Automatic Detection of Nigrosome Degeneration in Susceptibility-Weighted MRI for Computer-Aided Diagnosis of Parkinson's Disease Using Machine Learning

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Category: Parkinson's Disease: Neuroimaging

Objective: Automatize the detection of 'swallow-tail' appearance in substantia nigra dopaminergic neurons using MRI for more robust tests on Parkinson's disease (PD) diagnosis.

Background: Differential diagnosis of PD is challenging even in specialized centers. The use of imaging techniques can be beneficial for the diagnosis. Although DaTSCAN has been proven to be clinically useful, it is not widely available and has radiation risk and high-cost associated. Therefore, MRI scans for PD diagnosis offer several advantages over DaTSCAN [1].
Recent literature shows strong evidence of high diagnostic accuracy using the 'swallow-tail' shape of the dorsolateral substantia nigra in 3T – SWI [2]. Nevertheless, the majority of such studies rely on the subjective opinion of experts and manual methods for the analysis to assess the accuracy of these features. Alternatively, we propose a fully automated solution to evaluate the absence or presence of this feature for computer-aided diagnosis (CAD) of PD.

Method: Restrospective study of 27 PD and 18 non-PD was conducted, including standard high-resolution 3D MRI – T1 & SWI sequences (additionally, T2 scans were used to increase the registration references). Firstly, spatial registration and normalization of the images were performed. Then, the ROI was extracted using atlas references. Finally, a supervised machine learning model was built using 5-fold-within-5-fold nested cross-validation.

Results: Preliminary results show significant sensitivity (0.92) and ROC AUC (0.82), allowing for automated classification of patients based on swallow-tail biomarker from MRI.

Conclusion: Detection of nigrosome degeneration (swallow-tail biomarker) in accessible brain imaging techniques can be automatized with significant accuracy, allowing for computer-aided PD diagnosis.

References: [1] Schwarz, S. T., Xing, Y., Naidu, S., Birchall, J., Skelly, R., Perkins, A., ... & Gowland, P. (2017). Protocol of a single group prospective observational study on the diagnostic value of 3T susceptibility weighted MRI of nigrosome-1 in patients with parkinsonian symptoms: the N3iPD study (nigrosomal iron imaging in Parkinson's disease). BMJ open, 7(12), e016904. [2] – Schwarz, S. T., Afzal, M., Morgan, P. S., Bajaj, N., Gowland, P. A., & Auer, D. P. (2014). The 'swallow tail' appearance of the healthy nigrosome –a new accurate test of Parkinson's disease: a case-control and retrospective cross-sectional MRI study at 3T. PloS one, 9(4).

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