Computer Aided Diagnosis of Parkinson's Disease from T1-Weighted MRI

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Introduction: Parkinson's disease (PD) is a neurodegenerative disorder of the central nervous system, which affects the movement, balance, and muscle control. Substantia nigra (SN) and thalamus could have potential in the diagnosis of PD as SN suffers from progressive loss of dopaminergic neurons which perturb the activity of thalamic neurons[1,2]. White matter changes have been well documented in various neurodegenerative disorders[3]. In the present study, we used support vector machine[4] (SVM), a pattern recognition technique, to distinguish PD from controls at the individual level in terms of white matter changes in substantia nigra, thalamus and/ or combination of both areas.

Material & Methods: We studied 42 subjects: 21 controls (age ± SD = 51.9 ± 5.06 years, range: 45 to 68 years) without any known neurological deficits, and 21 PD subjects (age ± SD = 60.2 ± 6.36 years, range: 45 to 69 years) using 1.5 Tesla MR system. *MRI acquisition:* T1-weighted 3 dimensional magnetically prepared rapid gradient-echo (MPRAGE) sequences were acquired with the parameters: 176 sagittal slices (1 mm) in one slab, slice resolution: 80 dist factor 50%, T1:1100ms, TR/ TE: 1900/3.37, averages: 1, FOV: 256 mm, FOV phase: 93.8%, bandwidth: 130 Hz, echo spacing: 8.6 ms. *Preprocessing:* T1-weighted MR images were spatially normalized, modulated and segmented into gray matter, white matter and cerebrospinal fluid using SPM8 unified segmentation routine with default parameters. *Feature Extraction:* Experiments were performed on white matter only. White matter degeneration in thalamus and substantia nigra areas is a good marker to distinguish a PD subject from a normal subject. Therefore in order to evaluate the performance of computer aided classification of PD and controls, we considered relevant voxels from these areas as features. Feature vector comprised of all the voxels of the white tissue probability maps (preprocessed image) from a volume of interest (VOI). In experiments, three VOIs were considered: (a) VOI containing substantia nigra (SN) only (b) VOI containing thalamus (TH) only and (c) VOI containing substantia nigra and thalamus (SN+TH). VOI corresponding to thalamus was defined as two rectangular cuboids centered on (10,-18,4) and (10,-18,32) in the MNI space with dimensions 20, 32 and 24 mm in the x, y and z directions respectively. VOI for substantia nigra was centered on (27,-17,8) and (27,-17,30) with dimensions 6, 10 and 8 mm. SVM was used as a classifier to distinguish PD from controls based on the features so constructed from different VOIs.

Results: The performance of decision model was measured in terms of: sensitivity=tp/(tp+fn), specificity=tn/(tn+fp) and accuracy=(tp+tn)/(tp+tn+fp+fn), where tp, tn, fp and fn denoted true positives, true negatives, false positives and false negatives respectively. Experimental results in Table 1 are reported in terms of the average performance of 10-fold cross-validation of 10 runs. Variation in performance measures with the choice of VOI is shown using box-plot in Figure 1.

Table 1. Variation in average performance measures with different VOIs using linear SVM

VOIs	No. of Features	Sensitivity (in percentage)	Specificity (in percentage)	Accuracy (in percentage)
SN	240	49.17±2.75	88.00±2.92	68.6±1.61
TH	4862	70.00±4.58	89.00±4.46	79.30±3.19
SN+TH	5102	70.83±4.39	89.17±3.45	79.80±2.86

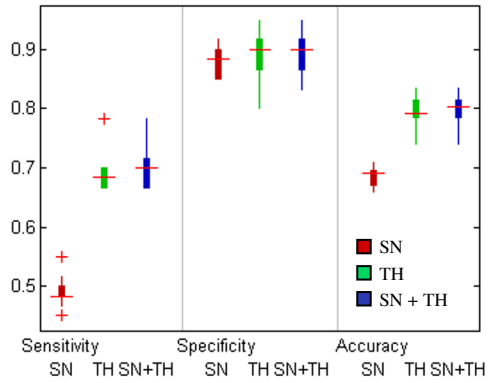

Figure 1. Variation in performance measures with different VOIs

Discussion: The best performance, in terms of sensitivity, specificity and accuracy, was observed when features were extracted from both thalamus and substantia nigra (SN+TH), in comparison with features from SN or TH independently. Specificity with all VOIs was comparatively more than sensitivity i.e. all methods able to predict controls more precisely. Sensitivity with SN was much less in comparison to other VOI's which signifies that PD patient will not be correctly classified when VOI is considered from SN only. This study demonstrates the importance of white matter change in thalamus and effectiveness of SVM to automatically distinguish PD from controls.

References:

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