Support Vector Machine-based classification of Alzheimer's Disease population using a combination of structural MRI biomarkers

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Target audience: Our study combines two extremely popular and current research topics, disease classification and supervised learning, which should be of interest to physicians and data scientists.

Purpose/Introduction: The aim of this study is to investigate the early detection of Alzheimer's disease (AD) and mild cognitive impairment (MCI) conversion to AD using a combination of structural magnetic resonance imaging (sMRI) biomarkers.

Methods:

Subjects and MRI-acquisition: Our study included 279 subjects from ADNI database. Our population consisted of healthy control subjects (HC, n=71), Alzheimer's disease patients (AD, n=77), progressive MCI patients (pMCI, n=86) who convert to AD during a 3 years follow-up and stable MCI patients (sMCI, n=45) that did not convert to AD during the follow-up. All groups are age- and gender-matched. Subjects were scanned on T1-weighted MRI (1.5 Tesla).

Features extraction and selection: Cortical thickness and cortical curvature measures were chosen as the sMRI biomarkers because of their ability to quantify morphological alterations of the cortical mantle in early stage of AD. Cortical thickness was computed in the whole cortex using an approach based on the resolution of Laplace's equation[1] and the curvature calculation was performed using Monga et al's method [2]. Cortical curvature measures are represented by the sulcal and gyral curvature of the internal (gray matter/white matter boundary) and external (gray matter/cerebrospinal fluid boundary) cortical surfaces.

Eight parameters were derived from the sMRI biomarkers and their histogram analysis: mean, median, peak height, peak location, 10th percentile, 25th percentile, 75th percentile and the 90th percentile. Then, a features selection approach is performed by using the Information Gain (IG) method. The optimal feature subset was processed in the Support Vector Machine (SVM) classification.

Classification and validation: Six groups (i.e. HC/AD, HC/sMCI, HC/pMCI, AD/sMCI, AD/pMCI, sMCI/pMCI) were classify using 10 times repeated, stratified 10-fold cross-validated SVM with gaussian RBF kernel. The performances of the classification were described by its accuracy (ACC), sensitivity (SE), specificity (SP) and Area Under the Curve (AUC).

Results: The most discriminative features according to IG algorithm are mostly the ones from the cortical thickness and the external cortical curvature. The performances of the proposed method are represented int Table1.The performances are mostly very satisfying, indeed the SVM classification distinguish HC and AD patients with a 93.1% accuracy but appears to be less effective for classifying sMCI from pMCI patients (65.4%ACC) and from HC subjects (65.2%ACC).

	HC/AD	HC/sMCI	HC/pMCI	AD/sMCI	AD/pMCI	sMCI/pMCI
ACC (%)	93.1	65.2	80.7	75.0	75.0	65.4
SE (%)	93.3	85.7	78.6	86.7	73.3	88.2
SP (%)	92.7	33.3	76.5	55.6	76.5	22.2
AUC (%)	96.2	74.6	83.6	80.0	74.1	62.8

Table 1 – The performances of the proposed method for MCI conversion prediction and early detection of AD (abbreviation: ACC, Accuracy; SE, Sensitivity; SP, Specificity)

Discussion: Our classification method based on SVM and histogram analysis of the sMRI biomarkers achieved comparable and even higher classification performances than previous studies using region of interest-based approaches. Indeed, histogram analysis avoid the bias in the positioning of regions and uses more information contained in the biomarkers.

Conclusion: The SVM classification based on the combination of the cortical thickness and the cortical curvature measures (i.e. internal and external sulcal and gyral curvature) obtains accurate classification of the Alzheimer's disease population. Moreover, Histogram analysis is a powerful aid to the study of neurological disease because of its ability to detect subtle change early in the course of the disease, which increase significantly the performances of the disease classification.

References:

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