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Combinational convolutional neural network approach for diabetic retinopathy diagnosis

Sheila Brown
Letterkenny Institute of Technology, Ireland

Diabetic Retinopathy (DR) is widely regarded as one of the most prevalent and perilous consequences of diabetes. Currently 145 million people suffer with DR, and 45 million with sight-threatening DR. These numbers are expected to exceed 224 million and 70 million respectively by 2040.

DR occurs when the diabetic condition damages blood vessels in the retina, where the undiagnosed sufferer remains unaware of the condition; often until irreparable. DR has been confirmed as the most common form of diabetic eye disease and the leading cause of blindness in adults aged 20–74.

Fortunately, the risk of diabetic blindness can be reduced by 95% with early detection and timely treatment. Unfortunately, early diagnosis poses one of the greatest challenges as determining the precise stage of DR is notoriously difficult requiring specialised human interpretation of fundus images. Timely and accurate streamlining of this diagnostic process is crucial to future reduction of the growing cases of DR blindness. This research investigates the use of Artificially Intelligent (AI) Convolutional Neural Networks (CNNs) to achieve precise DR diagnosis.

A CNN is a powerful image processing technique that uses Deep Learning (DL) to perform both generative and descriptive tasks, often using Machine Vision (MV) that includes image and video recognition. The use of CNNs is not new to the field of DR, however progress using such techniques is frequently hampered by the expense to the patient, patient wait times, and limited availability of medical professionals to perform the analysis.

A unique combinational CNN model for efficient and accurate fundus image identification was developed by combining image normalisation with a bespoke CNN comprising optimal minimal layers. The presented model was built on top of the Densenet-121 Architecture of CNNs, with additional layers for Global Average Pooling, Dropout, and Sigmoid Activation. Two datasets were used to train the CNN for peak performance achieving a Quadratic Weighted Kappa score of 0.8772 and validation accuracy of 93.96%.

Post training experiments using the custom-built CNN model were conducted using 7 retinal scan images depicting the current retinal health of the diabetic participant. The participant's independent physician provided a medical report testifying the participant presently had zero DR. This report provided an irrefutable measure of success for model prediction. Results showed that the model achieved 100% accuracy returning a zero DR diagnosis for the participant, thus surpassing the validation accuracy of 93.69% achieved in the training phase of development.

Following further experiments with a larger set of participants to corroborate these findings, the focus of future work is the deployment of this model as a 'personal retinal image scanner' to an individual's mobile device thus enabling both DR candidates and sufferers to routinely perform their own retinal scans and forward such scans to a physician for expert analysis. It is envisaged that such future work will significantly reduce the cost of expensive retinal scans, the wait time for crucial retinal scans appointments, and relieve the burden of 'local availability' for physicians, especially in the context of remote areas and underprivileged countries.

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