Rotation invariant features for Alzheimer’s disease identification using convolutional neural networks
Aymene Mohammed Bouayed, Samuel Deslauriers-Gauthier, Rachid Deriche

To cite this version:

HAL Id: hal-03691436
https://hal.science/hal-03691436v3
Submitted on 29 Jun 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Rotation invariant features for Alzheimer's disease identification using convolutional neural networks

Aymene Mohammed Bouayed†, Samuel Deslauriers-Gauthier¹, Rachid Deriche†
*Aix Marseille Université
¹Centre Inria d’Université Côte D’Azur

Abstract

Rotation Invariant Features (RIFs) [1] extracted from dMRI scans represent a generalisation of the usually used 2nd order invariants such as Fractional Anisotropy (FA) and Mean Diffusivity (MD). This work studies the usefulness all of the 12 algebraically independent RIFs extracted from Spherical Harmonics up to degree 4 in the context of Alzheimer Disease (AD) identification. To do so, we introduce a fair metric (B-score) that we use to evaluate the proposed deep Convolutional Neural Network (Subject CNN) which operates on subject slices to classify the whole subject while avoiding over-fitting. On the ADNI-SIEMENS² data that contains 46 AD and 352 Normal Connectivity (NC) subjects respectively, we observe that the 12 algebraically independent 4th degree RIFs are not equivalently useful to the classification task. A particular combination of a low degree RIF ($R_{12}^{[3]}$) with a high degree one ($R_{22224}^{[3]}$) achieves the best performance of 82.67% B-score and 84.88% accuracy on this data set. Also, the generated 3D Class Activation Maps (CAMs) [2] show that to classify a subject as AD or NC the model focuses on the value of the RIFs in the white matter around the ventricles.

Problem statement: How useful can the 4th order Rotation Invariant Features (RIFs) be in the context of Alzheimer’s disease identification? And are all these RIFs useful to the task?

Class Activation Map

Class Activation Map can be extracted from our architecture and provides the location of salient voxels used for the classification of AD and CN subjects.

Data set

The data set split over the ADNI-SIEMENS¹ data set.

<table>
<thead>
<tr>
<th></th>
<th>Train</th>
<th>Validation</th>
<th>Test</th>
<th>Not used</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD</td>
<td>30</td>
<td>6</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>NC</td>
<td>200</td>
<td>46</td>
<td>76</td>
<td>30</td>
</tr>
</tbody>
</table>

Single RIF performance

Identification of the most useful RIFs to the task of AD patient classification.

Multi-RIF performance

Combining the best RIFs as to improve performance.

B-score table:

<table>
<thead>
<tr>
<th>RIF</th>
<th>B-score</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{32}$</td>
<td>76.71%</td>
</tr>
<tr>
<td>$R_{12} \oplus R_{2224}$</td>
<td>82.67%</td>
</tr>
<tr>
<td>$R_{32} \oplus R_{2224} \oplus R_{2224}$</td>
<td>75.26%</td>
</tr>
<tr>
<td>$R_{12} \oplus R_{2224} \oplus R_{2224} \oplus R_{9}$</td>
<td>73.62%</td>
</tr>
</tbody>
</table>

Conclusion

This work allows us to conclude that the 12 algebraically independent 4th degree RIFs contain information that is very useful to AD identification and we can achieve a high performance on the ADNI-SIEMENS data set. It can also be noted that not all the RIFs are equivalently informative to the task at hand and careful RIF selection is important.

References


1. Alzheimer’s Disease Neuroimaging Initiative website: https://adni.loni.usc.edu/

This work has been supported by the French government, through the 3IA Côte d’Azur Investments in the Future project managed by the National Research Agency (ANR) with the reference number ANR-19-P3IA-0002.