



UNDERGRADUATE THESIS

**HYBRID METHOD OF EFFICIENTNET-B0 AND
PROTOTYPICAL NETWORK FOR MULTI-
CLASS CLASSIFICATION OF DIABETIC
RETINOPATHY**

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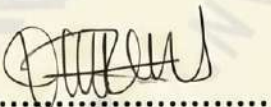
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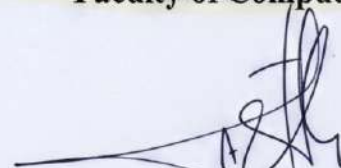
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ABSTRACT

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Diabetic Retinopathy (DR) is a microvascular complication of diabetes mellitus that can lead to permanent blindness if not detected at an early stage. Automated deep learning-based classification systems have emerged as a practical approach to support consistent and efficient screening processes. However, severe class distribution imbalance in retinal fundus image datasets remains a fundamental challenge that degrades model performance, particularly for classes with limited training samples. This study proposes a hybrid model that integrates EfficientNet-B0 as a transfer learning-based feature extractor with a Prototypical Network as a metric learning-based classifier, trained *end-to-end* for five-class DR severity classification using the *APTOS 2019 dataset*. Four baseline models were constructed as comparators, consisting of EfficientNet-B0 with a softmax classifier and a standalone Prototypical Network, each evaluated with and without enhanced green channel preprocessing. Model performance was assessed using accuracy, macro precision, macro recall, macro F1-score, and Quadratic Weighted Kappa (QWK) as the primary metric given its suitability for ordinal classification. The proposed model without preprocessing achieved the best results with an accuracy of 82.26% and QWK of 0.8807, outperforming Baseline 1 as the strongest baseline model which reached only 80.35% accuracy and QWK of 0.8529. Confusion matrix analysis shows that the proposed model produces error patterns more consistent with the ordinal class structure, where misclassifications predominantly occur between adjacent severity classes rather than distant ones. t-SNE visualizations further confirm that the proposed model forms a more structured *embedding space* with clearer inter-class separability, attributed to the prototypical loss mechanism that explicitly optimizes inter-class distances. Additionally, this study reveals that enhanced green preprocessing produces opposing effects depending on the model type, degrading performance for transfer learning-based models while improving it for from-scratch models, which implies that preprocessing strategy must be aligned with the architectural properties and the source domain of the pretrained weights used.

Keywords: Diabetic Retinopathy, EfficientNet-B0, Prototypical Network, *Few-shot learning*, Transfer Learning

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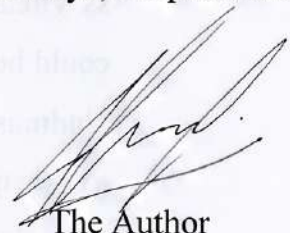
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