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AI-BASED NON-INVASIVE DIABETIES PREDICTIO USING EYE IMAGE

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Abstract: Diabetes mellitus is a rapidly increasing chronic disease that leads to severe complications such as diabetic retinopathy, which can cause irreversible vision loss if not detected early. Traditional diagnostic methods rely on invasive blood tests and specialized ophthalmic examinations, making them costly, time-consuming, and inaccessible in rural and resource-limited areas. This paper proposes a non-invasive, AI-based system for diabetes prediction using eye images. The system utilizes computer vision techniques for eye detection and image preprocessing, followed by classification using a trained deep learning model. The model categorizes inputs into non-diabetic, diabetic without retinopathy, and diabetic retinopathy. The system is implemented as a web-based application using Flask and integrates OpenCV and Keras for image processing and machine learning inference. It supports both real-time webcam analysis and offline image upload.Additionally, an AI-powered chatbot is integrated to provide user guidance. The proposed system offers a cost- effective and accessible solution for early screening and preventive healthcare.

I. INTRODUCTION

Diabetes mellitus is one of the most prevalent chronic diseases worldwide, affecting individuals across all age groups. Persistent high blood glucose levels can lead to complications such as diabetic retinopathy, which is a major cause of vision loss. One of the major challenges associated with diabetic retinopathy is that it progresses silently in the early stages without noticeable symptoms. Traditional diagnostic methods rely on invasive blood tests and specialized ophthalmic examinations that require clinical infrastructure and trained professionals. These methods are often expensive and not easily accessible, particularly in rural and remote areas.

To address these limitations, this research proposes a non- invasive system that predicts diabetic conditions using eye images. By leveraging computer vision and deep learning techniques, the system provides a user-friendly and accessible solution for early detection and screening.

I. RESEARCH METHODOLOGY

a) Module Description

1. Authentication Module

The authentication module manages secure user access to the system. It allows users to register, login using OTP verification, and logout securely. User details, OTP records, and session information are stored in MongoDB. This module ensures privacy and secure access to the diabetic screening platform.

2. Image Acquisition Module

The image acquisition module is responsible for collecting retinal or eye images for analysis. Users can either upload eye images from their device or use a live webcam for real-time scanning. OpenCV is used for capturing images and video frames from the webcam.

3. Eye Detection and Preprocessing Module

This module detects the face and extracts the eye region using Haar Cascade classifiers. After detection, preprocessing operations such as resizing, grayscale conversion, normalization, and image enhancement are performed. These steps improve image quality and prepare standardized input for the prediction model.

4. Machine Learning Prediction Module

The machine learning module is the core component of the system. A trained Keras deep learning model analyzes the processed eye image and predicts the diabetic condition. The model classifies the image into three categories:

Non-Diabetic

Diabetic without Retinopathy Diabetic Retinopathy

The prediction result is displayed on the user dashboard.

5. Live Webcam Scanning Module

This module supports real-time diabetic eye screening using webcam video streaming. OpenCV continuously captures frames, detects the eye region, preprocesses the image, and sends it to the prediction model for live analysis. The prediction results are displayed instantly on the video stream.

6. Chatbot Assistance Module

The chatbot module provides AI-powered diabetic eye-care guidance and user support. It is integrated using OpenRouter API with AI models such as Mistral, Gemma, and LLaMA. Users can ask questions related to diabetes, precautions, symptoms, and eye care.

7. Report Generation Module

This module generates medical reports in PDF format using ReportLab. The reports contain patient details, prediction results, and analysis information. Users can download reports or send them through email using Gmail SMTP services.

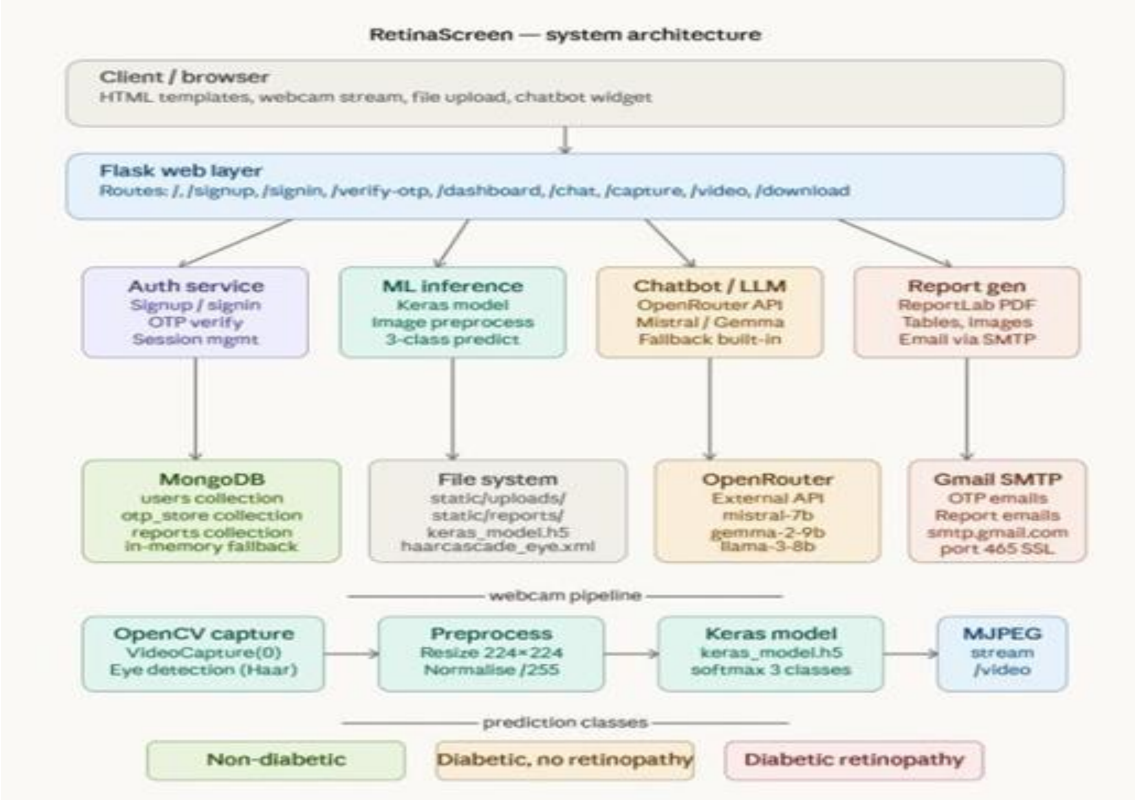
8. Database Management Module

The database module uses MongoDB to store user details, OTP records, prediction reports, and scan history. It helps in maintaining secure and organized records for future reference and monitoring.

9. Web Interface Module

The web interface module provides interaction between users and the system. It is developed using HTML, CSS, Bootstrap, and JavaScript. This module allows users to upload images, access webcam scanning, view prediction results, interact with the chatbot, and manage reports through a responsive interface.

b) System Architecture:



The System Architecture Diagram represents the overall structure and working flow of the RetinaScreen system. It shows how different modules are connected to perform diabetic eye prediction and user interaction.

The client layer provides the web interface for users to upload images, access webcam scanning, and interact with the chatbot. The Flask backend acts as the central controller and manages communication between all modules.

The authentication module handles secure login and OTP verification. The image processing and machine learning modules analyze retinal images using OpenCV and a trained Keras deep learning model to predict diabetic conditions. The chatbot module provides AI-powered medical guidance using OpenRouter API.

MongoDB is used for storing user details, reports, and scan history, while the report generation module creates PDF reports and supports email sharing. Overall, the architecture integrates computer vision, deep learning, database management, and web technologies to provide a complete non-invasive diabetic eye screening system.

b) *Algorithm Description with Justification :*

The proposed system follows a sequence of processing steps to perform non-invasive diabetic eye prediction using retinal and eye images. The algorithm begins when the user accesses the web application and selects a suitable module such as retinal image upload, live webcam scanning, or chatbot interaction. Providing multiple input methods improves system flexibility and allows users to perform both real-time and offline analysis conveniently.

After selecting the module, the system acquires the eye image either through webcam capture or image upload. The webcam remains inactive initially and is enabled only when the user starts live scanning. This approach reduces unnecessary resource usage and provides better user control over camera access.

Once the image is obtained, OpenCV and Haar Cascade classifiers are used to detect the face and extract the eye region from the image. Detecting only the required eye area minimizes background noise and improves processing efficiency and prediction accuracy.

The extracted eye image then undergoes preprocessing operations such as resizing, normalization, grayscale conversion, and image enhancement. These preprocessing techniques standardize the image format and improve visual quality, ensuring consistent input for the deep learning model.

After preprocessing, the processed image is provided to the trained Keras deep learning model. The model analyzes important visual features present in the eye image and predicts the diabetic condition. Based on the analysis, the system classifies the result into categories such as Non-Diabetic, Diabetic without Retinopathy, and Diabetic Retinopathy. Using deep learning improves prediction accuracy and enables efficient automated screening.

The prediction results are displayed instantly on the web interface, allowing users to obtain quick feedback about their diabetic eye condition. For real-time webcam scanning, the system continuously captures video frames, preprocesses them, and performs live prediction using the same workflow.

To improve user awareness and interaction, the system integrates an AI-powered chatbot using OpenRouter API. The chatbot provides diabetic eye-care guidance, precautions, and answers general user queries related to diabetes and eye health.

Finally, the system generates PDF reports containing patient details and prediction results. These reports can be downloaded or shared through email. User information, reports, and scan history are stored securely in MongoDB for future reference and monitoring.

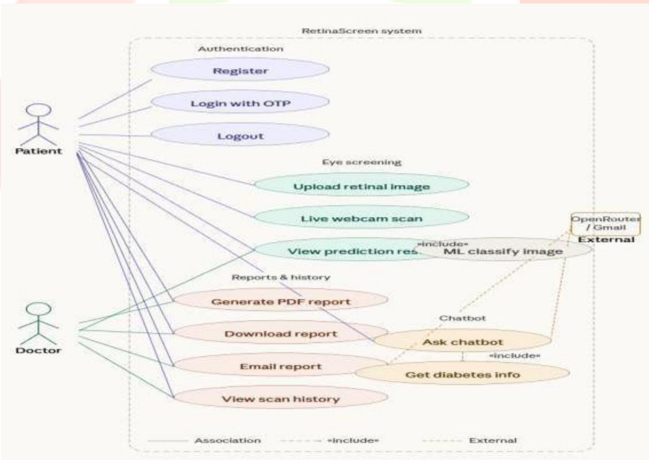
Overall, the algorithm combines image processing, deep learning, real-time analysis, and AI-based guidance to provide an efficient, user-friendly, and cost-effective diabetic eye screening system.

c) *System Requirements:*

HARDWARE:
Laptop/Desktop System
Intel i3 / Ryzen 3 or higher processor Minimum 8 GB RAM Webcam (Built-in or External) Internet Connection Minimum 256 GB Storage

SOFTWARE:
Windows / Linux / macOS Python 3.x Flask Framework
HTML, CSS, Bootstrap, JavaScript OpenCV TensorFlow / Keras MongoDB
NumPy and Pandas ReportLab VS Code / PyCharm
Google Chrome / Microsoft Edge / Firefox OpenRouter API Gmail SMTP
Haar Cascade XML Classifier

d) *Use case diagram :*



The Use Case Diagram represents the interaction between users and the RetinaScreen system. The main actors are the Patient,

Doctor, and External Services. The patient can register, login using OTP verification, upload retinal images, perform live webcam scanning, view prediction results, generate reports, download reports, and access scan history. The doctor can view and manage patient reports. External services such as Gmail SMTP and OpenRouter API are used for email services and chatbot communication. The diagram mainly describes the functionalities related to authentication, diabetic eye screening,remanagement, and AI-powered chatbot assistance.

IV. RESULTS AND DISCUSSION

A. Development Environment

The system is developed using Python as the core programming language. Flask is used as the backend framework to handle routing, API communication, and integration of different modules.

B. Frontend Implementation

The frontend is developed using HTML, CSS, Bootstrap, and JavaScript. It provides a user-friendly interface for registration, image upload, webcam capture, result visualization, and chatbot interaction.

C. Backend Implementation

The backend handles request processing, image handling, prediction, database communication, and report generation. Flask routes are defined for different functionalities such as login, prediction, and report download.

D. Image Processing Implementation

OpenCV is used for capturing images, detecting faces and eyes, and preprocessing images. Haar Cascade classifiers are used for accurate eye detection.

E. Machine Learning Implementation

A trained Keras model is used for classification. The model processes preprocessed images and outputs prediction results using softmax classification.

F. Database Implementation

MongoDB is used to store user data, OTP verification details, and report metadata. It ensures efficient data management and retrieval.

G. Chatbot Implementation

The chatbot is implemented using OpenRouter API and integrates models such as Mistral and LLaMA. It provides real-time responses to user queries.

H. Report Generation Implementation

PDF reports are generated using ReportLab and sent via email using SMTP protocol.

A. *Real-Time Video Implementation*

OpenCV captures video frames and processes them continuously. Predictions are displayed in real time using MJPEG streaming.

II. ACKNOWLEDGMENT

III. The project AI-Based Non-Invasive Diabetes Prediction Using Eye Image provides a simple, cost-effective, and user-friendly solution for preliminary diabetic eye screening. The system uses Artificial Intelligence, image processing, and deep learning techniques to analyze retinal and eye images without invasive medical procedures.

IV. By integrating webcam-based scanning, image upload, real-time prediction, and AI-powered chatbot assistance, the system improves accessibility and user awareness regarding diabetic eye conditions. The use of deep learning models helps in detecting diabetic risk efficiently and supports early diagnosis and preventive healthcare.

V. Overall, the proposed system can assist in early diabetic eye screening, especially in remote and resource-limited areas, and encourages users to seek timely medical consultation for better eye health management.

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