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# Automatic Deep Learning-based Models for Retinal Layer Thickness Analysis as a Biomarker for Neurodegenerative Diseases

Mateo Gende; Joaquim de Moura; Beatriz Cordón; Elisa Vilades; Elena García-Martín; Clara I. Sánchez; Jorge Novo; Marcos Ortega

Abstract

**Purpose** : The retina is the most accessible part of the central nervous system, allowing its non-invasive exploration and measurement. Optical Coherence Tomography (OCT) offers an objective monitoring method of progression in Neurodegenerative Disease (NDD), enabling the extraction of biomarkers such as retinal layer thickness. Machine learning models allow the automatic and repeatable measurement of the retinal layers and enable an early diagnosis of NDD. These need to be trained on annotated images representative of the visual patterns that characterise these diseases. We present a study in the automatic measurement of retinal layer thickness in patients of different NDDs and an assessment of the mutual compatibility of models trained in representative images of these diseases.

**Methods** : Five independent samples of multiple sclerosis, Alzheimer's disease, Parkinson's disease and essential tremor patients, along with

healthy controls were prospectively recruited (N=50). Macula centred OCT volumes from these patients were annotated with the area of the Retinal Nerve Fibre Layer (RNFL) and between the Ganglion Cell Layer and Bruch's Membrane (GCL-BM), for 1250 B-scans in total. In a first experiment, a series of deep learning models were trained on every NDD but one and evaluated in terms of their ability to segment the retinal layers of the unseen NDD. In a second experiment, the models were trained on images from a specific NDD and then evaluated on each of the other ones.

**Results** : The average thickness for each layer was measured and separately compared for each NDD using a one-way ANOVA test. This test found no significant differences between the thickness of either RNFL or GCL-BM ($p>0.05$). The results show that the models are able to accurately segment the retinal layers, with an overall Dice coefficient of $0.96\pm0.02$ for Experiment 1 and $0.95\pm0.03$ for Experiment 2. However, these results do not translate equally for every NDD. The models trained in diseases such as Alzheimer's and essential tremor can better generalise to other NDDs, while healthy control images achieved the second worst results.

**Conclusions** : Patients of different NDDs may present visual differences in their retinal OCTs, which affect the performance of automatic retinal layer segmentation models.

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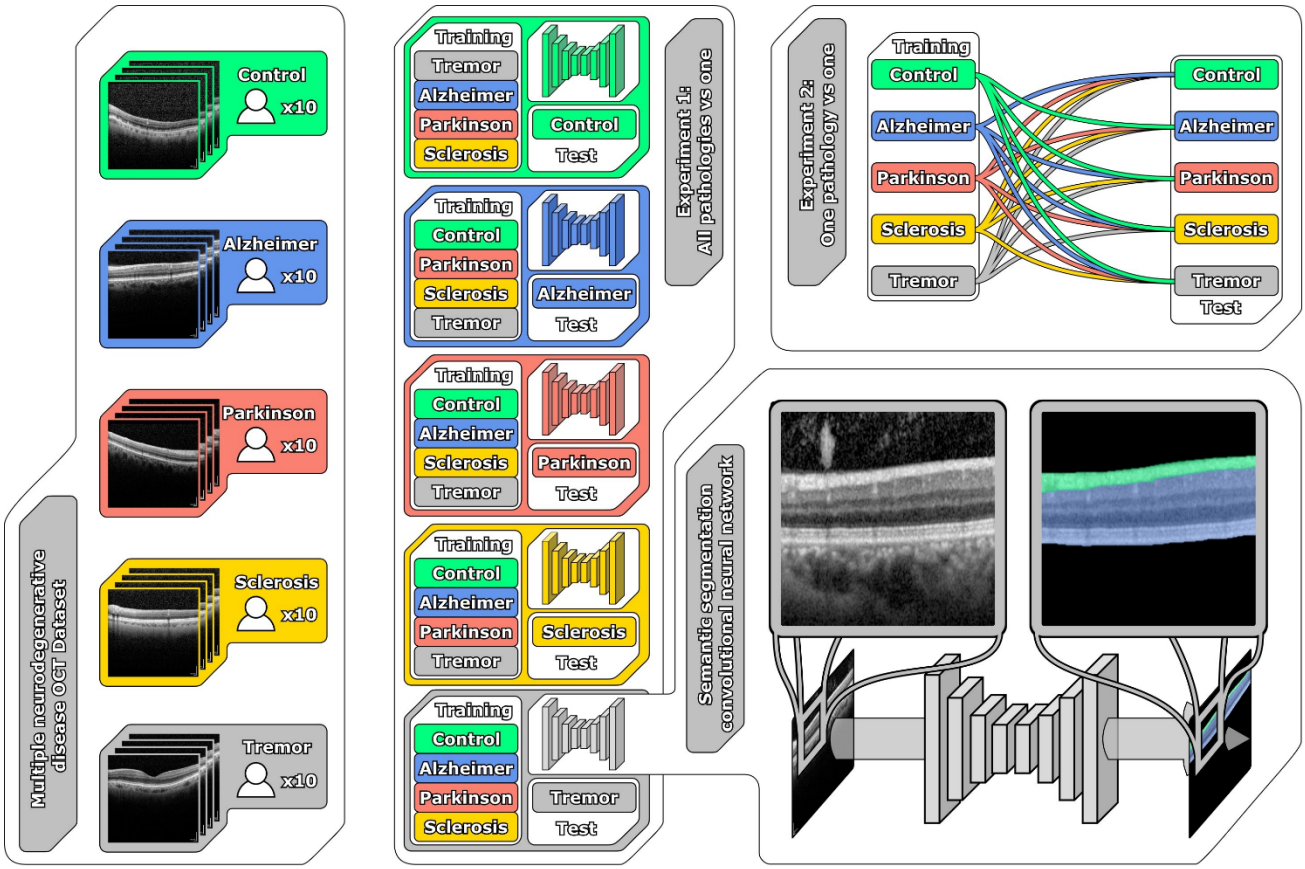
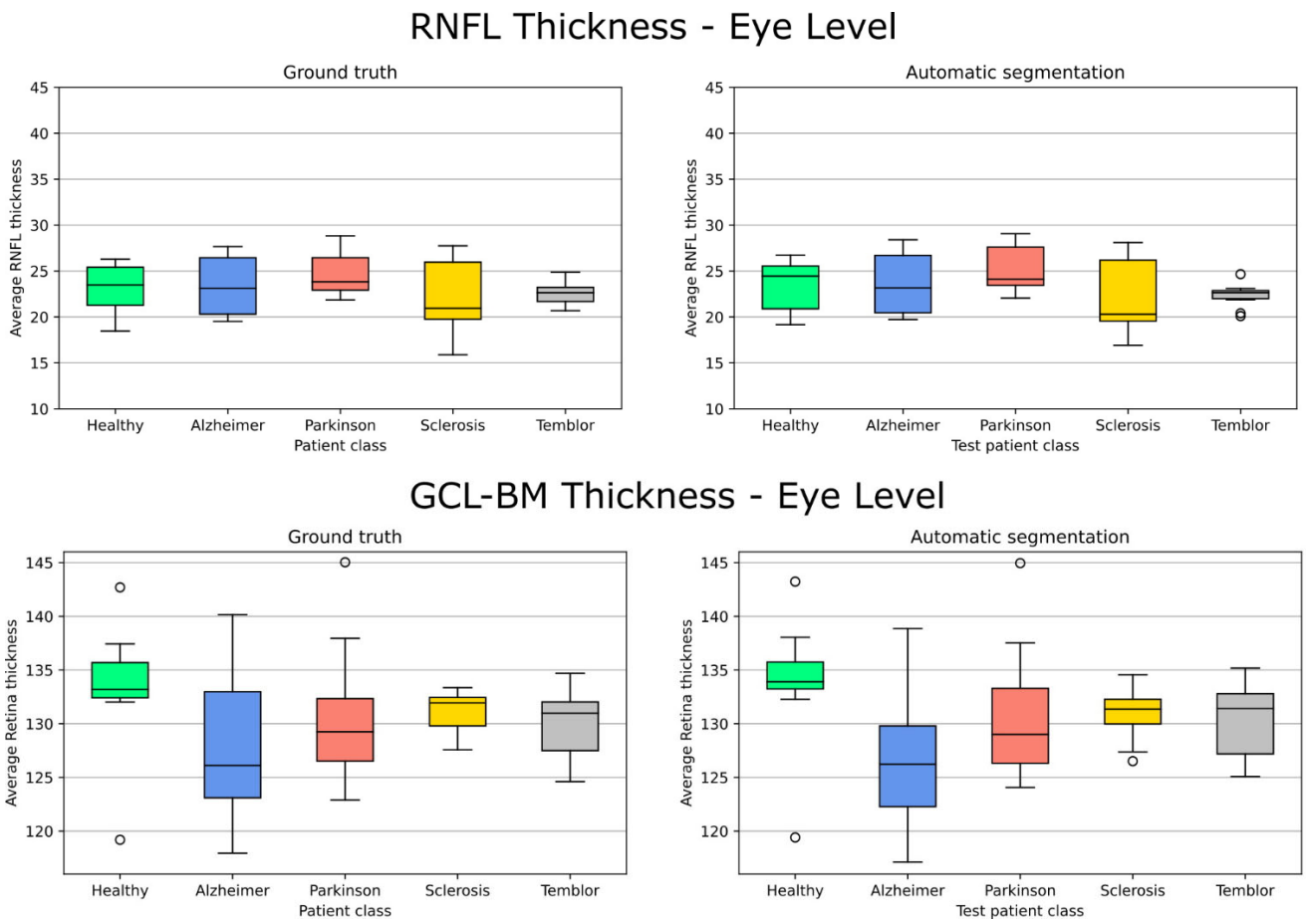



Summary of the experiments performed in this work.




Annotated and measured thickness for each layer at the eye level.