QUANTIFYING THE TOPOLOGY OF CONSCIOUSNESS

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The existing problem of misdiagnosing neurological disorders is very common. Indeed, there are many neurological problems but only a limited number of neurological symptoms. Due to misdiagnosis the patients may experience severe consequences in their health. Establishing a correct neurological disorder diagnosis has major implications for the health, occupation and social interactions of patients. Misdiagnosis rates for neurological disorders are unfortunately high. Several studies point out that nearly 20% of new Multiple Sclerosis (MS) patients are misdiagnosed [1, 2]. Most of them actually had migraines, but unnecessarily received MS treatments that lasted several years and have a known risk of severe side effects, namely progressive multi-focal leukoencephalopathy. Tourrette's syndrome sometimes is confused with epilepsy, and there are many other distinct examples. It is no surprise since the brain is the most unknown part of human body. Our base data are maps of functional neural connections in the brain, known as connectomes. This data has been obtained through graph-based analysis on fMRI images by our collaborator Prof. Sophie Achard.

We have used a new method of geometric and topological data analysis—through approximating the length spectrum of the first homotopy group of a graph—together with manifold learning techniques, in order to distinguish fMRI brain data of patients and thereby classify various medical conditions. We have implemented theoretical tools from geometry and topology, to the brain data analysis used in previous studies, improving upon their results [4, 5].

Our method consist of a combination of several techniques: Spectral Non-Backtracking Eigenvalue pseudo-Metric (SuNBEaM) [3], Uniform Manifold Approximation Projection (UMAP) [6], and traditional machine learning methods for comparison. We have been able to perfectly discriminate connectomes of healthy and comatose patients. This was previously not possible with the methods employed beforehand. We have tested our procedure on other data sets, obtaining high accuracy in classification. The observed results motivate us to expand our techniques to a wider range of neurological diseases, to ultimately help doctors increase diagnostic accuracy, and test medication success. Moreover, using data mining techniques, we expect to find geometric and topological characterizations of neurological disorders.

References

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