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Integrating Retinal Image Analysis with Clinical Data for Enhanced Diabetic Retinopathy Classification: A Review of Machine Learning Approaches

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Abstract

Diabetic Retinopathy (DR) is one of the leading causes of blindness worldwide. Preventing severe vision loss requires early detection and accurate classification. Convolutional Neural Networks (CNNs), a recent advancement in machine learning, have greatly enhanced DR detection by recognizing retinal characteristics such as hemorrhages and microaneurysms in images. Nonetheless, many imaging models fail to consider important clinical parameters that contribute to the disease's progression, such as blood pressure, HbA1c, and diabetes duration. This review provides an overview of machine learning techniques combined with retinal images to extract clinically significant information. Through a comprehensive literature review, emerging technologies, including convolutional neural networks, random forest algorithms, and hybrid systems were analyzed. The focus was on how integrating basic imaging data with other clinical information enhances the classification of diabetic retinopathy. The findings indicate that CNNs play a crucial role in feature recognition from images. Additionally supplementing clinical data improves the precision and personalization of diabetic retinopathy (DR) models. The models integrated with clinical information are better positioned to stage disease severity and possibly enable targeted therapies. The discussion emphasizes the necessity of combining diverse data types to improve diabetic retinopathy (DR) management. Nonetheless, challenges remain, particularly the limited availability of diverse and large datasets. Future research should focus on developing robust methodologies that integrate clinical and imaging data, ensuring broader applicability across diverse patient populations.

Keywords: *Clinical data integration, Deep learning, Diabetic retinopathy classification, Machine learning, Retinal imaging*