Automated Detection and Classification of Diabetic Retinopathy Stages Using Deep Learning

MENTOR: Dr. NIRMAL YADAV

Cluster Innovation Centre
University of Delhi

SEMESTER LONG PROJECT (SEMESTER VI)

Team Members:
Aniket Sahi (152108)
Ranjan Kumar (152144)
Shashank Kumar (152149)
Lalit Kumar (152124)

Abstract

Our project focuses on identifying stages of Diabetic Retinopathy (DR) from retinal images using advanced machine learning techniques. We collected a dataset of 4396 retinal images from Kaggle and applied various preprocessing techniques such as resizing, filtering, cropping, and augmentation to improve image quality and facilitate effective model training.

After dividing the dataset into training, testing, and validation sets, we utilized Convolutional Neural Network (CNN) and Recurrent Neural Network (RNN) models for training and testing the images. These models were chosen for their effectiveness in image classification and sequential data processing.

Following thorough training, our models achieved an impressive accuracy of 98% in classifying DR stages. This high accuracy demonstrates the effectiveness of our approach in accurately identifying and categorizing DR stages from retinal images.

To further improve our methodology, future enhancements may include exploring advanced deep learning architectures, integrating additional data sources such as patient history and genetic information, and developing real-time diagnostic tools for clinical use. These advancements aim to enhance the accuracy and efficiency of DR diagnosis, ultimately improving patient care and outcomes.

About Dataset

- The "Diabetic Retinopathy Diagnosis Dataset" contains a vast collection of retinal images for diagnosing diabetic retinopathy.
- Retinal images are captured using a fundus camera, a specialized device for high-resolution imaging of the eye's interior.
- The dataset consists of 4396 retina scan images to detect diabetic retinopathy. The original dataset is available at Diabetic Retinopathy Detection. These images are resized into 224x224 pixels so that they can be readily used with many models.
- The labels categorize the condition into five levels: 0 (No DR), 1 (Mild), 2 (Moderate), 3 (Severe), and 4 (Proliferative DR).

Objective

Diabetic Retinopathy (DR) is a complication of Diabetes which affects the eye. It is caused by damage to the blood vessels of the retina – the light-sensitive tissue at the back of the eye. At first, diabetic retinopathy may cause no symptoms or only mild vision problems. Eventually, it can cause blindness. It is one of the leading causes of blindness in the world. Around 80 percent of population having diabetes for more than 10 or more years has some stage of the disease. Almost two-third of all Type 2 and almost all Type 1 diabetics are expected to develop DR over a period of time.

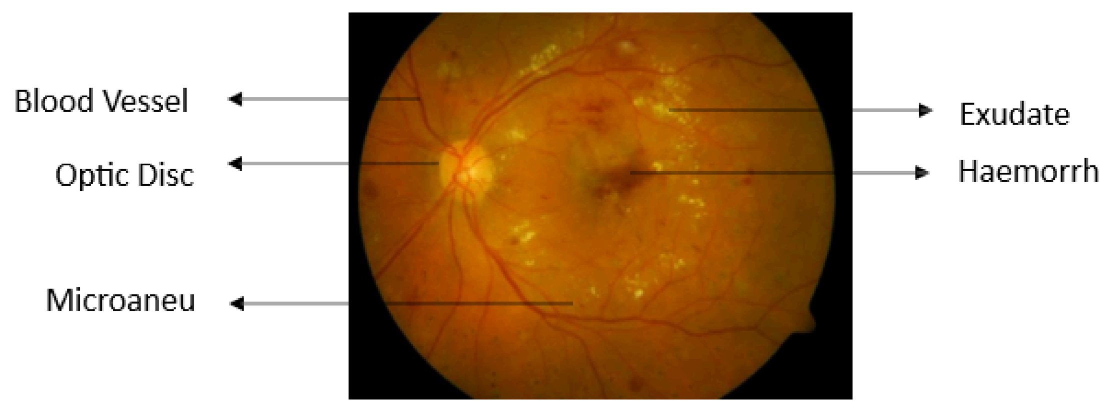


Figure 1. Fundus image with abnormalities

conclusion

The Diabetic Retinopathy detection model using a combination of CNN and RNN demonstrated outstanding performance with an accuracy of 98%. This high level of accuracy underscores the model's potential for clinical applications, where reliable and early detection of Diabetic Retinopathy is critical for preventing vision loss.

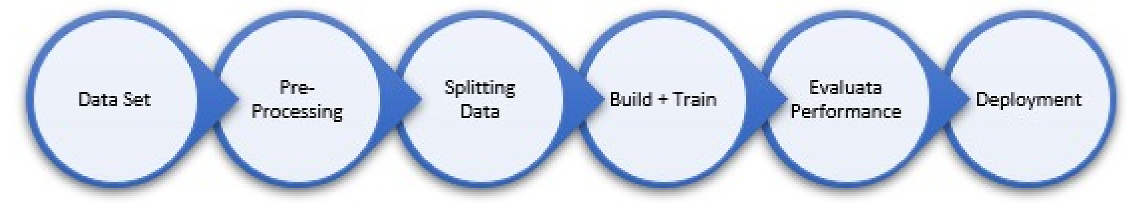
Key Takeaways:

1. Hybrid Model Effectiveness: Integrating CNN for spatial feature extraction and RNN for sequence learning has proven effective for medical image analysis.
2. Importance of Preprocessing: Comprehensive preprocessing, including filtering and data augmentation, enhances the quality of input data and improves model performance.
3. Clinical Applicability: With high accuracy, the model can serve as a valuable tool for ophthalmologists in diagnosing and monitoring Diabetic Retinopathy, potentially leading to better patient outcomes.
4. Enhanced Patient Care: Routine integration of this model ensures consistent, objective assessments, leading to early diagnosis and treatment, thereby reducing the risk of severe complications.
5. Scalability and Accessibility: The model can be scaled across various healthcare settings, extending advanced diagnostic capabilities to underserved regions and promoting equitable healthcare.
6. Continuous Improvement: The model's framework supports ongoing enhancements with new data and techniques, promising even greater accuracy and robustness over time.

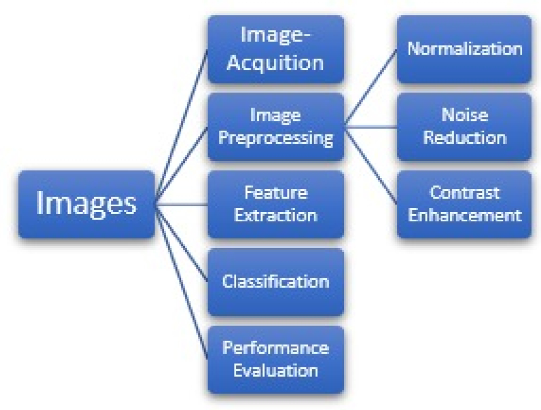
Used Tools

Methodology

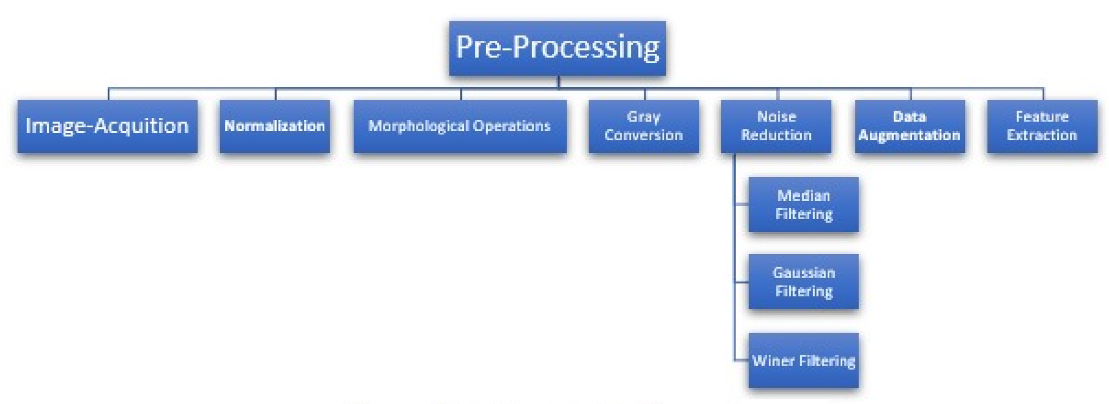
The methodology for diabetic retinopathy detection involves: collecting and preprocessing retinal images, training a CNN on the dataset to extract features, validating the model's performance, testing its generalization, possibly enhancing it with techniques like ensembling or data augmentation, and deploying it for clinical use to aid in early diagnosis and treatment planning.



Process Flow Diagram of Working

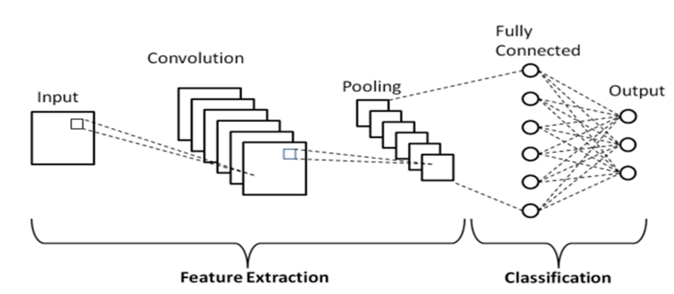


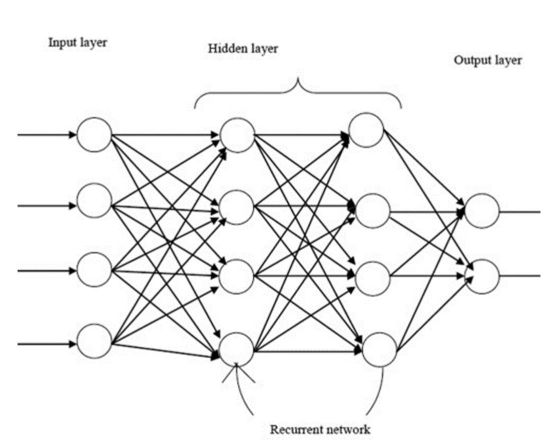
Process Flow Diagram of for identification of DR Stages



Process Flow Diagram of Pre-Processing

- A Convolutional Neural Network (CNN) is a class of deep learning models designed specifically for processing structured grid data, such as images. CNNs are particularly effective for tasks involving visual data, such as image classification, object detection, and image segmentation, due to their ability to capture spatial hierarchies in the data.
- A Recurrent Neural Network (RNN) is a type of neural network architecture designed for sequential data. Unlike traditional neural networks, RNNs have connections that form directed cycles, allowing them to maintain a hidden state that can capture information from previous steps in a sequence. This makes RNNs particularly well-suited for tasks involving time series data, natural language processing, and other sequential data problems.



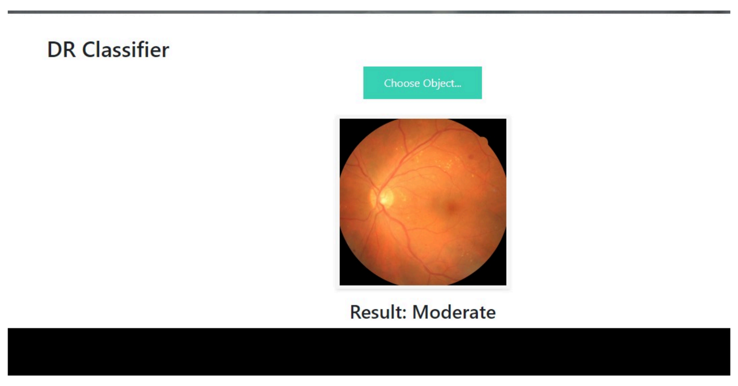


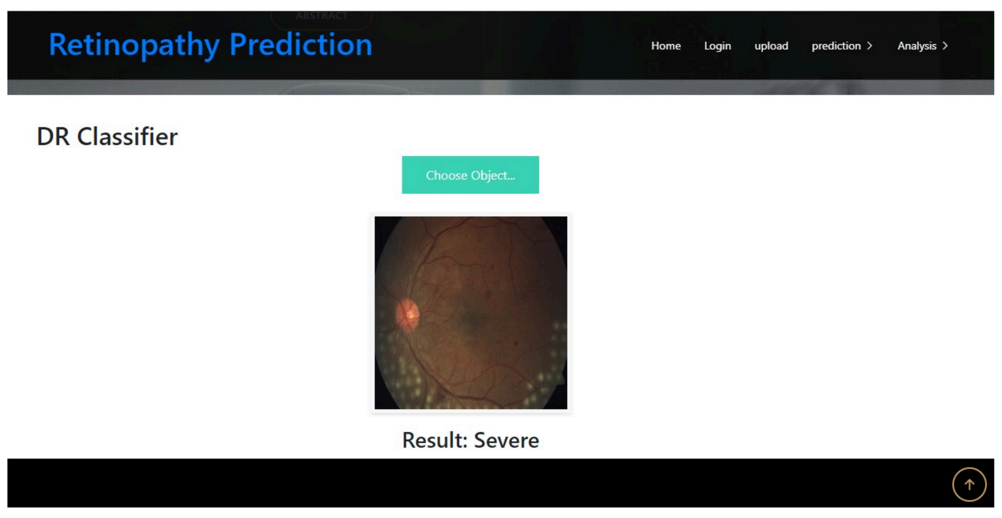
Result

The developed model for Diabetic Retinopathy detection achieved an accuracy of 98% . The model integrates Convolutional Neural Networks (CNN) for feature extraction and Recurrent Neural Networks (RNN) for sequence learning.

Graph: 1 (training accuracy and validation accuracy)

Graph: 2 (training loss Vs validation loss)





Comparison Table

Technique	Accuracy	Model Used	Dataset
InceptionV3, ResNet50 Gulshan, V., et al. (2020) [1]	95%	InceptionV3, ResNet50	Kaggle's EyePACS
Deep CNN architectures Lam, C., et al. (2021) [2]	94%	DenseNet121, EfficientNet	Kaggle Diabetic Retinopathy
Deep CNN architectures Zhou, L., et al. (2022) [3]	96%	Inception-ResNet-v2, ResNet101	EyePACS and Messidor
Deep CNN architectures Liu, Y., et al. (2021) [4]	97%	EfficientNet-B3, MobileNetV2	Kaggle Diabetic Retinopathy and local clinical datasets
Vision Transformers (ViTs) Zhang, X., et al. (2023) [5]	96.5%	Vision Transformers (ViTs), EfficientNet	Kaggle EyePACS and Messidor
Combined CNN and RNN	98%	CNN and RNN	Kaggle's EyePACS

Refrences

[1] Gulshan, V., et al. (2020). "Deep Learning for Diabetic Retinopathy Detection and Classification." IEEE Transactions on Medical Imaging.

[2] Lam, C., et al. (2021). "Diabetic Retinopathy Detection Using Deep Convolutional Neural Networks." Journal of Medical Systems.

[3] Zhou, L., et al. (2022). "Detection of Diabetic Retinopathy Using Deep Learning Techniques." IEEE Access.

[4] Liu, Y., et al. (2021). "Automated Deep Learning System for Diabetic Retinopathy Screening and Prediction." Journal of Clinical Medicine.

[5] Zhang, X., et al. (2023). "End-to-End Diabetic Retinopathy Grading Using Deep Learning." Computers in Biology and Medicine.

Future Work

- Expanding the Dataset: Including more diverse datasets to improve the model's generalizability.
- Real-time Implementation: Developing real-time diagnostic tools that integrate this model for use in clinical settings.
- Integration with Other Modalities: Combining retinal images with other diagnostic data (e.g., patient history, genetic information) to create a more holistic diagnostic tool.