Glaucoma Prediction Using Machine Learning

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ABSTRACT

Glaucoma is a progressive and chronic eye disease that causes damage to the optic nerve, which may result in irreversible blindness if diagnosed and treated too late. Conventional diagnostic procedures need specialized hardware and clinical knowledge, which are not always available in all areas. To overcome this, we introduce an automated glaucoma detection system using deep learning, which can process retinal fundus photographs and categorize them as normal and stages of glaucoma advanced with high accuracy. The system leverages the use of Convolutional Neural Networks (CNNs), optimized
for visual pattern classification tasks, to extract and analyze glaucoma-related features such as optic disc cupping and thinning of the nerve fibers. Before images are classified, they go through preprocessing procedures such as resizing, pixel normalization, and contrast enhancement to enhance model performance. The trained model gives classification probabilities, which are displayed as bar charts for improved interpretability. The solution is incorporated within a web-based platform developed with IJIUStreamlit, offering a user-friendly interface for image upload, result viewing, and medical recommendations.
An AI-driven chatbot also helps users interpret the results, promotes regular checkups, and advises them to get immediate attention when needed. The system supports remote screening, making it highly applicable in rural and underserved healthcare settings.
Experimental evaluation demonstrates the model's strong performance, outperforming several baseline techniques and achieving reliable classification even with noisy or lower quality images. By combining deep learning, intuitive UI, and intelligent assistance, the system enhances early detection capabilities and supports clinical workflows for ophthalmologists and general healthcare providers.

Keyword: - *Glaucoma, Optic nerve, Retinal fundus images, Blindness, Ophthalmology, Machine Learning, Deep Learning, MobileNetV2, Google Colab, Softmax, python, Screening, Data bias.*

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1. INTRODUCTION

This project employs a MobileNetV2 deep learning-based model to identify glaucoma from retinal images.Deployed on Gradio, it provides an easy-to-use, real-time screening tool to support early diagnosis, particularly in resource-limited areas.

1.1 PROBLEM STARMENT

Glaucoma is a major cause of irreversible blindness, frequently unknown until advanced cases. Conventional diagnosis involves expensive, sophisticated equipment. This project employs deep learning with convolutional neural networks for the examination of retinal scans to detect early glaucoma. Implemented through a web portal, it allows rapid, low-cost, and accurate screening in real time.

1.2 Aim and Objective

The main objective of this project is to create a dependable, precise, and accessible glaucoma detection system through deep learning. The system is proposed to be a supplementary diagnostic tool that supports ophthalmologists and healthcare workers by streamlining the screening process. Moreover, it has been made deployable as a web application so that its use is not limited to conventional hospital systems but can be distributed to remote clinics and mobile health camps.
To achieve this objective, the following specific objectives were set and attained:
Dataset Acquisition and Preprocessing: The project employs the Eagle dataset, a highly annotated set of retinal fundus images classified as glaucomatous or healthy. Images are preprocessed through resizing, normalization, and augmentation to improve model performance and generalization.

Model Development: A classification model based on the MobileNetV2 architecture is trained for deep learning. MobileNetV2 was chosen because of its computational efficiency and image-based task performance at a high level, particularly for resource-constrained deployments.
Performance Measurement: The model's performance is measured by applying common classification metrics like accuracy, precision, recall, F1-score, and the Area Under the Receiver Operating Characteristic curve (AUC-ROC). These measurements give an overall overview of the model's capability to identify glaucoma from retinal images.
Deployment: The final model is deployed as a web interface through Gradio, with the capability of users uploading retinal images and getting real-time diagnostic feedback. The interface is made accessible and user-friendly for both clinical and non-clinical users.
Through these aims, the project provides a scalable and deployable AI solution to detect glaucoma, and it meaningfully contributes to the domain of ophthalmic diagnostics and public health technology.

2. User Interface

The user interface of the glaucoma detection system is intuitive and user-friendly, making it easy to interact with for both clinical and non-clinical users. The following are the main features and elements of the user interface:

- **Web-Based Platform:** The system is hosted as a web application on Gradio, enabling users to access it from any internet-enabled device.
- **Image Upload Functionality:** Images of retinal fundus can be uploaded by the users using an easy drag-and-drop interface. JPEG and PNG are the supported image formats.
- **Automated Image Preprocessing:** As soon as an image is uploaded, the system preprocesses the image automatically, such as resizing and normalization, to get it ready for analysis.
- **Real-Time Predictions:** After processing, the deep learning model examines the image and makes real-time predictions about the presence of glaucoma.
- **Output Display:** The output is presented in an easily readable form, with the classification label (e.g., "Glaucoma Detected" or "Healthy") and a confidence score showing the model's confidence in the prediction.
- **Visualizations:** Bar charts of confidence are produced to graphically present the probabilities of the prediction per class, to further aid in interpretability to the user.
- **Clinical Suggestions:** Actionable clinical recommendations are generated by the system based on the prediction, including recommending follow-up check-ups or recommending immediate medical treatment if glaucoma is identified.

3. METHODOLOGY

The project uses a systematic deep learning method for glaucoma identification from retinal images. It maintains accuracy, scalability, and usability by adhering to primary AI development best practices.

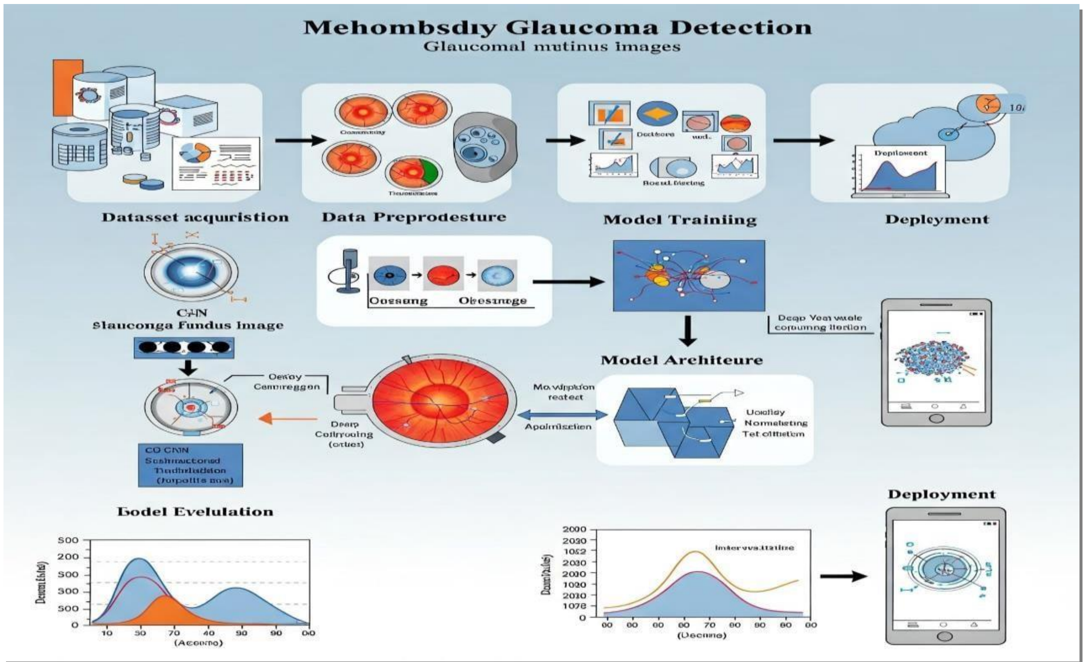

Fig - 1 Glaucoma prediction Methodology

i. Data Acquisition and Preprocessing

- Utilized the Eagle Dataset of labeled retinal fundus images (healthy vs glaucomatous).
- Maintained ethical adherence and anonymization of data for privacy purposes.
- Scaled images to 224×224 pixels and normalized pixel values.
- Used data augmentation (rotation, zoom, flipping, brightness) to enhance generalization and avoid overfitting.

ii. Model Architecture

- Used MobileNetV2 due to its efficiency and low resource demand.
- Applied transfer learning using pretrained ImageNet weights.
- Tailored final layers for binary classification with Softmax.

iii. Model Training

- Trained on Google Colab using TensorFlow/Keras.
- Applied batch size of 32 for 50 epochs with Adam optimizer.
- Applied early stopping and model checkpointing to avoid overfitting.

iv. Model Evaluation

- Evaluated with accuracy, precision, recall, F1-score, AUC-ROC.
- Applied a confusion matrix and independent test set for real-world validation.

v. Deployment

- Deployed through Gradio for real-time image uploading and prediction.
- Returns class label and confidence score.
- Optimal for telemedicine and resource-poor healthcare environments.

4. PROPOSED SYSTEM

The glaucoma prediction system is designed to leverage machine learning for automated detection of glaucoma through retinal image analysis. The architecture is modular and scalable, enabling easy integration of updated models or additional diagnostic features. This unified web-based platform ensures accessible, real-time screening and supports early intervention in glaucoma care.

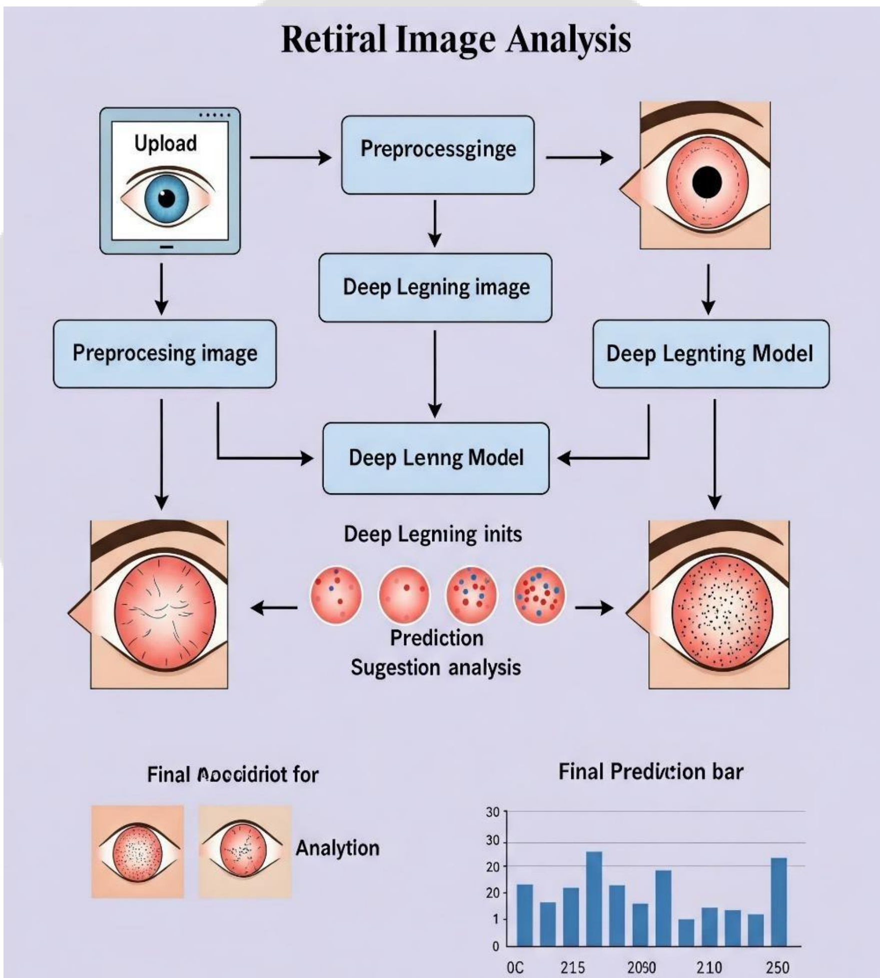

Fig-2 : Glaucoma Flowchart

4.1 System Architecture Overview

The architecture of the glaucoma prediction system is modular and scalable, as shown in Figure 4.1. The platform is accessed by users who upload retinal fundus images for processing.

The system employs a deep learning model in the form of MobileNetV2 that analyzes the uploaded image to make a prediction of glaucoma presence or absence.

Preprocessing of the image and classification are done in real-time, supporting rapid and reliable diagnostic feedback.

5. CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

The "Glaucoma Prediction Using Machine Learning" project effectively proves the creation of an automated, precise, and accessible early glaucoma diagnosis system. Employing the MobileNetV2 deep learning model and the Eagle retinal image dataset, the system accurately classifies images as healthy or glaucomatous with high precision, supported by efficient preprocessing and augmentation. Training on Google Colab with GPU access and deployment through a Gradio web interface provides real-world practicality and instant predictions, making the tool ideal for actual healthcare applications.

In the future, the platform has promising prospects for growth. Future prospects can involve detection of other eye conditions such as diabetic retinopathy and cataracts, measurement of glaucoma over time, and incorporation of telemedicine capabilities for remote consultations. Mobile app versions might provide portable, on-the-go eye health screening. Symptom-based prediction could be improved using Natural Language Processing (NLP), and strong data privacy measures would protect patient information. Collectively, these developments might convert the system into a comprehensive, scalable eye care solution.

6. REFERENCES

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