DEEP LEARNING FUNDUS IMAGE ANALYSIS
FOR EARLY DETECTION OF DIABETIC RETINOPATHY

A PROJECT REPORT

Submitted in partial fulfilment of the requirements
for the award of the degree of BACHELOR OF TECHNOLOGY IN COMPUTER SCIENCE AND ENGINEERING

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Abstract:

Diabetic Retinopathy (DR) is a major cause of blindness among diabetic patients worldwide. Early detection and diagnosis of diabetic retinopathy can significantly reduce the risk of vision loss. Traditional diagnosis methods require manual examination of fundus images by ophthalmologists, which is time-consuming and expensive. To overcome these limitations, this project proposes a Deep Learning-based automated system for early detection of diabetic retinopathy using Convolutional Neural Networks (CNN). The model is trained on retinal fundus images obtained from Kaggle and implemented using Google Colab. The system uses image preprocessing, data augmentation, and CNN architecture to classify fundus images into different stages of diabetic retinopathy. The trained model is deployed using Streamlit and Ngrok to provide a real-time web application for disease prediction. This project helps in fast, accurate, and automated medical screening.

Chapter 1: Introduction

1.1 Overview:

Diabetic Retinopathy is a diabetes-related eye disease that affects the retina and may lead to permanent blindness if not detected early. The retina contains blood vessels that get damaged due to high blood sugar levels. Early detection plays a crucial role in preventing severe vision loss.

With the advancement of Artificial Intelligence and Deep Learning, medical image analysis has improved significantly. Deep learning models, especially Convolutional Neural Networks (CNN), are highly effective in detecting patterns in medical images such as retinal fundus images.

This project focuses on developing an automated deep learning system that analyzes fundus images and detects diabetic retinopathy at an early stage.

1.2 Problem Statement:

Manual detection of diabetic retinopathy through fundus image examination is:

- Time-consuming
- Expensive

- Dependent on expert doctors
- Prone to human error

There is a need for an automated system that can accurately detect diabetic retinopathy using deep learning techniques.

1.3 Objectives of the Project:

- To develop a CNN-based model for fundus image analysis
- To detect diabetic retinopathy at an early stage
- To improve medical diagnosis accuracy using deep learning
- To implement the model using Google Colab
- To deploy the model using Streamlit and Ngrok
- To create a user-friendly medical prediction system

Chapter 2: Literature Survey

Several research studies have shown that deep learning models outperform traditional machine learning methods in medical image classification. CNN models are widely used for retinal image analysis due to their ability to automatically extract image features. Previous systems used manual feature extraction techniques which were less accurate. Modern deep learning approaches use automated feature learning, which significantly improves classification performance in diabetic retinopathy detection.

Chapter 3: System Analysis:

3.1 Existing System

The existing system involves manual diagnosis of fundus images by ophthalmologists.
Disadvantages:

- Slow diagnosis process
- High medical cost
- Limited availability of specialists
- Chances of misdiagnosis

3.2 Proposed System

The proposed system uses a CNN-based deep learning model to automatically analyze retinal fundus images and detect diabetic retinopathy stages. The model provides fast and accurate predictions through a web application interface.

Advantages:

- Automatic detection
- High accuracy
- Early diagnosis support
- User-friendly interface
- Real-time prediction

Chapter 4: System Architecture

4.1 Architecture Overview

System workflow:

User Upload Image → Image Preprocessing → CNN Model → Prediction → Result Display

Main Modules:

- Data Collection
- Data Preprocessing
- Data Augmentation
- CNN Model Training
- Model Evaluation
- Streamlit Deployment
- Prediction Output

Chapter 5: Dataset Description

5.1 Dataset Source

The dataset used in this project is collected from Kaggle and contains retinal fundus images labeled according to diabetic retinopathy severity levels.

5.2 Dataset Features

- Medical fundus retinal images
- Multi-class labeled dataset
- High-resolution images
- Suitable for deep learning training
- Classes (Typical DR Levels):
- No DR

- Mild DR
- Moderate DR
- Severe DR
- Proliferative DR

Chapter 6: Data Preprocessing

6.1 Image Resizing

All fundus images are resized to a fixed dimension (224×224 pixels) to match the CNN model input requirements.

6.2 Image Normalization

Pixel values are normalized between 0 and 1 to improve model performance and training stability.

6.3 Data Cleaning

- Removal of corrupted images
- Standardization of image formats
- Filtering low-quality images

Chapter 7: Data Augmentation

7.1 Definition

Data Augmentation is a technique used to increase the size of the dataset by creating modified versions of existing images.

7.2 Techniques Used

- Rotation

- Horizontal Flip
- Zooming
- Brightness Adjustment
- Rescaling

7.3 Importance in Medical Imaging

Data augmentation helps to:

- Prevent overfitting
- Improve model generalization
- Increase dataset diversity
- Enhance model accuracy

Chapter 8: Model Building (CNN)

8.1 Convolutional Neural Network (CNN)

CNN is a deep learning model specially designed for image classification tasks. It automatically extracts features from images using convolution layers.

8.2 CNN Architecture Used

- Input Layer (224×224×3 Fundus Image)
- Convolution Layer + ReLU
- Max Pooling Layer
- Dropout Layer
- Flatten Layer
- Dense Fully Connected Layer
- Softmax Output Layer

8.3 Activation Function

ReLU (Rectified Linear Unit) is used to introduce non-linearity in the model.

8.4 Optimizer

Adam optimizer is used for faster and efficient training.

Chapter 9: Model Training (Google Colab)

The CNN model is trained using Google Colab with GPU acceleration for faster computation.

Training Parameters:

- Epochs: Multiple iterations
- Batch Size: Optimized based on memory
- Optimizer: Adam
- Loss: Categorical Crossentropy

Benefits of using Colab:

- Free GPU support
- Easy dataset integration
- Faster model training
- Cloud-based environment

Chapter 10: Model Evaluation

10.1 Evaluation Metrics

- Accuracy
- Precision
- Recall

- F1-Score
- Confusion Matrix

10.2 Performance Analysis

- The CNN model is evaluated on test dataset to measure prediction performance and classification accuracy for diabetic retinopathy detection.

Chapter 11: Application Development (Streamlit)

11.1 Streamlit Framework

Streamlit is used to build a web-based user interface for real-time prediction of diabetic retinopathy from fundus images.

11.2 Features of the Web Application

- Image Upload Option
- Image Preview
- Predict Button
- DR Stage Prediction Output
- Confidence Score Display

Chapter 12: Deployment Using Ngrok

12.1 Ngrok Integration

Ngrok is used to create a public URL for accessing the Streamlit web application from any browser.

12.2 Deployment Workflow

1. Install Streamlit and Pyngrok in Colab
2. Run Streamlit app
3. Generate public URL using Ngrok
4. Access application through browser

Advantages:

- Easy online access
- Real-time prediction
- No complex server setup

Chapter 13: Project Flow

1. User opens Streamlit web application
2. Uploads retinal fundus image
3. Image is preprocessed and resized
4. CNN model analyzes image features
5. Model predicts diabetic retinopathy stage
6. Result displayed on web interface

Chapter 14: Project Structure

```
Deep-Learning-DR-Detection/
|
├── dataset/
├── model/ (cnn_model.h5)
├── app.py (Streamlit App)
```

```
 ├── train_model.ipynb (Colab)
 ├── requirements.txt
└── images/
```

Chapter 15: Advantages of the System

- Early detection of diabetic retinopathy
- High accuracy using CNN
- Automated medical diagnosis
- User-friendly interface
- Real-time prediction
- Cost-effective healthcare solution

Chapter 16: Applications

- Hospitals and Eye Clinics
- Medical Research Centers
- Telemedicine Systems
- AI-based Healthcare Platforms
- Early Screening Programs

Chapter 17: Future Scope

- Integration with mobile applications
- Use of advanced models like ResNet or EfficientNet
- Cloud deployment for large-scale screening
- Integration with hospital databases

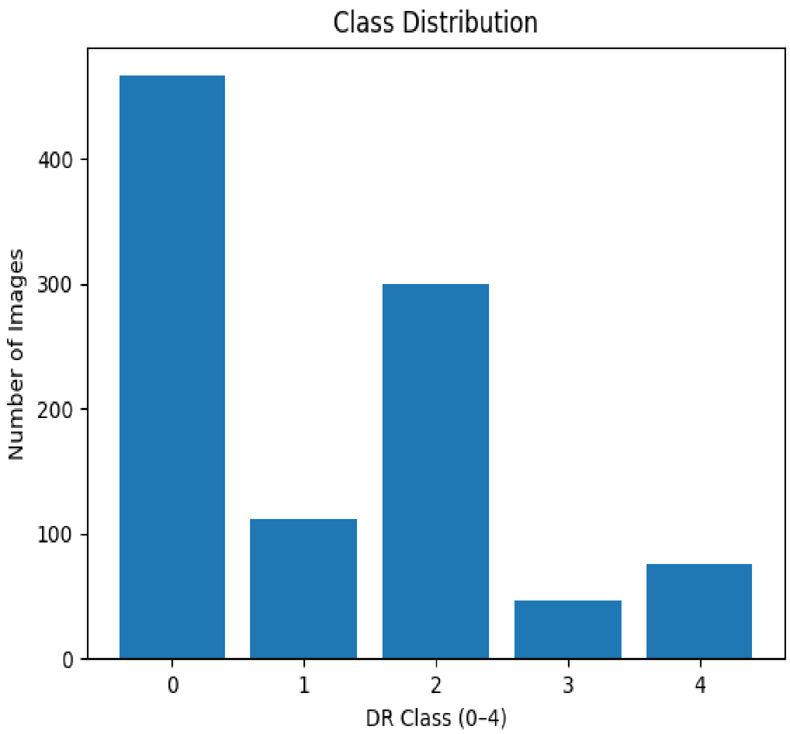
- Real-time medical decision support systems

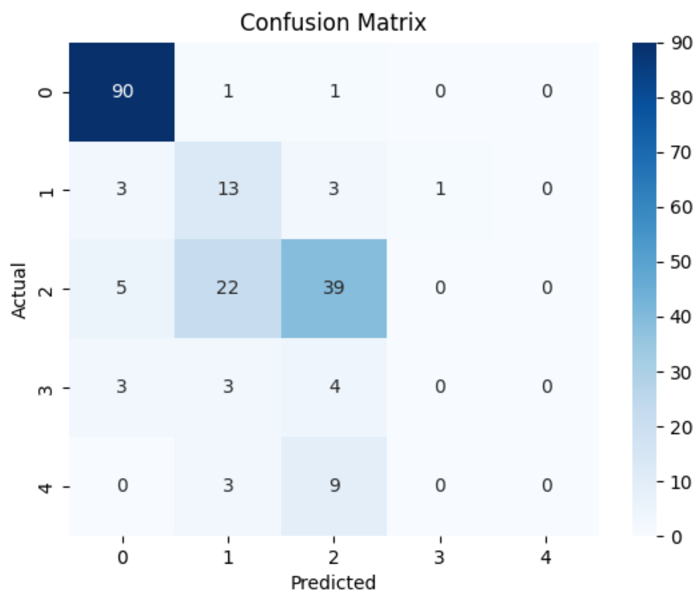
Chapter 18: Conclusion

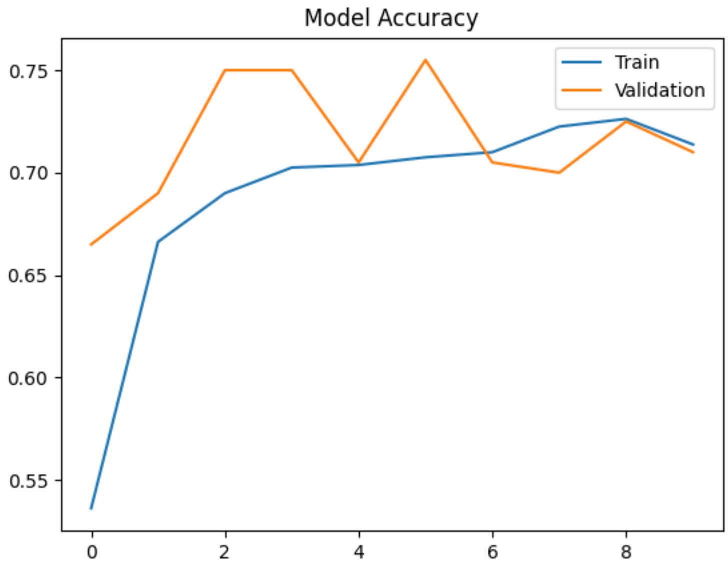
This project successfully implements a Deep Learning-based system for early detection of Diabetic Retinopathy using fundus image analysis. The CNN model trained on Kaggle dataset and implemented using Google Colab provides accurate classification of retinal images. The deployment using Streamlit and Ngrok enables real-time prediction through a user-friendly web interface. The system reduces manual diagnosis effort, improves early detection, and supports healthcare professionals in medical screening. This project demonstrates the effectiveness of deep learning in medical image analysis and its potential to prevent blindness through early diagnosis.

Chapter 19: References

1. Deep Learning for Medical Image Analysis – Research Papers
2. Kaggle Diabetic Retinopathy Dataset Documentation
3. TensorFlow and Keras Official Documentation
4. Streamlit Official Documentation
5. Medical Imaging and CNN Research Journals


Class Distribution
Number of Images
400
300
200
100
0
0
1
2
3
4
DR Class (0–4)


Confusion Matrix
Actual
Predicted
0
1
2
3
4
90 1 1 0 0
3 13 3 1 0
5 22 39 0 0
3 3 4 0 0
0 3 9 0 0
0
1
2
3
4
90
80
70
60
50
40
30
20
10
0


Model Accuracy
Train
Validation
0.75
0.70
0.65
0.60
0.55
0
2
4
6
8