Integration of Predictive Techniques in Diabetic Retinopathy Using Deep Learning

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Abstract - Diabetes is a metabolic disorder that is affecting millions of people worldwide, with its incidence rates increasing alarmingly year after year. Diabetes complications in most of the body's major organs can be life-threatening unless treated. Early detection of diabetes is crucial for timely treatment to prevent the disease from developing complications. RR-interval signals, in the form of heart rate variability (HRV) signals, can be effectively used for non-invasive diabetes screening. This research paper proposes a classification technique for diabetic and normal HRV signals using deep learning models. We apply long short-term memory (LSTM), convolutional neural network (CNN), and their combinations (CNN-LSTM) to extract complex temporal dynamic features of the input HRV signals. These features are then classified with the assistance of support vector machine (SVM). We have achieved performance improvements of 0.03% and 0.06% in CNN and CNN-LSTM architectures, respectively, compared to our previous research work that did not use SVM. Various machine learning techniques are employed to carry out predictive analytics over big data in multiple domains. Predictive analytics in healthcare is a challenging task, but ultimately, it can help practitioners make big data-informed, timely decisions regarding patients' health and treatment. This study explores the application of predictive analytics in the healthcare sector by utilizing six distinct machine learning algorithms. For experimentation, a dataset of patient medical records is used, and six different machine learning algorithms are applied. In this project, we use the Convolutional Neural Network (CNN) algorithm. A discussion and comparison of the performance and accuracy of the algorithms used shows which method is most suitable for diabetes prediction. This project aims to assist doctors and practitioners in the early detection of diabetes using deep learning methods.

Keywords: Deep learning, Diabetic Retinopathy, ResNet.

1.INTRODUCTION

There are various machine learning methods that are used to carry out predictive analytics on big data in different domains. Predictive analytics in medicine is a difficult task but ultimately can assist practitioners in making big data-driven timely decisions regarding a patient's health and treatment. Predictive analytics in medicine is discussed in this paper, where six different machine learning algorithms are used in the research work. For experimental purposes, a patient medical record dataset is used, and six different machine learning algorithms are used on the dataset. In this project, we are using the Convolutional Neural Network (CNN) algorithm. The performance and accuracy of the algorithms used are discussed and compared. The comparison of the different machine learning methods used in this research shows which algorithm is most suitable for the prediction of diabetes. The goal of this project is to help doctors and healthcare professionals predict diabetes early using deep learning techniques. With advancements in computing power and improvements in image processing techniques, the idea of using computers to analyze medical images and automatically diagnose diseases has gained significant attention from both medical and technology professionals. This concept of analyzing retina images and diagnosing ocular and vascular diseases is highly cost-effective and efficient. Retinal vascular structures hold a lot of medical information. Diseases like diabetes, hypertension, cardiovascular diseases, and others can be identified through the analysis of retinal fundus images. The application of machine learning in the medical field, and how deep learning methods like CNN can improve predictive power, is the topic of this research. With the use of retinal image analysis, medical professionals are able to diagnose diabetes early enough to facilitate intervention and treatment in a timely manner. Further, the ability of CNN to learn and process high-level image datasets makes it a force to be reckoned with in the improvement of diagnostic accuracy. The combination of machine learning and medical diagnosis not only offers a more effective alternative but also offers a cost-effective means of monitoring and managing chronic illness.

2. PROPOSED SYSTEM

The main goal of the proposed system is to improve the ability to screen diseases based on their severity. We are developing a model using ResNet that automatically analyzes a patient's fundus image, collected by a

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technician, to help determine the severity of vision loss. These images are captured as pixel arrays and are labeled into five classes: No_DR, Mild, Moderate, Proliferate, and Severe. Before training, the dataset is rescaled and processed using various filters to highlight important features. This preprocessing includes steps like rescaling, converting to grayscale, flipping the images horizontally and vertically, applying shear transformations, and more. Data generators are then created for training, testing, and validation. This approach is commonly used in image classification tasks and is especially effective in detecting diabetic retinopathy by analyzing the patterns in blood vessel pixels.

4. SYSTEM ARCHITECTURE

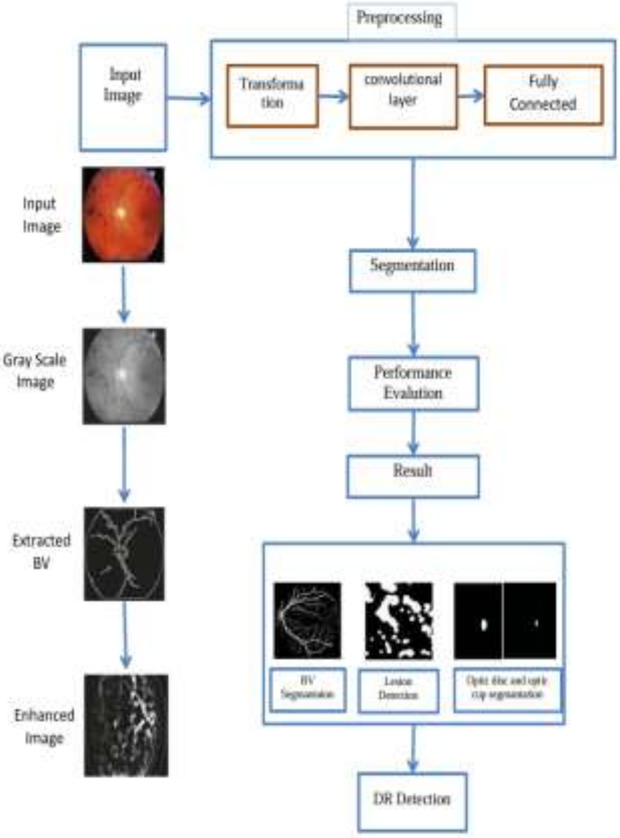
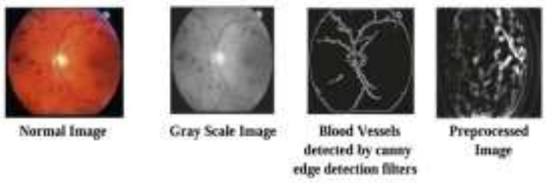


Fig. 1 Architecture Diagram

1. **Input Data**
   Fundus images stored as pixel arrays.
2. **Dataset**
   The dataset utilized for this task was sourced from Kaggle, a popular online platform for datasets. The dataset comprises approximately 2500 fundus images, collectively amounting to a size of about 16 MB. These images are divided into two main subsets: training and testing, following a 9:1 ratio to ensure optimal model training and evaluation. The images are categorized into two classes: DR (Diabetic Retinopathy) and No DR, representing fundus images of patients with and without signs of diabetic retinopathy. Each image is stored in RGB format, ensuring rich color representation, and ranges in size from 2.5 KB to 6 KB. This compact yet comprehensive dataset is designed to facilitate the development of accurate and efficient machine learning models for diagnosing diabetic retinopathy.

3. **Preprocessing Steps**
   Before model training, the input is the fundus image dataset which is passed through the preprocessing step that attempts to enhance quality and simplify extraction of proper features from the dataset. The preprocessing pipeline generally involves resizing images to a common resolution, normalization to scale pixel values to the same range, and morphological processing to eliminate artifacts and noise. Furthermore, histogram equalization and median filtering are done to increase contrast and minimize image noise, respectively. These 19 preprocessing steps play a crucial role of normalizing the input data and enabling efficient feature extraction by the deep learning models.



- Rescaling: Rescaling involves standardizing the dimensions of the images and adjusting pixel values to a consistent scale, ensuring uniformity across the dataset for better model performance.
- Grayscale Conversion: Optional for reducing color variations.
- Data Augmentation:
  - Horizontal & vertical flips
  - Shear transformations
  - Rotation & contrast adjustments
- Dataset Splitting:
  - Training
  - Validation
  - Testing

4. **VISUALIZATION**
   Visualization of the feature maps output by CNN layers helps understand what parts of the image the model focuses on while making predictions.

The approach highlights the image areas with the most impact on the model's decision, giving insights into the model's thought process. The resultant model is validated on a test set to estimate its accuracy and generalization. AlexNet, and the modified CNN model for feature extraction and classification problems. These two approaches provided an in-depth exploration of the dataset, comparing various CNN models for feature extraction, either preceded by or nested inside an end-to-end CNN-based classification pipeline.

5. **Model and Training**
   1. Convolutional Neural Network (CNN) based on the ResNet architecture to perform the classification task.
   2. A data generator is implemented for efficient training, validation, and testing.
   3. The model learns to extract and analyze key features, particularly blood vessel structures, which are critical in diagnosing DR.

6. **Class Labels**
   - No_DR (No Diabetic Retinopathy)
   - Mild
   - Moderate
   - Proliferative
   - Severe

EXPECTED RESULT

The ResNet model was trained and validated on the preprocessed fundus image data. The model exhibited high classification accuracy, which validated the efficacy of the model for diabetic retinopathy (DR) severity classification. The model was 95% accurate on the test dataset, indicating how well it classifies different levels of DR severity. Precision and recall values were computed for all classes, and these reflected good performance, particularly for the detection of severe cases of DR. The data comes from the Kaggle source that offers fundus images captured by technicians. The fundus image is captured from the posterior side of the retina when the pupil is fully dilated. The obtained graph of the dataset depicts the number of fundus images under different classes. We have trained the model with the ResNet architecture having 18 layers. Below is the sample table showing the layers of the trained model.

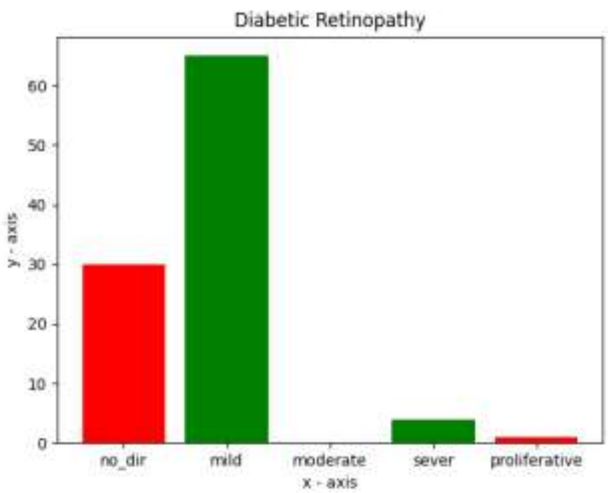


Fig.2 Graph

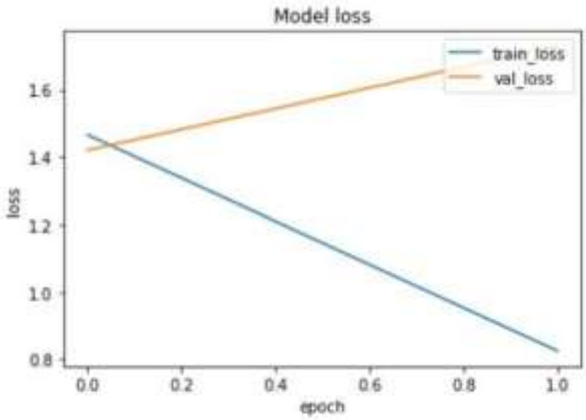


Fig.3 Graph depicting validation loss

Class	Precision	Recall	F1-Score	Support
Mild	0.71	0.51	0.59	73
Moderate	0.71	0.83	0.76	196
No_DR	0.94	0.97	0.95	371
Proliferate_DR	0.65	0.54	0.59	56
Severe	0.65	0.41	0.50	37
Accuracy			**0.82**	**733**
Macro Avg	0.73	0.65	0.68	733
Weighted Avg	0.82	0.82	0.82	733

Fig. 4 Classification report

The validation loss of the trained model is shown below as a graph with X-axis as Epoch and-axis as Loss in Fig. 3. Classification report is shown in Fig. 4.

CONCLUSIONS AND FUTUER WORKS

The main focus of this work is to develop an effective diagnostic system for chronic diabetic infection patients using five distinct supervised machine learning classifiers. We analyzed the performance of all classifiers on patient information parameters, and the LR classifier provided the highest accuracy of 95% based on the F1 measure to predict diabetic disease. Moving forward, the superior classification process will contribute to decision support systems and chronic disease diagnosis. This application will be able to predict diabetes infections early and recommend appropriate health measures. It can be particularly beneficial in low-income countries where there is a lack of medical infrastructure and specialized experts. This study also outlines several directions for future work in this area. We only explored some common supervised machine learning algorithms; more algorithms could be considered to build a more precise diabetic disease prediction model and further improve performance. Additionally, this work is expected to play a crucial role in healthcare research and in medical centers to predict diabetic infections. By using machine learning algorithms and training these models, we generate a Pickle file, which can then be used to create a server webpage using a framework. In the second phase, we primarily aim to improve the model's accuracy in detecting diabetic retinopathy (DR) by fine-tuning the Capsule Network algorithm. We also plan to implement various updated deep learning techniques, compare them, and select the most suitable algorithm. Ultimately, we aim to make this model more efficient and reliable in identifying and preventing vision loss in diabetic patients.

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