









Innovative Training Networks INSPiRE-MED

#### Tensor Factorization of Brain Structural Graph for Unsupervised Classification in Multiple Sclerosis

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### Introduction

Analysis of longitudinal changes in brain diseases is essential for a better characterization of pathological processes and evaluation of disease progression [1]. In recent years, several studies were conducted to differentiate MS clinical forms with the help of DTI [2,3]. Appling non-negative tensor factorization (NTF) on structural graph data, we are able to detect pathological patterns of the brain White Matter (WM) network affected by significant longitudinal variations and from them perform unsupervised classification of MS phenotypes. Using the latent factors obtained from NTF process we were able to precisely identify the most affected WM links responsible for discriminate different Multiple Sclerosis phenotypes.

# **Proposed Method**



A recursive approach based on NTF was used. Starting from the adjacency matrix (A) multiple Markovian Random Walks (MRW) were generated and stacked together to form multiple MRW Matrices (B). From them, a 3rd order tensor was constructed and NTF was applied to retrieve the factorized anomalous components. 100 Monte Carlo iterations were performed for each subject and the anomalous brain network connection counting was obtained and used to construct a Matrix of Anomalies (C). Finally, k-means clustering was apply to the obtained distributions in order to retrieve a label assignment for each MS patient.

# Dataset description

- 70 MS patients, distributed into the four classes as 12 CIS, 30 RR, 28 SP.
  - Multiple examination at different time points (every six months during three years) were collected per each subject which resulted in a sample composed as follow: 63 CIS, 199 RR, 190 SP.
- After acquiring MRI images from Magnetic Resonance Examination (1.5T Siemens Sonata system), the T 1 grey
  matter parcellation and the tractography of diffusion tensor imaging (DTI) is combined to obtain structural
  connectivity graphs of the brain.

# **Results and Conclusion**

Good level of separation were obtained between different MS clinical profiles demonstrating the effectiveness of our method. The best results are obtained for CIS patients while comparing RRMS and SPMS some degree of overlap was observed.



In the present work we provided an algorithm capable to exploit the longitudinal variations in order to perform classification of different MS clinical phenotypes. Statistical analysis showed that a comprehensive interpretation of the results is possible using NTF. The Frontal, Temporal and Parietal brain network links resulted the most anomalous providing highly important features for discriminating between MS clinical profiles.

Group Comparison	CIS vs SP	RR vs SP	CIS+RR vs SP
F1	76.67 (5.01)	70.17 (3.37)	74.17 (3.66)
Precision	79.33 (4.63)	77.67 (5.24)	77.50 (3.39)
Recall	76.17 (4.31)	70.83 (2.99)	74.33 (3.33)
AUC	76.33 (5.68)	70.00 (3.29)	73.83 (3.60)

[1] Stamile C., Kocevar, G., Cotton, F., et al., "Multiparametric non-negative matrix factorization for longitudinal variations detection in white-matter fiber bundles," IEEE journal of biomedical and health informatics, vol. 24, no. 4, pp. 1137–1148, 2020.

[2] Cao B., He L., Wei X., Xing M., et al., "t-bne: Tensor-based brain network embedding," International Conference on Data Mining, 2017.
[3] Kocevar, G., Stamile, C., Hannoun, S. et al., "Graph theory-based brain connectivity for automatic classification of multiple sclerosis clinical courses," Frontiers in neuroscience, vol. 10, no. 478, 2016.