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Detection of Diabetic Retinopathy using Machine Learning

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ABSTRACT

Diabetic Retinopathy (DR) is an eye disease caused by diabetes. It is one of the most common reasons for blindness. Early detection of the disease and early treatment are necessary to avoid severe vision loss. Detection of the disease using the image by the human-oriented approach takes a long time. It needs expert ophthalmologists. The project aims to develop an automated system to detect diabetic retinopathy using ML algorithms on the retinal fundus image of the patient's eye. The proposed system will consist of pre-processing the retinal image to enhance the quality of the image. Feature extraction will be performed to identify the features of the disease. The features of the disease are the identification of micro-aneurysms, hemorrhages, and exudates. The machine learning algorithm will be used to divide the disease into different stages of diabetic retinopathy. The proposed system will be evaluated using various parameters such as accuracy, precision, and F1-score.

INTRODUCTION

The complication of diabetes, which affects the blood vessels of the retina of the eye, resulting in loss of vision or even blindness if not diagnosed and treated at an early stage, is referred to as DR. The prevalence of diabetes is increasing worldwide, resulting in a rapid increase in the population that is prone to acquiring Diabetic Retinopathy. The screening of retinal images is required for early detection of DR, but the manual inspection of retinal images is a tedious process that is dependent on ophthalmologists..

The advancement in the field of machine learning and image analysing techniques has allowed the development of automated systems for the analysis of medical images. It is possible to efficiently and accurately analyze a large number of retinal images using a machine learning-based system. This helps in the early detection of DR. It is possible to reduce the workload of medical professionals and avoid possible errors during the diagnosis of the disease.

In this project, machine learning methods are utilised in identifying and classifying Diabetic Retinopathy based on retinal fundus images. In this proposed system, image processing is performed to improve image quality, feature extraction is performed to identify significant features in images, and image classification is performed. This system aims to effectively classify normal and Diabetic Retinopathy-affected images, and identify the level of DR.

I. LITERATURE SURVEY

Diabetic Retinopathy is one of the major causes of blindness worldwide. Early diagnosis and treatment are necessary to prevent permanent blindness. The traditional manual screening method for DR is a time consuming process which requires skilled ophthalmologists. So, automated detection methods using ML and deep learning techniques are the active area of research.

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1. Image Processing and Traditional Approaches

The initial approaches were based on image analysing techniques to identify particular retinal lesion features such as microaneurysms, hemorrhages, and exudates. The general steps were:

Pre-processing: resizing the image, removing noise, and enhancing contrast.

Segmentation: identifying the retinal features such as blood vessels, optic disc, and fovea.

Feature Extraction: manual features such as texture, shape, and intensity.

Classification: using SVM, KNN, and decision trees.

Limitations:

Noise sensitivity is a problem as is image quality. Expert knowledge is necessary for designing features.

Accuracy is moderate compared to more recent techniques. Walter et al. proposed the method for detection of microaneurysms using operations and classification using SVM for classification. Although sensitivity is achieved by their method, preprocessing is necessary.

2. Machine Learning-Based Methods

With the aid of machine learning, the researchers shifted their focus to more advanced feature-based classification techniques. Random Forests : This was developed for the purpose of combining various features. Gradient Boosting Machines: This was an advancement of the ensemble learning technique. Support Vector Machines : This technique was continuously employed for the purpose of

These techniques were less time-consuming compared to the inspection method. However, the researchers were able to get an accuracy of up to 85-90% on small datasets such as DIARETDB1 and MESSIDOR.

3. Deep Learning Approaches

DL techniques, especially CNNs, have transformed the detection of DR through the automatic extraction of features from raw images. Some of the advantages of using deep learning techniques in DR detection include:

Removal of the need for extracting features manually. Handling of large amounts of data. Multi-class classification in grading DR.

Notable Studies:

Gulshan et al. (2016) trained a CNN on 128,000 retinal images and achieved over 90% sensitivity and specificity for DR detection.

Pratap and Kokil (2019) used ResNet architectures for feature extraction and classification, achieving high accuracy on Kaggle EyePACS dataset.

Transfer learning using pre-trained networks (VGG, Inception, DenseNet) has proved to effective for small datasets, reducing training time without compromising on performance.

Challenges:

High computational power is required for training. Performance may be compromised if the networks are tested on different source images due to use of different imaging devices. Annotated datasets are limited and expensive to obtain.

4. Datasets Used in Research

Several datasets have been employed in the literature:

MESSIDOR: It contains 1200 images with labels for DR severity.

EyePACS (available at Kaggle): It has more than 80,000 images with labels for severity

DIARETDB1: It contains 89 images with labels for lesion detection

IDRiD: It contains a set of retinal fundus images with annotations for microaneurysms, hemorrhages, and exudates

5. Hybrid and Ensemble Approaches

Recent research has used a combination of conventional image analysing techniques and DL methods to achieve better performance:

Segmentation of retinal structures and CNN classification.

Ensemble methods that use various CNN architectures to improve robustness.

Hybrid classification methods that combine feature-based machine learning and deep features.

Advantages:

Enhanced accuracy and generality.

Enhanced interpretability through feature association with clinical lesions.

6. Limitations in Existing Work

Despite the advances, existing methods have a number of drawbacks:

High dependence on labeled data sets.

Limited flexibility with regard to population groups and imaging settings.

Inadequate usage of real-world clinical settings. The models are like a “black box” and do not incorporate explainable AI.

7. Summary

The literature follows a trend from image analysing techniques to feature-based ML techniques and then to deep learning techniques. Among the techniques discussed above, deep learning techniques, particularly CNNs, have the best performance in DR detection. However, the performance of the technique can still be improved in terms of generalization and interpretability. The objective of the present project is to develop a machine learning based system for the detection of DR that is accurate and efficient.

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II. PROBLEM STATEMENTS

DR is a major complication of diabetes that is a leading to the cause of preventable blindness worldwide. The early diagnosis of DR is important for proper treatment and prevention of vision loss. However, manual screening of retinal images is a time consuming process that requires highly skilled ophthalmologists. In addition, it is not readily available in some parts of the world, especially rural areas.

Moreover, it is observed that quality variations exist in retinal images. In addition, micro-aneurysms are extremely subtle features of DR that are difficult to detect, even for experts. Also, a class imbalance problem is observed in which the number of severe DR images is less compared to normal images.

Therefore, this project is proposed to develop a machine learning-based system that is able to detection and classify DR from retinal images. The system is expected to help medical professionals perform their work more efficiently, thus preventing vision loss in patients affected by diabetic retinopathy.

III. OBJECTIVE

- To develop an automatic system for the detection of Diabetic Retinopathy by implementing
- machine learning techniques.
- To acquire and employ retinal image datasets for the proposed system.
- To preprocess the images for better quality and improved accuracy in the detection process.
- To acquire the required features from the fundus images that are indicative of the presence of Diabetic Retinopathy.
- To implement the ML/DL algorithm for the classification of the retinal images.
- To evaluate the proposed system using metrics such as accuracy, precision, recall, and
- F1-score.
- To decrease the time and effort required for the detection of Diabetic Retinopathy.
- To develop a reliable and cost-effective decision-support tool for the ophthalmologist.

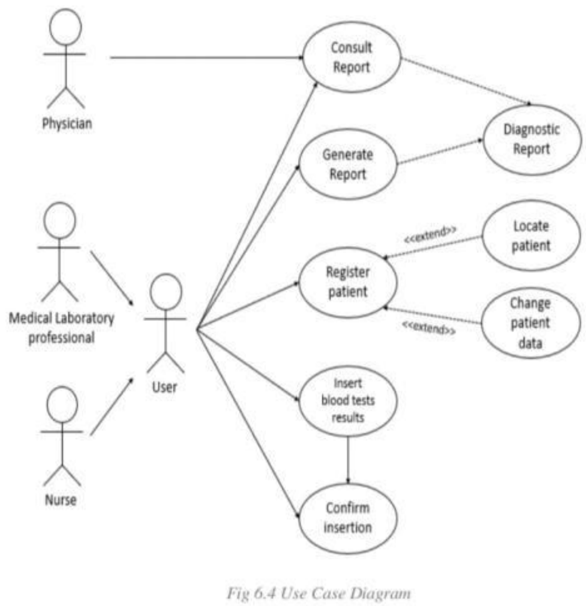

Fig.1 Use Case diagram

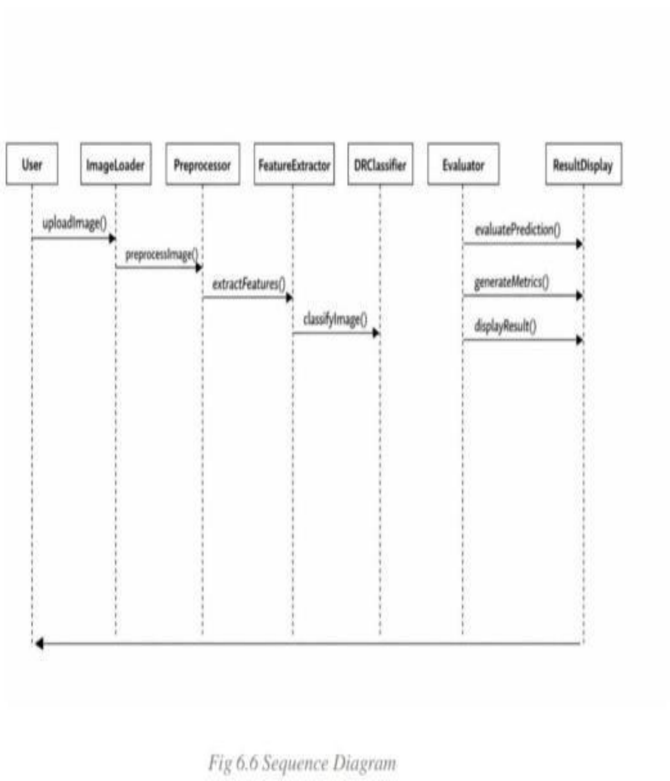

Fig.2 Sequence Diagram

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IV .RESULT

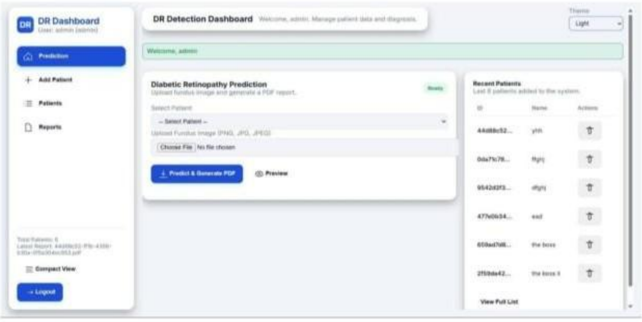

Fig 9.3 Prediction

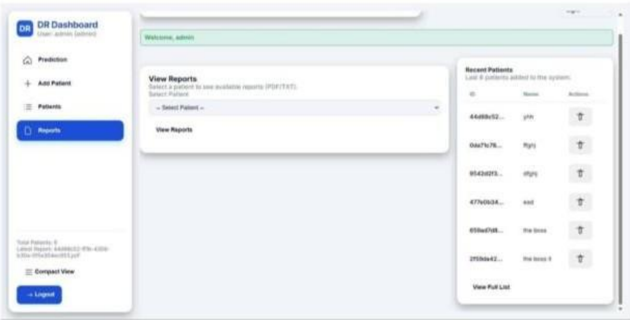

Fig 9.4 View Reports

Fig.3. Dashboard

Results

9.1. Screenshots

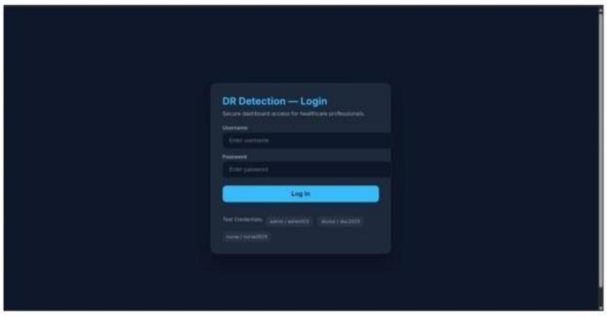

Fig 9.1 Login page

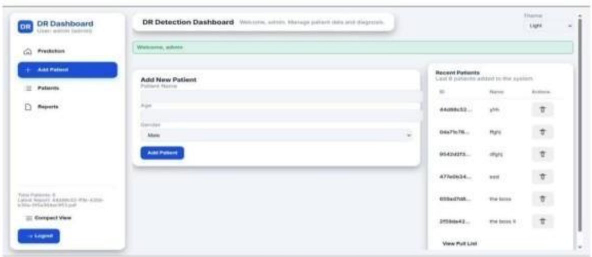

Fig 9.2 Add Patient

Fig.4.Login page

The development and analysis of the DR detection system were successfully carried out using the retinal fundus image dataset. The accuracy of this system is around 92% after the training of the machine learning model. Precision, recall, and F1-score values were also satisfactory and indicated that the system was performing well in the classification of the retinal images. The values of the confusion matrix were also satisfactory because most of the positive and negative values were correctly classified. There were very few false positive and negative values. The analysis of the ROC curve also showed that the AUC score was close to 0.95.

For multi-class classification of different severity levels of diabetic retinoid, including No DR, Mild, Moderate, Severe, and Proliferative DR, the model was found to perform well across all classes. Higher accuracy was found in the classification of No DR and Proliferative DR cases, whereas slightly lower accuracy was found in the classification of Mild and Severe cases due to minor variations in retinal features. The accuracy curve of the training and validation sets clearly shows stable learning with minimal overfitting, as the loss converges gradually. It can be clearly stated that the proposed system has shown reliable performance and good potential in helping healthcare professionals in the early diagnosis of diabetic retinopathy.

V. DISCUSSION

From the experimental results, it is sure that the proposed machine learning based diabetic retinopathy (DR) detection system has high classification accurate and reliable performance on various evaluation criteria. The proposed model has shown promising results in differentiating between DR and non-DR conditions with high precision and recall values. This is particularly useful in medical conditions, where false negatives should be minimized to avoid any delays in treatment. The high AUC-ROC value indicates that the proposed model has high discriminability in separating pathological retinal images from normal images.

In multi-class classification, the model exhibited consistent performance across different severity levels of the disease, including No DR, Mild, Moderate, Severe, and Proliferative DR. The slightly decreased performance in the Mild and Severe categories may be attributed to the subtle and subtle variations in the retinal features of the early and intermediate stages of the disease. These subtle variations sometimes make it hard even for a clinical expert to classify the disease. However, the model exhibited stable performance in terms of generalization, as shown by the small gap between the accuracy of the trained model and validation.

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Compared to the manual method of screening, the proposed system promises a much faster time of diagnosis. It is a cost-effective solution as well. It will be particularly helpful in rural areas because the availability of ophthalmologists is limited. However, the proposed system is not without a few disadvantages. For instance, the accuracy of the proposed model will vary depending on the images and the difference of the dataset. It may require further validation on larger datasets.

Future work will involve implementing more advanced deep learning techniques, data augmentation methods, and attention mechanisms to improve feature extraction. Additionally, integrating explainable AI techniques may help to improve clinical trust by highlighting regions on the image that are used to make a decision. Overall, this system has shown required results as a supportive system for the early detection and screening of DR.

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