

Ordinal-Aware Contrastive Learning for Enhanced Diabetic Retinopathy Grading

Alagiah Suthakaran*, Siyamalan Manivannan

Department of Computer Science, University of Jaffna, Sri Lanka

*suthakarana@esn.ac.lk

Diabetic retinopathy (DR) is a leading cause of preventable blindness worldwide. Automated DR grading is inherently challenging due to the ordinal nature of disease stages, where misclassifications across distant stages (e.g., No DR vs. Severe DR) are more critical than between adjacent ones. Existing contrastive and classification-based methods often fail to model these ordinal relationships between severity stages, leading to clinically inconsistent grading outcomes. To address this, we propose an Order-aware Contrastive Loss (OCL) that incorporates inter-class distance weighting to enforce ordinal consistency during representation learning. Furthermore, we introduce a multi-branch architecture built upon a DenseNet-121 backbone, which integrates OCL with two complementary objectives in a unified multi-head framework. The entire network is jointly optimized to enhance both predictive accuracy and ordinal alignment. To the best of our knowledge, this is the first contrastive learning framework that explicitly integrates ordinal distance weighting for diabetic retinopathy grading. The proposed approach is evaluated on two benchmark datasets: EyePACS, a large-scale dataset containing 35,126 training and 42,670 test images across five stages, and APTOS2019, which includes 3,662 images. On EyePACS, our method achieves 86.93% accuracy, 0.8644 quadratic weighted kappa (QWK), and 0.8694 F1-score, surpassing the previous state-of-the-art (84.55% accuracy, 0.8631 QWK, 0.8440 F1-score). Similar improvements are observed on APTOS2019. These results highlight the effectiveness of incorporating order-aware representation learning with multi-objective optimization on a strong DenseNet based architecture, setting a new benchmark for ordinal DR classification.

Keywords: Ordinal Classification, Contrastive learning, Diabetic Retinopathy