Deep Learning Fundus Image Analysis for Early Detection of Diabetic Retinopathy

A GROUP PROJECT REPORT

Submitted By

1. Shafika Shakil Nadaf
2. Gauri Anil Chougale
3. Sanika Arjun Savant

College Name:

D. Y. Patil Agriculture and Technical University, Talsande

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1. Introduction

Diabetic Retinopathy (DR) is a severe eye condition caused by prolonged diabetes, leading to damage of the retinal blood vessels. It is one of the major causes of vision impairment and blindness worldwide. Early detection and timely treatment can significantly reduce the risk of vision loss. However, manual screening of fundus images by ophthalmologists is time-consuming and requires specialized expertise.

With the rapid advancement of Artificial Intelligence (AI) and Deep Learning, automated analysis of retinal images has become a promising solution. This project focuses on developing a deep learning–based system using Convolutional Neural Networks (CNNs) to analyze fundus images and detect diabetic retinopathy at an early stage. The system integrates a trained deep learning model with a Flask-based web application for easy and efficient diagnosis support.

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2. Problem Statement

Early diagnosis of diabetic retinopathy is challenging due to the lack of trained ophthalmologists, especially in rural and remote areas. Manual screening is prone to human error and is not scalable for large populations. Hence, there is a need for an automated, accurate, and efficient system to detect diabetic retinopathy from retinal fundus images.

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3. Objectives

- To develop a deep learning model for detecting diabetic retinopathy using fundus images.
- To apply transfer learning techniques using pre-trained CNN models such as Xception.
- To preprocess and augment retinal images to improve model performance.
- To integrate the trained model into a Flask-based web application.
- To store and manage user data using IBM Cloudant DB.

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4. Scope of the Project

The project focuses on early-stage detection of diabetic retinopathy using retinal fundus images. It is intended for use in hospitals, clinics, screening camps, and telemedicine platforms. The system assists healthcare professionals by providing preliminary analysis and does not replace medical experts.

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5. System Architecture

The system architecture consists of the following components: - User Interface (Web Application) - Flask Server - Deep Learning Model (Xception) - Cloudant Database

Workflow:

1. User uploads a fundus image through the web interface.
2. The Flask server receives the image and preprocesses it.
3. The trained Xception model analyzes the image.
4. Prediction results are displayed on the UI.
5. User information and results are stored in Cloudant DB.

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6. Tools and Technologies Used

- Programming Language: Python
- Deep Learning Framework: TensorFlow, Keras
- Model Architecture: Xception (Transfer Learning)
- Web Framework: Flask
- Database: IBM Cloudant
- IDE: PyCharm / Spyder
- Platform: IBM Cloud

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7. Dataset Description

The dataset consists of retinal fundus images categorized into different classes representing stages of diabetic retinopathy. The dataset is divided into training and testing folders. Images are resized to 299×299 pixels to match the input requirements of the Xception model.

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8. Data Preprocessing

Data preprocessing includes: - Image resizing - Normalization - Data augmentation using ImageDataGenerator

Augmentation techniques used: - Rotation - Zooming - Width and height shifting - Horizontal and vertical flipping - Brightness adjustment

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9. Model Building

9.1 Pre-trained Model

The Xception model pre-trained on ImageNet is used as a feature extractor. The top layers are excluded, and convolutional layers are frozen to retain learned features.

9.2 Dense Layers

Custom dense layers are added on top of the Xception model: - Flatten Layer - Fully Connected Dense Layer - Output Layer with Softmax activation

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10. Model Compilation and Training

- Optimizer: Adam
- Loss Function: Categorical Crossentropy
- Metrics: Accuracy

The model is trained for 30 epochs using fit_generator with training and validation datasets. The best model is saved based on minimum validation loss.

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11. Model Testing and Evaluation

The trained model is tested on unseen test data to evaluate its performance. Accuracy and loss metrics are analyzed to assess model reliability.

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12. Web Application Development

A Flask-based web application is developed to interact with the trained model.

Features:

- User registration and login

- Image upload functionality
- Prediction display
- Result storage in database

HTML templates and static files are used to design the user interface.

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13. Cloudant Database Integration

IBM Cloudant DB is used to store user credentials and prediction results. Secure access is established using service credentials including API key and username.

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14. Advantages of the System

- Early detection of diabetic retinopathy
- Reduces dependency on specialists
- Fast and accurate diagnosis support
- Suitable for large-scale screening
- Supports telemedicine applications

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15. Applications

- Hospitals and eye clinics
- Public health screening programs
- Telemedicine platforms
- Remote healthcare services

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16. Limitations

- Depends on image quality
- Requires internet connectivity

- Cannot replace professional diagnosis

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17. Future Enhancements

- Support for multi-disease detection
- Mobile application integration
- Improved accuracy with larger datasets
- Real-time camera integration

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18. Conclusion

This project demonstrates the effectiveness of deep learning techniques in detecting diabetic retinopathy from fundus images. By integrating the trained model with a web application, the system provides a practical solution for early diagnosis and large-scale screening, contributing to improved healthcare outcomes.

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19. References

6. TensorFlow and Keras Documentation
7. Research papers on Diabetic Retinopathy Detection
8. IBM Cloud Documentation
9. Towards Data Science Articles on CNN and Xception