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

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CORES 2013, Milkow, Poland
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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

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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

Original T1 → Skull Stripped → Affine Reg. → Deformation Jacobian → Non linear Reg.
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

\[ F - score = 2 \cdot \frac{\text{precision} \cdot \text{recall}}{\text{precision} + \text{recall}}, \]

\[ \text{precision} = \frac{TP}{TP + FP}, \]

\[ \text{recall} = \frac{TP}{TP + FN}. \]

\[ \text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN} \]

\[ \text{Specificity} = \frac{TN}{TN + FP}; \]
Results

Voxel locations for feature selection with threshold 0.4
Results

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

<table>
<thead>
<tr>
<th>Th (#ft)</th>
<th>0.1 (6759)</th>
<th>0.2 (1257)</th>
<th>0.3 (331)</th>
<th>0.4 (114)</th>
<th>0.5 (49)</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>All</td>
<td>PCA(6)</td>
<td>All</td>
<td>PCA(8)</td>
<td>All</td>
</tr>
<tr>
<td>Acc</td>
<td>60.00</td>
<td>72.50</td>
<td>67.50</td>
<td>67.50</td>
<td>75.00</td>
</tr>
<tr>
<td>Sens</td>
<td>65.00</td>
<td>80.00</td>
<td>70.00</td>
<td>75.00</td>
<td>75.00</td>
</tr>
<tr>
<td>Spec</td>
<td>55.00</td>
<td>65.00</td>
<td>65.00</td>
<td>60.00</td>
<td>75.00</td>
</tr>
<tr>
<td>F</td>
<td>61.90</td>
<td>74.42</td>
<td>68.29</td>
<td>69.77</td>
<td>75.00</td>
</tr>
</tbody>
</table>

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