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Detection of an Autism EEG Signature through a New Processing Method Based on a Topological Approach

Background:

Many different mathematical approaches have been tested in the last few years to disentangle the EEG data complexity and determine if it is possible to distinguish children with ASD from typically developing children or children with other neuropsychiatric disorders. Each method has advantages and disadvantages, like for example, the large computational time required to achieve the final task.

Objectives:

We present an alternative pre-processing approach of EEG data based on a novel algorithm applied to raw data to detect topological EEG features. Our assumption is that brain connection abnormalities can be detected through a specific mathematical topological approach, which is able to compare the minimal structure of functional networks beneath scalp electrodes.

Methods:

This new pre-processing approach of EEG data to detect topological EEG features has been applied to a continuous segment of artifact-free EEG data lasting 10 minutes in ASCII format derived from 50 ASD children and 50 children with other Neuropsychiatric disorders matched for age and male/female ratios whose data were obtained from a clinical archive. Both groups had the same age range (4-10 years) and the same gender distribution (m=39, f=11). None of the subjects were affected by genetic conditions, cerebral malformations, or epilepsy. In the control group, the range of primary diagnoses were ADHD (n=41), mood disorders (n=4), anxiety disorders (n=16), sleep disorders (n=12), ODD (n=6), and TBI (n=5).

Each EEG was manipulated using “Cin-Cin” algorithm, based on an input vector characterized by a linear composition of city-block matrix distances among 19 electrodes. From the resulting triangular matrix of 171 numbers expressing all of the one-by-one distances among the 19 electrodes a minimum spanning tree (MST) is calculated. Electrode identification serial codes sorted according to the decreasing number of links in MST, and the number of links in MST are taken as input vectors for machine learning systems. With this method all the content of an EEG is transformed in 38 numbers which represent the input vectors for machine learning systems

classifiers. The advantage is the simplicity and the small computational time required.

Results:

The robust set of 38 features related to MST were used as input for Machine Learning classifiers. KNN algorithm was used to develop a predictive model to distinguish subjects belonging to the two diagnostic classes (autism vs other disorders). Models' performances were tested with training/testing cross-validation procedures.

The best machine learning system (KNN algorithm) obtained a global accuracy of 93.2% (92.37 % sensitivity and 94.03 % specificity) in differentiating ASD subjects from NPD subjects (table 1).

Conclusions:

In conclusion the results obtained in this study suggest that the new preprocessing methods introduced, in particular the MST algorithm, have great potential to allow a machine learning system to discriminate EEGs obtained from subjects with autism from EEGs obtained from subjects affected by other psychiatric disorders.

Table 1. Predictive performance of machine learning systems

machine learning	Recs	ASD	Other	sensitivity	specificity	overall accuracy
KNN	55	22	33	95.45%	93.94%	94.70%
KNN	45	28	17	89.29%	94.12%	91.70%
Mean/sum	100	50	50	92.37%	94.03%	93.20%

Title*

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