

Diagnosis of Bipolar Disorder based on Principal Component Analysis and Support Vector Machines over the MRI deformation Jacobian

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Introduction

- Bipolar disorder (BD)
 - psychiatric disorder
 - at least one episode of mania or hypomania
 - or a mixed episode <-> a depressive episode,
 - changes in mood states and psychotic symptoms.
- It is associated with cognitive, affective and functional impairment.
- A diagnosis BD
 - symptoms,
 - course of illness and,
 - family history,
 - neuroimaging
 - identified several regions that are affected by the disease



Introduction

- we compare brain structural MRI of healthy controls with patients with bipolar disorder,
 - to discriminate between both groups
 - selecting relevant information embedded in the images.
- Machine Learning (ML)
 - of feature vectors extracted from the deformation of the structural MRI images
 - computer aided diagnosis (CAD) tools.
- Preprocessing,
 - registration of the volumes,
 - affine and non-linear registrations to a standard MNI template.
 - The **Jacobian** of the deformation at each voxel will be used to extract the **relevant features**



Materials

- Patients recruited at the psychiatric unit at Alava University Hospital, Vitoria (Spain)
- All patients were living independently in the community.
 - clinical evaluation,
 - a cognitive and a neuropsychological evaluation,
 - and brain imaging (MRI).
- Forty men and women elderly subjects were included in the present study.
 - The healthy control group included 20 subjects without memory complaints
 - (mean age 74.10 (SD:8.03 years))
 - and BD group included 20 subjects fulfilling DSM IV's criteria
 - (mean age 70.37 (SD: 9.07 years)).
- Subjects with psychiatric disorders (i.e. major depression) or other conditions (i.e. brain tumors) were not considered for this study.
- Structural MRI 3D data (T1-weighted).

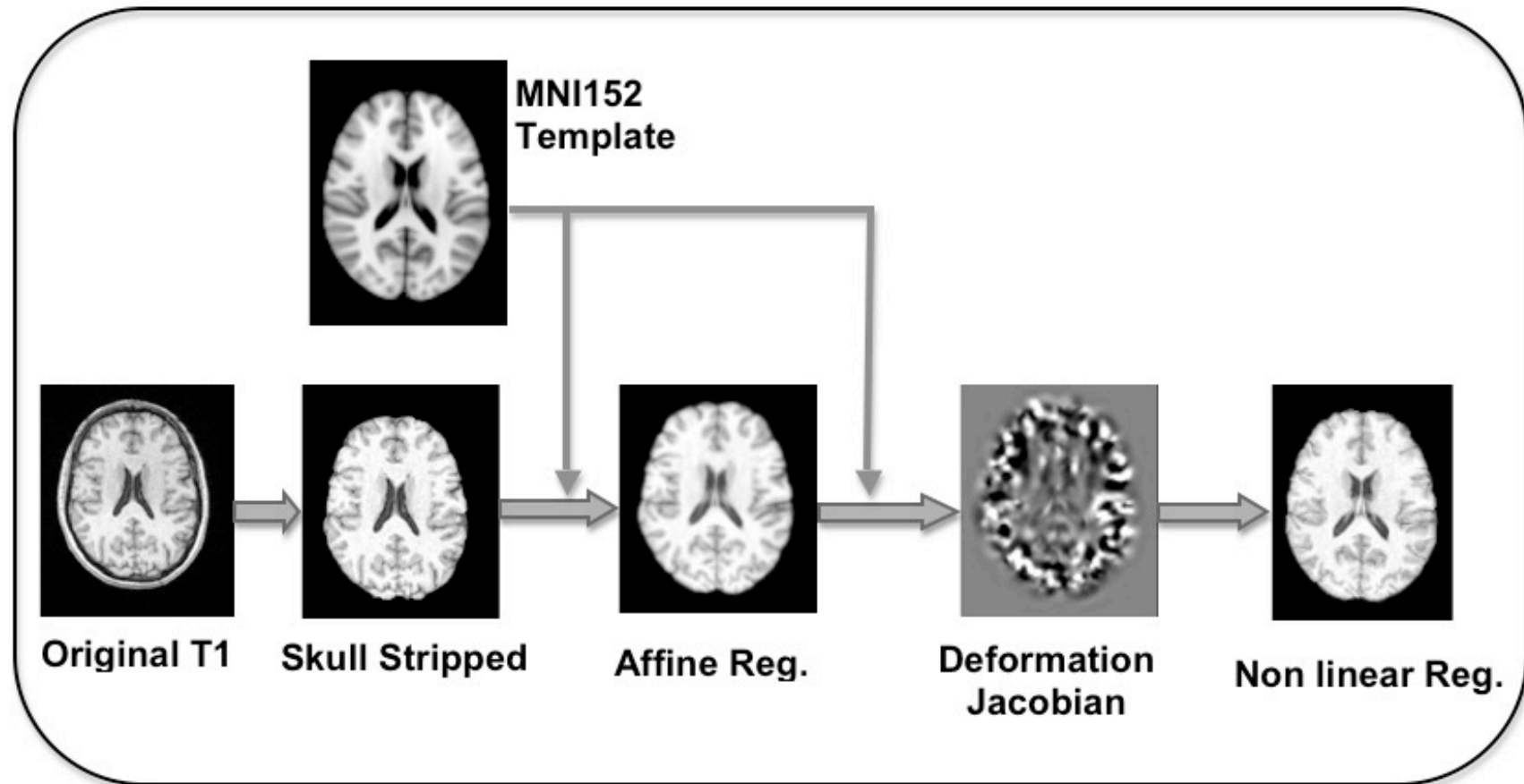


Methods

- Image preprocessing
 - Affine and elastic registration
 - Tensor deformation map
 - Jacobian at each voxel
- Feature selection
 - Voxel sites with distinctive values of the deformation Jacobian
 - Dimension reduction: PCA
- Classification:
 - Linear SVM
 - Validation: Leave One Out



Methods



Methods

- Feature selection
 - Compute voxel-wise means of each class
 - healthy controls
 - BD patients
 - Compute histogram of class means differences
 - Select the tail percentile according to a threshold



Methods

- Classification performance measures

$$F - score = 2 \cdot \frac{precision \cdot recall}{precision + recall},$$

$$precision = \frac{TP}{TP+FP},$$

$$recall = \frac{TP}{TP+FN}.$$

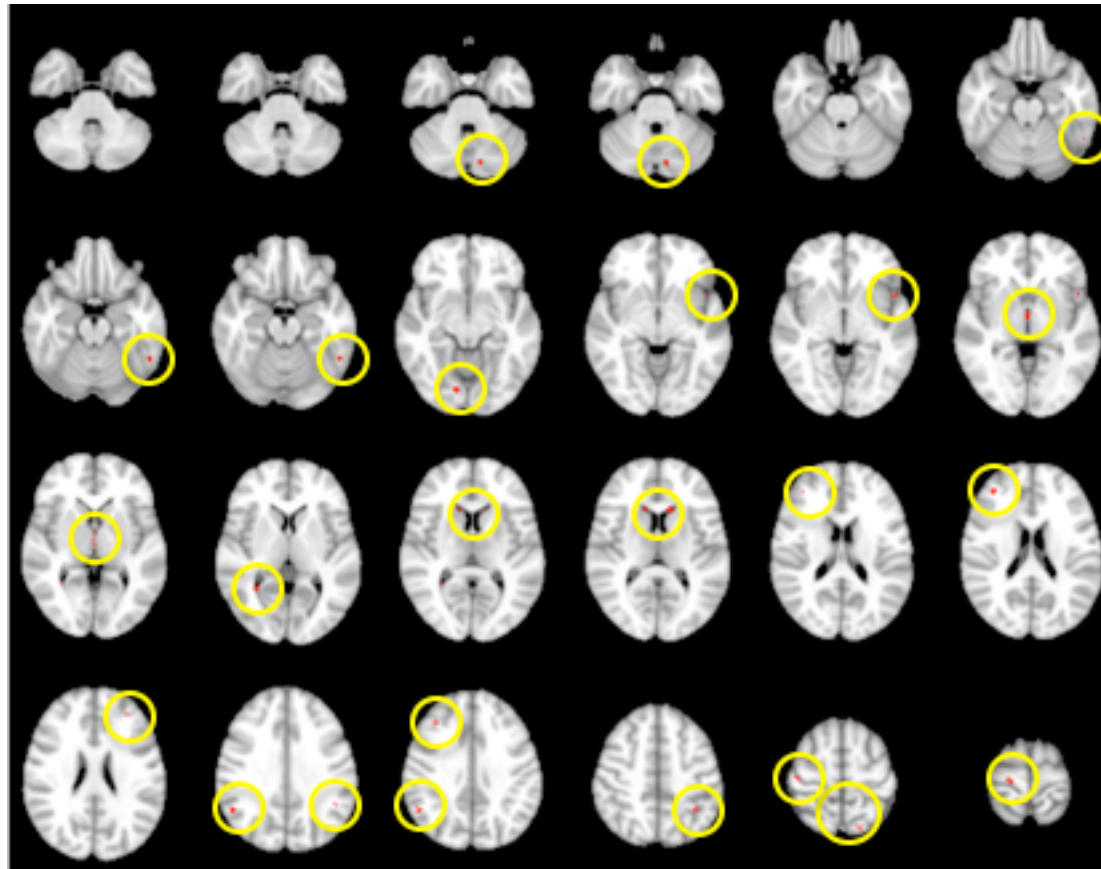
$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN}$$

$$Specificity = \frac{TN}{TN+FP};$$



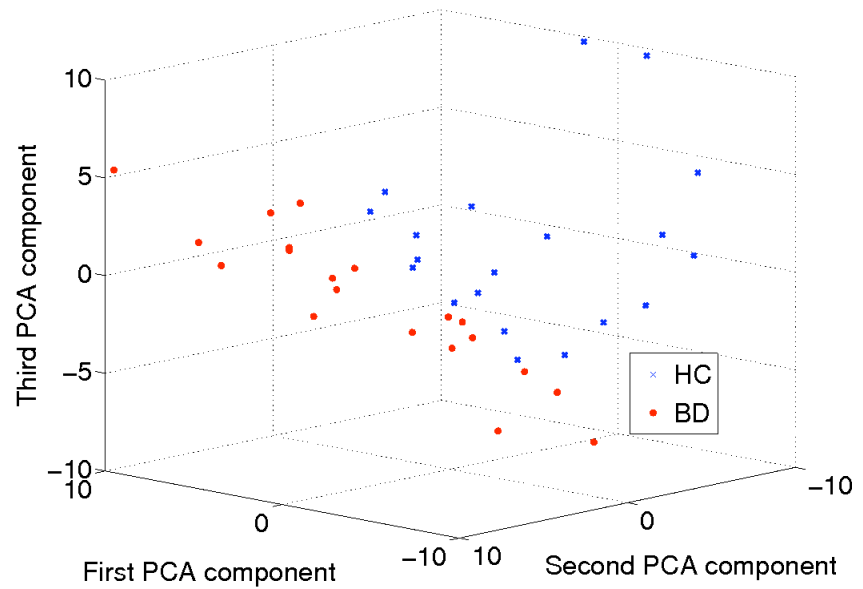
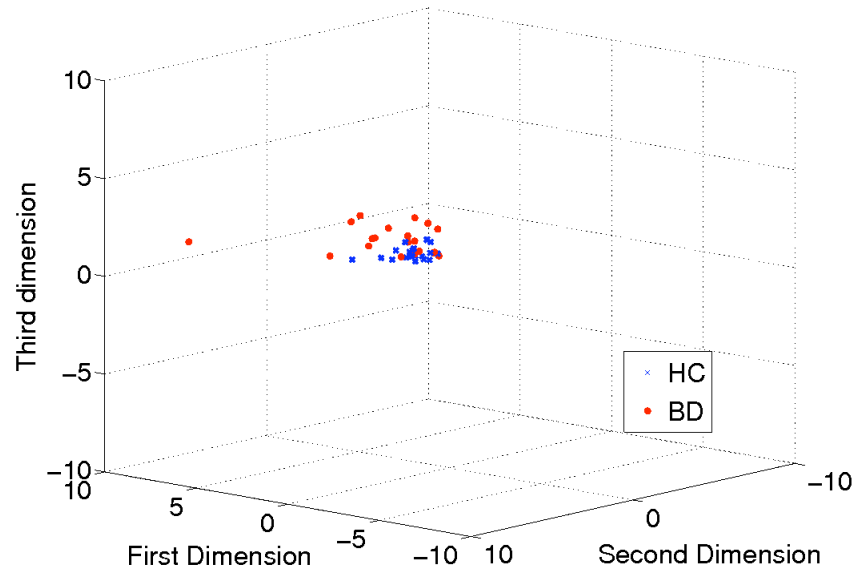
Results

Voxel locations for feature selection with threshold 0.4



Results

3 first PCA before (left) and after (right) feature selection



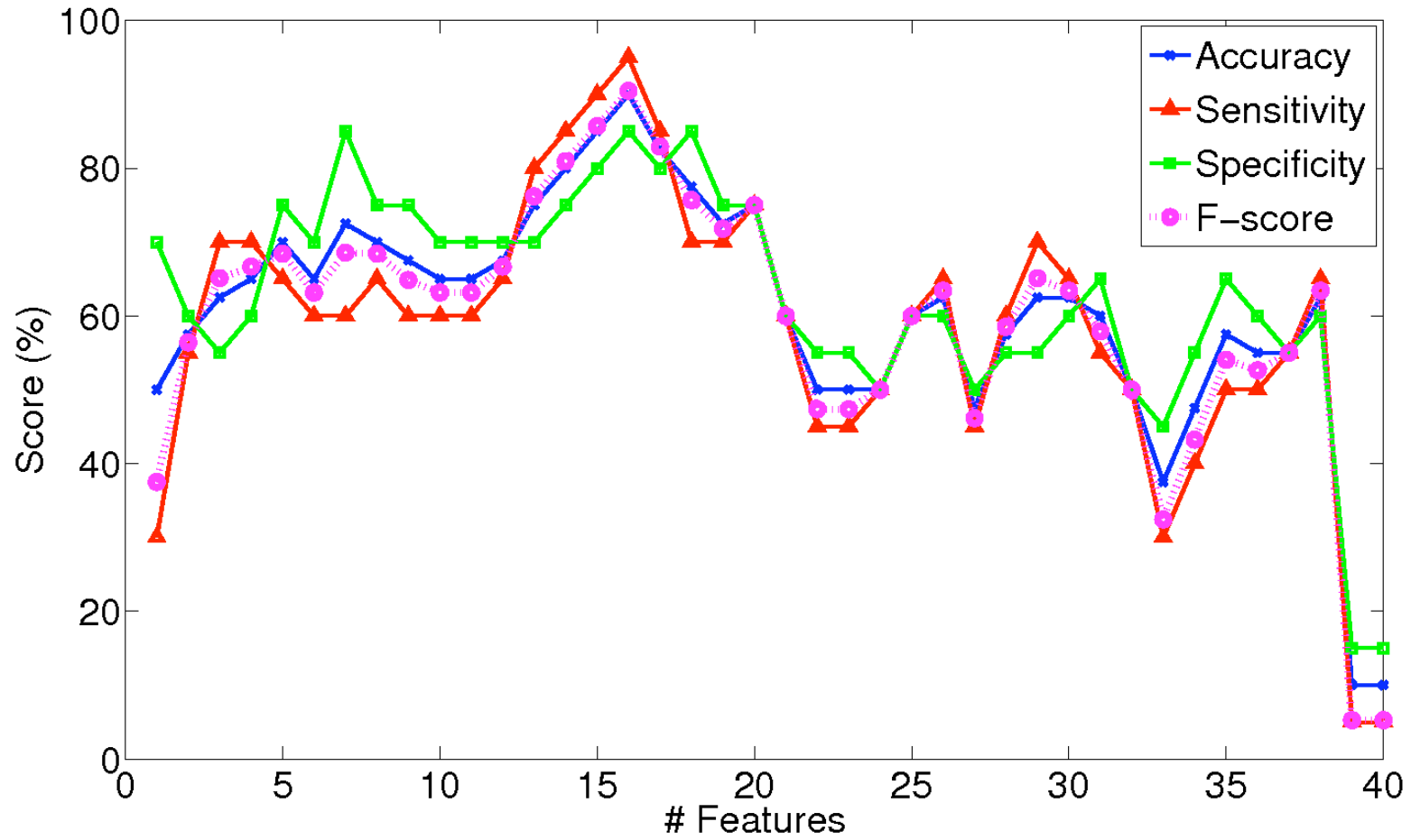
Results

Th (#ft)	0.1 (6759)		0.2 (1257)		0.3 (331)		0.4 (114)		0.5 (49)	
%	All	PCA(6)	All	PCA(8)	All	PCA(21)	All	PCA(16)	All	PCA(22)
Acc	60.00	72.50	67.50	67.50	75.00	72.50	70.00	90.00	72.50	77.50
Sens	65.00	80.00	70.00	75.00	75.00	85.00	65.00	95.00	75.00	85.00
Spec	55.00	65.00	65.00	60.00	75.00	60.00	75.00	85.00	70.00	70.00
F	61.90	74.42	68.29	69.77	75.00	75.56	68.42	90.48	73.17	79.07

Table 1: Classification results for a features selection procedure based on PCA and a linear SVM as classifier. Th: threshold; Acc: accuracy; Sens=sensitivity or recall; Spec: specificity. In brackets, we show the number of features selected.



Results



Conclusions

- Free of circularity
 - Feature selection is performed in each LOO step
 - PCA is unsupervised
- Selected voxels are located in
 - thalamus and angular gyrus,
 - precuneous cortex, precentral and postcentral gyrus, supramarginal gyrus, rightlateral ventricle, superior parietal lobe, inferior temporal gyrus and cerebellum.
- Thalamus is one of the most relevant biomarkers in bipolar disorder
 - Also superior parietal lobe , precuneous cortex, precentral gyrus and Cerebellum.
- Validation of the approach
 - with no disease *a priori* information we find **brain discriminant regions** consistent with **known biomarkers** of BD

