Title: An Approach for the Automated Identification of Pterygium and Pinguecula in Ocular Images

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ABSTRACT

Conjunctival abnormalities, particularly pinguecula and pterygium, are serious public health concerns that have a negative impact on the quality of life and occupational productivity of working-aged and older people. Early and effective screening is thus essential for preventing the disease progression and minimizing the risk of long-term ocular problems. This study aims to develop and compare the performance of deep learning models in classifying digital eye images into normal and abnormal categories, where the abnormalities include pinguecula and pterygium. The study evaluated three pretrained convolutional neural network architectures: DenseNet121, EfficientNet-B4, and ResNet50. To improve diagnostic interpretability, the Gradient-weighted Class Activation Mapping (Grad-CAM) technique was adapted to generate heatmaps highlighting the clinically significant regions. Model performance was systematically measured using standard classification metrics, including accuracy, precision, and recall. The experimental results showed that DenseNet121 and ResNet50 consistently outperformed EfficientNet-B4 across all evaluation criteria. DenseNet121 achieved an accuracy of 99.55% without heatmap integration and improved to 99.70% with heatmap guidance, while ResNet50 achieved 99.70% without heatmap and increased to 99.85% when combined with heatmap, representing the highest overall performance. In contrast, EfficientNet-B4 achieved 93.48% without heatmap and slightly decreased to 92.27% with heatmap integration. In particular, the use of Grad-CAM heatmaps positively influenced the classification performance by allowing for the more accurate location of ocular abnormalities. ResNet50 integrated with the heatmap analysis outperformed the other tested architectures in delivering the highest accuracy, resulting in improved stability in clinical prediction, and also provided lower false-negative rates for the high-risk cases. In conclusion, the integration of deep learning-

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based architectures with explainable AI mechanisms provides a high-potential framework for preliminary ophthalmic screenings. These findings suggest that the selected models with an enhanced approach can serve as an effective clinical decision support system to enhance the ocular diagnostic efficiency and the patient care in the public health infrastructures.

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