI152 template was computed.

Feature Selection process

- Procedure:
  - Considering each voxel site independently, we compose a vector with the intensities at the voxel site across all the subjects.
  - We compute Pearson's correlation coefficient between this vector and the control variable (Control=0; Patients=1) obtaining a volume of correlation values at each voxel.
  - We select a threshold corresponding to a percentile of the absolute correlation distribution, retaining the voxel sites with absolute value of correlation above this threshold.
  - For each percentile selected, we compose a feature vector for each subject.

Feature Extraction pipeline

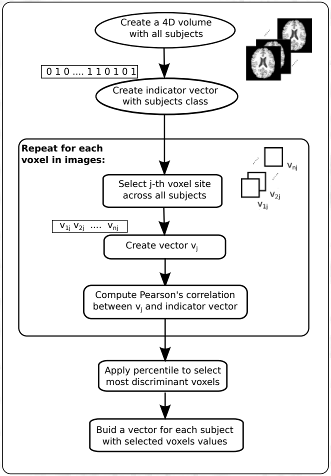

Figure: Feature Extraction Process.

Dimensionality reduction

Percentile (%)	# Features	Percentile (%)	# Features
no processed	10.092.544	99,85	3.187
0	7.221.032	99,90	2.125
99,50	10.624	99,92	1.699
99,55	9.561	99,95	1.062
99,60	8.499	99,97	637
99,65	7.437	99,99	212
99,70	6.374	99,995	106
99,75	5.312	99,999	21
99,80	4.250		

Table: Dimensionality reduction

Outline

Support Vector Machines

- Support Vector Machines (SVM) approach is a pattern recognition technique based on statistical learning theory.
- Its training principle consists of finding an optimal hyperplane that minimize the expected classification error.

$$y(x;w) = \sum_{i=1}^{N} w_i K(x, x_i) + w_0$$

Support Vector Machines

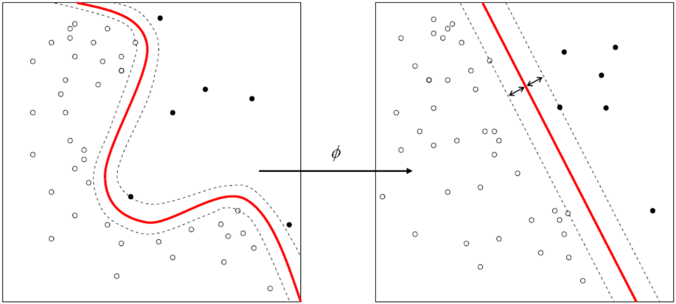

Figure: SVM linear separation.

Outline

Methodology

- To evaluate performance:
  - Leave one out cross-validation.
- To quantify results:
  - Accuracy.
  - Sensitivity.
  - Specificity.

Classification Results

(%)	99.50 - 99.90	99.92	99.95	99.97	99.99	99.995	99.999
Specificity	100.00	100.00	100.00	100.00	100.00	96.67	80.00
Sensitivity	100.00	100.00	100.00	100.00	97.14	97.14	88.57
Accuracy	100.00	100.00	100.00	100.00	98.46	96.92	84.61

Table: SVM classification results

Feature Extraction result

- Voxels selected for the feature vectors were localized in:
  - Cerebral cortex
  - Planum polare
  - Insula
  - Parahippocampus
  - Cerebellum.
- MNI structural atlas and Harvard-Oxford cortical and subcortical atlases.
- Tool: AtlasQuery tool of FSL.

Feature Extraction result

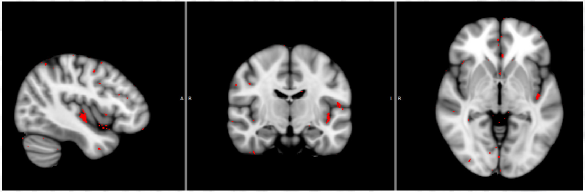

Figure: Most discriminant voxels for 99.50% percentile.

Outline

Summary

- We present a procedure for the construction of classifers able to distinguish cocaine dependent patients from healthy subjects using structural brain MRI.
- We preprocess the images to ensure anatomical correspondence of intersubjects, extract the most significant features (Pearson's correlation) and use SVMs to classify these features.

Conclusions

- Results are 100% accuracy, sensitivity and specificity for almost all the percentiles we tested.
- Brain regions where we find relevant information are also found in the literature, supporting our methodology and validating our results.

Further work

- Main limitation:
  - Results come from a small database.
- More extensive testing will be needed to confirm our conclusions.

Thanks

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