A learning by example approach for MRI analysis of human brain in the context of mental health

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Objective:
The paper introduces a learning by example approach for the analysis of human brains in the context of mental health research. A dataset of MRI acquisitions for both patients with schizophrenia and normal controls has been processed. Source data have been transformed into several alternative representations in order to reduce the amount of data space and to find the most discriminative features in distinguishing between the two classes of examples (i.e., healthy and unhealthy). The final goal is to select the best representation which will be able to characterize the mental health disorder taken into consideration (i.e., schizophrenia).

Methodology:
The proposed method is based on the learning by example approach: starting from a set of data samples a classifier is trained to distinguish among the involved classes. In particular, in the training phase the class of each sample is given to the classifier. Then, after the learning phase, the classifier is able to classify also the previously unseen examples. In this study the involved classifier is based on the Support Vector Machine (SVM) which has already demostrated its effectiveness in several pattern recognition applications. In order to improve the learning phase, from the source data several feature extraction techniques have been carried out such as the histogram of gradients or wavelet coefficients. Moreover, in order to reduce the amount of data a Principal Component Analysis (PCA) has been applied on data by obtaining a more compact representation of the source data.

Results:
An exhaustive experimentation have been carried out starting from a set of 60 patients with schizophrenia and 60 normal controls. In particular, for each subject two kinds of MRI were available: 3D Anatomical acquisitions (3DA) and Diffusion Weighted Imaging (DWI) data. Furthermore, some tests have been performed by clustering the subjects according to their age or sex. The table below shows a summary of the main results by evidencing the kind of considered data, the extracted features and the classification score.

Controls	Patients	Cluster	Feature	3DA	DWI	Score
60	60	All	Wavelet + PCA	no	yes	81.67%
60	60	All	Hystogram of Image	yes	yes	79.19%
60	60	All	Hystogram of Grad	yes	no	70.83%
20	20	Age (24-38)	Hystogram of Grad	no	yes	95.00%
15	15	Female	Hystogram of Grad	no	yes	80.00%
15	15	Male	Hystogram of Image	no	yes	86.67%

Conclusions:
Thi study shows that the learning approach may be useful for human brain analysis. The results are very promising since up to 81.67% of patients with schizophrenia were detected with this tecnique. In particular, diffusion weighted imaging (DWI) data discriminated patients from controls better than 3D anatomical MRI acquistions. This may be due to the information provided by DWI, which is related to the microstructure integrity of the brain, specifically of white matter. Also, the detection of patients with schizophrenia was even more consistent when the samples were matched for age. Indeed, there are strong evidences that white matter disruption is a key point for the pathophysiology of schizophrenia, possibly progressing with aging. In conclusion, this may be may a promising technique to detect brain microstructure integrity features in schizophrenia from DWI data.