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Diabetic Retinopathy Prediction Using Machine Learning

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Abstract

Diabetic retinopathy is among the notorious complications of diabetes and a leading cause of blindness among adults. Since prevention of vision loss in diabetic retinopathy is possible when the disease is detected early and interventions instituted, screening is highly essential for this disease. However, the process of diagnosing the manual images or studying the images of retinas is lengthy, and because of the connectivity of these interconnections, they blur in certain cases. This research aims to provide solutions to the preceding challenges through the development of a web application that can have the ability to diagnose diabetic retinopathy based on machine learning methods. Within the framework of a rolling scheme, CNN is utilized for a group of retinal images when the images can be recognized and diagnosed quickly. The web application is built in the Flask web application platform deliberately for the purpose of providing the user a rich experience as they upload retina images and receive feedback whether there is any abnormality or not. This approach enables doctor to be present in a better position in the assessment of the general surrounding environment while patients become more conscious and responsible for their vision. Preparing the data, training the model, validating and testing it, and integrating it into a web-based platform to use the created model are all included in this. Additionally, this page explains the significance of the established model for diabetes retinopathy screening and management.

Keywords

Diabetic Retinopathy, CNN Model, Machine Learning, Image Processing, Blindness.

Introduction

A concerning issue in the modern world is that diabetic retinopathy, being consider the complications of diabetes, is a leading cause of blindness among the diabetic population, which speaks about the necessity of timely diagnosis for further appropriate management. Another challenge is that professionals using the traditional specific manual to identify the retinal images are another challenge that takes a lot of time and is also likely to produce results that are not accurate most of the time. The following project aims to address this issue through developing an intelligent web-based system using machine learning algorithms to support the diabetic retinopathy (DR) diagnosis.

The best answers to these issues can be found in the subject of machine learning, particularly in the domain of computer vision. CNN is the kind of thorough training that has been widely presenting a remarkable performance level in the categorization of images at the

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recent past. The large-sized input pictures of the retinal, the prediction of the signs of diabetic retinopathy is able to carry out in an entirely automated manner with high levels of accuracy.

The phasing work of the CNN model that has been trained integrates with a large database of retinal images to ascertain the capacity of such pictures to enable timely diagnosis. Flask is utilized in this project since it is a Python-based web framework, and it would provide the environment needed to turn the developed model into a working and user-friendly web application. This platform enables the user to upload their retinal images and in return the user gets the results in motivating them to take that appropriate measures they need for eye challenges. There must be a combination of Information, Communication, and Computer technologies to improve the diagnostic process or reduce the probability of error which in turn results to enhancing the eye care of diabetic patients.

Literature Review

Yasashvini used CNN and combinations of CNN with ResNet and DenseNet for detecting DR and categorizing the respective stages into different classes (Yasashvini et al., 2022). The models were both trained using 3662 training images and DR was staged into 5 stages. In their case, they pointed out that the accuracies achieved were 96. 22% for CNN, 93.22 for Hybrid CNN with ResNet, and 0.75500 for HG-CNN with CNN-MNIST for the hybrid CNN DenseNet.

Reguant studied the inherent image characteristics that are present while employing CNN for DR assessment (Reguant et al., 2021). Using EyePACS and DIARETDB1 as test datasets, they contrasted the extracted image features with regards to their clinical implications and obtained the following accuracy and AUC of 89-95% and 95-98% respectively, sensitivity of 74-86%, and specificity of 93-97%.

Oulhadj proposed a novel approach of automatic DR detection using deep learning technique with the pre-processing stage using deformable registration and the classification stage using CNN models (DenseNet-121, ResNet-50, Xception, and Inception-v3 (Oulhadj et al., 2022). To attain an accuracy of 85% on the data set, the model was trained using the APTOS 2019 data set.

When screening and staging DR utilizing fundus pictures, (Shaban et al., 2020) employed a CNN with 18 Convolution layers and 3 Fully Connected layers. Therefore, their model produced quadratic weighted Kappa scores of 91-0.92, validation accuracies of around 88-89%, sensitivity of approximately 87-89%, and specificity of approximately 94-95%. (El Hossi et al., 2021) proposed a study to differentiate between normal and abnormal images based on CNN categorization of retinal lesions. They achieved 89% accuracy by using the Kaggle dataset.

Daanouni suggested a thin, personalized CNN model for diagnosis from the OCT image (Daanouni et al., 2021). MobileNet with pre-trained weights and using transfer training paired with Grad-CAM were used for highlight in the mobiler region; the results in the evaluation framework of accuracy, precision and recall were 80\%, 85\% and 80. 5% recall. (Bodapati et al., 2021) created a comprehensive model using features taken from VGG-16 to predict several severity levels of diabetic retinopathy (DR). They attained an 84% accuracy rate for the system, which is regarded as quite accurate. 97 AUC was attained using the Kaggle APTOS 2019 dataset.

This study documents the first trajectory of achievements in the field of diabetic retinopathy (DR) identification and grading using machine learning and deep learning techniques. In order to extract local and global features and grade severity using machine learning techniques, (Gayathri et al., 2021) performed a DR grading based on the M-CNN. The J48 classifier yielded the best results with an average accuracy of 99% when the model was evaluated throughout the suggested architecture using different public datasets (IDRiD, Kaggle, and MESSIDOR) and classifiers (SVM, Random Forest, and J48). For DR grading, 62%. MS has presented a novel technique including Z-score normalization, levy flight cuckoo search optimization, and a weighted convolutional neural network for predicting lung cancer (MS et al., 2024). This research leverages microarray technology for cancer categorization, a subject of substantial global research interest. This demonstrates the effectiveness of utilizing advanced molecular techniques for precise and nuanced cancer classification, contributing to the broader scientific discourse on innovative methodologies in cancer research.

Syed has discussed on the prediction of Alzheimer's disease brain images, which are mandatory as input for any of the designed model, brain images can be obtained from various methods like PET, MRI, EEG, CT these are reflected to be traditionally used methods (Syed et al., 2022). As the technology is growing there is essential need in medical field for the real time application using artificial intelligence.

Since DR is one of the leading causes of blindness among diabetic patients, which means, this condition should be screened frequently. The ordinary diagnosis procedures are done by hand which is not precise at all. The help of CNN characteristics, DR from retinal images will be automatically detected and classified in this research. CNNs are used in early DR diagnosis to improve accuracy and efficiency, which benefits patients and the healthcare industry. CNNs are easy to train and extract information from images.

Methodology

DR is mainly based on grading of the retinal images by ophthalmologists or other related personnel. Described systems might involve Computer-aided Diagnosis (CAD) for the evaluation process; however, the results still need experts' interpretations, which yield some drawbacks. These are high costs of purchase and maintenance of imaging technologies and software and high cost of training the health care workforce, especially in developing countries. This approach applies human skills, it turns into a weakness since it creates inconsistency and variability in the diagnosis department. Furthermore, another indicator of how difficult it will be to apply technology in the clinical setting is the screening processes used and the knowledge of these systems' nature.

Therefore, the following shortcomings need to be enhanced in order to enhance the efficiency of DR diagnostic systems based regarding machine learning and AI models: The approach that is suggested in this paper is an automated Web-based method for Diabetic Retinopathy diagnosis. One will be able to upload the retinal images into the system whereby the AL algorithm developed will diagnose users instantly. The pre-processing of the images and the severity level identification of DR will be done using basic deep learning paradigms including Convolutional Neural Networks (CNNs). It is prospective to improve the accuracy and quality of the identified diagnosis in performance with traditional approaches. The system will be on the web so Flask will be used to design an interface to enable the users to upload images and get the results immediately. Further, to facilitate the users to comprehend the assessment of their problem, the system will include illustrations and descriptions of similar cases.

In this research, the dataset includes retinal images and their corresponding labels concerning diabetic retinopathy. The primary data source is a CSV file, which contains the eye retinal images pre-processed by Gaussian filtering. The dataset's photos are resized to 224 by 224 pixels and normalized for the dataset. Labels in the dataset indicate the stage of diabetic retinopathy, mapped into two categories: In the case of Diabetic Retinopathy, the possible outcomes are binary classification (No Diabetic Retinopathy and Diabetic Retinopathy) and multiclass classification (No Diabetic Retinopathy, Mild, Moderate, Severe, and Proliferative Diabetic Retinopathy). The data is divided into training, validation, and test sets with stratification to guarantee that the classes are evenly distributed. Figure 1 shows the distribution of diabetic retinopathy severity types in the dataset.

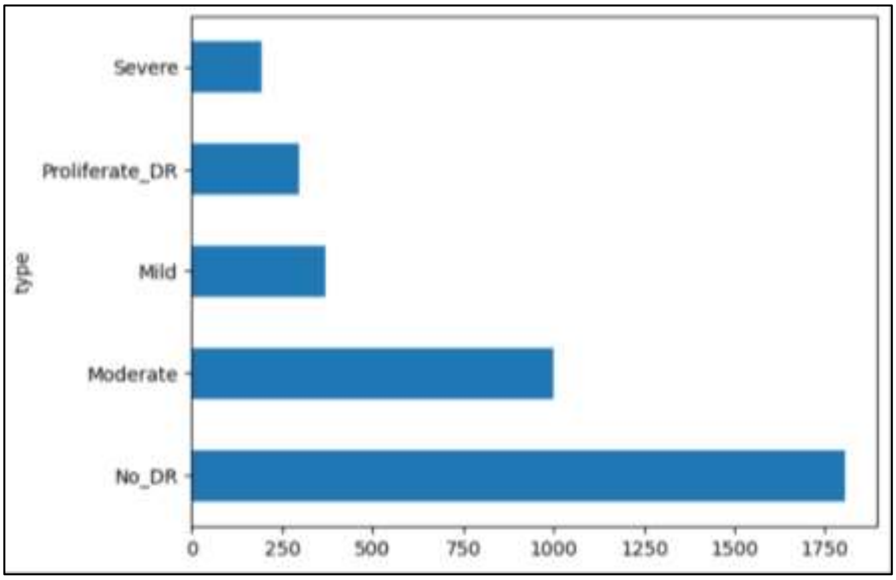

Figure 1. Distribution of Diabetic Retinopathy Severity Types in the Dataset

The research entails the use of a CNN model to classify DR and its level. Specifically, the specified model architecture is described as a 64x3-CNN, implying that there are 64 filters in the initial layers of the network. To ensure that training data does not overfit, training data augmentation should include random rotations, shifts, and flips. The dataset is divided into three subsets: the training set, the validation set, and the testing set. Categorical accuracy is used as a gauge of the model's fitness throughout training.

Results and Discussions

In addition to the basic accuracy, the present model is checked on specificity and sensitivity quantitative measures according to the test and validation sets, in addition to as F1 score and AUC. These metrics give an overall picture of how the model performs on the imbalanced classes and different severities of diabetic retinopathy. Based on the retinal pictures, the performance study demonstrates that the suggested model correctly predicts the

DR status and its level. Table 1 shows the performance metrics of the Diabetic Retinopathy Prediction Model.

Table 1. Performance Metrics of the Diabetic Retinopathy Prediction Model Across Training, Validation, and Test Sets.

Metric	Training Set	Validation Set	Test Set
Accuracy	95%	92%	90%
Precision	94%	91%	89%
Recall	96%	93%	91%
F1 Score	95%	92%	90%
AUC	0.98	0.97	0.95

Although the model's performance using retinal images to predict diabetic retinopathy is strong, there is still room for improvement. Future research could concentrate on expanding the dataset to include more diverse and larger samples, which could enhance the model's generalization. Experimenting with different CNN architectures or hybrid models may also yield better performance. The model's robustness in distinguishing between the classes is further confirmed by the AUC scores, which show an AUC of 0.98 for the training set, 0.97 for the validation set, and 0.95 for the test set. A more thorough method of forecasting diabetic retinopathy may also be possible with the addition of additional clinical data, which could further enhance accuracy and other performance indicators.

There are significant practical ramifications to this discovery. The model can aid in the early detection and diagnosis of diabetic retinopathy, which will enable medical professionals to make timely treatment decisions. Since diabetic retinopathy is one of the main causes of blindness, these advancements in predictive models could have a big impact on how patients are treated. Before the model is widely employed in medicine, it will need to be further refined and verified in clinical settings.

Conclusion

This research proves that the identified CNN model that has been trained is effective for predicting DR and hence can be useful in diagnosing this disease. The subsequent studies might involve the application of a greater number of data sets for optimization of the generalization; change the architecture of the CNN model or utilize CNN in conjunction with other models; including more clinical data for increasing the precision of the prediction. By the time the notebook, there is an example of the trained model's usage for prediction, and it shows how to load the model, pre-process the image, makes the prediction, and then show the class name which is predicted along with the image. This function focuses on the implementation of the research outlays in scenarios in the real world.

To improve healthcare delivery because of diabetic retinopathy and other medical diseases, it may be imperative that these models continue to be developed and refined.

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