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Vision for All with Digital Health

OCT image interpretation using Deep Learning and explainable AI

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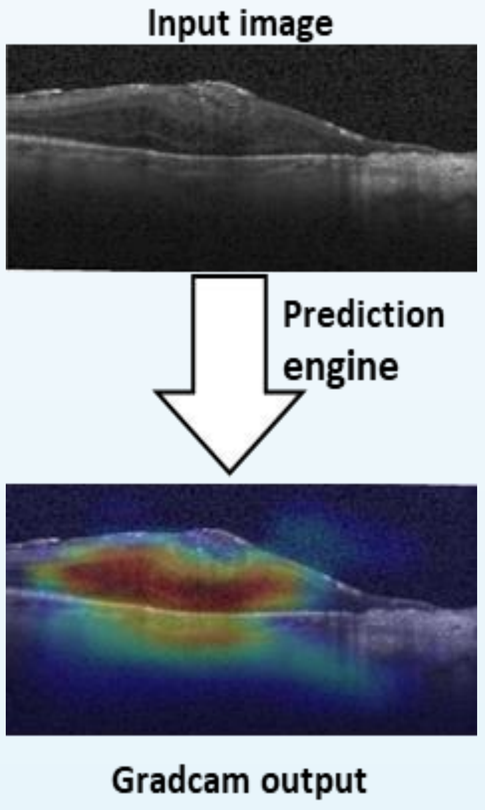
Purpose: The purpose of this study is to develop a robust and accurate model capable of reading Optical Coherence Tomography (OCT) images to classify retinal diseases into distinct categories using deep learning, transfer learning and explainable AI. The ultimate goal is to provide a valuable tool for accurate diagnosis of retinal diseases for application in early diagnosis and screening.

Methods: Our methodology is rooted in the adaptation and fine-tuning of a pre-trained EfficientNet architecture, which was originally designed for chest X-ray analysis. We optimize this architecture on a diverse OCT dataset (n = 1,12,820) comprising six distinct classes, viz., Normal, Drusen, Macular Edema (ME), Choroidal Neovascular Membranes (CNVM), Central Serous Retinopathy (CSR), and Macular Hole (MH) (table 1). To bolster interpretability, we introduce a multi-head channel-based attention mechanism. This innovative approach allows the model to focus on salient image regions, enhancing its ability to make informed decisions. In addition, we utilize Grad-CAM to generate heatmaps, furthering the development of explainable AI and providing valuable visual insights into the model's complex decision-making process.



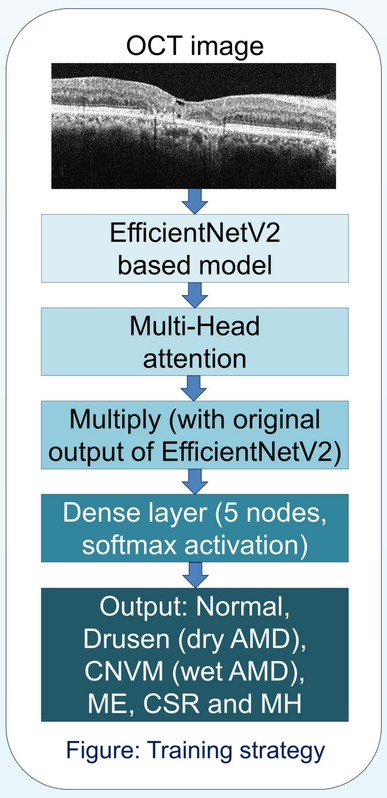


Figure: Training strategy

Condition	Training Data	Validation Data	Test Data	Sensitivity (%)	Specificity (%)	F1 score (%)
Normal	42,238	10,552	250	99.2	99.8	99.4
CNVM	30,912	7,717	376	99.8	96.2	96.1
ME	9,157	2,289	259	99.6	99.7	99.4
Drusen	6,892	1,724	250	88.8	99.7	93.6
CSR	75	18	9	77.8	100.0	87.5
MH	75	18	9	100.0	100.0	100
Total	**1,12,820**			**94.1**	**99.2**	**96.0**

Table 1

Results: Our study successfully developed a robust & accurate model for retinal disease classification based on OCT.

This model with its high sensitivity & interpretability is a valuable tool for Healthcare practitioners. It empowers early diagnosis, distant screening & hence timely intervention benefitting patients and community in a larger perspective.

Discussion: Our model excelled classifying diseases successfully consistently, exceeding 98%. This is crucial for early diagnosis. Literature review also confirms that:

1. 99.6% accuracy achieved by Takumasa Tsuji *et al*, in their study "Classification of optical coherence tomography image using a capsule network."
2. Lilong Wang *et al* reported sensitivities of 96.39% and 94.89% and specificities of 98.91% and 98.76% in two data sets in their paper "An Intelligent Optical Coherence Tomography-based system for pathological retinal cases – Identification and urgent referrals."
3. Daniel S Kermany *et al* achieved 96% accuracy in their paper "Identifying Medical Diagnoses and Treatable Diseases by Image-Based Deep Learning."

Conclusion: Our study has successfully developed a robust and accurate model for retinal disease classification. This model, with its high sensitivities and enhanced interpretability, is a valuable tool for healthcare practitioners. It empowers accurate diagnoses and timely interventions, benefiting patients affected by retinal diseases.

This research highlights the potential of deep learning and explainable AI in the medical field. Such models have the capacity to revolutionize early disease detection and treatment, ultimately improving patient outcomes and reducing the burden of vision impairment.

1. Takumasa Tsuji et al. BMC Ophthalmol 2020 Mar 19;20(1):114. doi: 10.1186/s12886-020-01382-4 l 2. Lilong Wang et al. Translational Vision Science & Technology August 2020, Vol.9, 46. doi:https://doi.org/10.1167/tvst.9.2.46 l 3. Daniel S Kermany et al. Cell 2018 Feb 22;172(5):1122-1131.e9. doi: 10.1016/j.cell.2018.02.010 l Glossary: AI: Artificial Intelligence, Grad-CAM: Gradient-weighted class activation mapping