Eye Disease Detection and Classification (ROP): EyeCare

Prof. Savita B. Ghatte[1], Mr. Gaurang Sonawane[2], Mr. Rohit Shinde[3]

[1]Assistant Professor, Department of Computer Engineering, Zeal College of Engineering and Research , Narhe, Pune -411041, Maharashtra, India

[23]BE Final Year, Department of Computer Engineering, Zeal College of Engineering and Research , Narhe, Pune - 411041, Maharashtra, India

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Abstract— *Eye diseases such as Retinopathy of Prematurity (ROP), glaucoma, diabetic retinopathy, and cataracts are major causes of vision impairment. Early and accurate detection is essential to prevent permanent blindness, yet manual screening is slow and depends on specialist availability. EyeCare is an AI-powered diagnostic system that automates the detection and classification of eye diseases from retinal (fundus) images. It uses a VGG19-based CNN model for multi-scale feature extraction and disease staging. The system integrates ReactJS (frontend), Python with OpenCV (backend), and a secure database, ensuring a smooth, scalable, and user-friendly experience. Experimental evaluation shows high accuracy and reliability, making EyeCare suitable for clinical diagnosis and mass screening programs.*

Key Words: *Eye disease detection, Retinopathy of Prematurity, VGG19, CNN, Fundus Imaging, Deep Learning, Computer Vision.*

1. INTRODUCTION

Eye diseases like ROP, diabetic retinopathy, glaucoma, and cataracts are major global causes of vision loss. Retinopathy of Prematurity (ROP) particularly threatens premature infants, where early detection is vital to prevent blindness. Traditional diagnosis depends on specialists and costly equipment, making it difficult in rural or low-resource areas. EyeCare addresses this challenge using AI and deep learning to automate eye disease detection. The system uses VGG19 with transfer learning to extract deep retinal features and classify disease types and stages, including ROP. Combining computer vision, machine learning, and secure medical data management, EyeCare assists doctors, minimizes manual workload, and makes eye disease diagnosis more accurate, faster, and widely accessible.

2. PROBLEM STATEMENT

Retinopathy of Prematurity (ROP) is a major cause of preventable blindness in premature infants, where early detection is crucial. Current diagnosis relies on manual examination of retinal images by ophthalmologists, making it slow, subjective, and difficult to access in rural areas with few specialists. To overcome these challenges, this project proposes an automated AI-based diagnostic system using VGG19 and CNN architectures to accurately analyze retinal images and classify ROP into different severity stages. The system also includes patient record management and automated reporting, supporting doctors in faster and more consistent decision-making. This approach reduces screening time, lowers workload, and enables scalable, accessible, and reliable eye care in both urban and rural healthcare settings.

3. RELATED WORK

Recent studies in automated eye disease detection have leveraged deep learning, image processing, and medical imaging to enhance diagnostic precision and scalability.

Patel et al. [1] used CNNs for diabetic retinopathy detection with 92% accuracy but lacked coverage of other retinal diseases like ROP.

Brown et al. [2] developed an ROP screening model that detected plus disease effectively but suffered from limited datasets.

Fu et al. [3] applied U-Net for vessel segmentation, improving interpretability but requiring manual annotations.

Das et al. [4] utilized transfer learning (VGG, ResNet) for early ROP detection, though overfitting hindered deployment.

Wang et al. [5] proposed a CNN-LSTM hybrid capturing spatial features but with high computational cost.

Holzinger et al. [6] focused on explainable AI through attention maps, improving trust but not addressing ROP specifically.

Ting et al. [7] created a multi-disease detection framework for glaucoma and diabetic retinopathy, excluding ROP.

Li et al. [8] explored multi-disease transfer learning, achieving generalization but limited accuracy in early-stage ROP due to data imbalance.

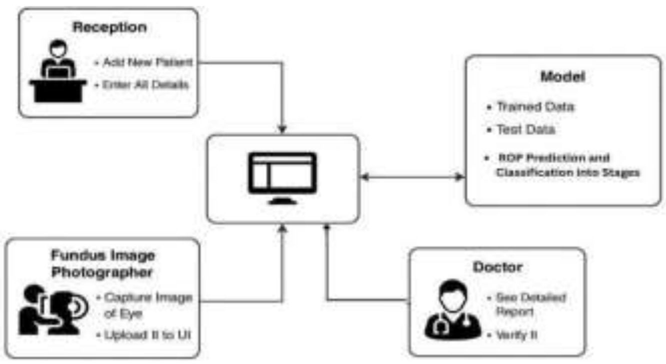

Chart -1: System Architecture

A. User Registration (EyeCare)

1. Actors:

- Receptionist: Registers new patients.
- Administrator: Manages staff and oversees registration operations.
- System: Includes the database (MongoDB) and backend API (Flask).

2. Process Description:

The Receptionist or Administrator accesses the EyeCare Web Application developed using React.js and Tailwind CSS.
They navigate to the Patient Registration Form to enter new patient details.

3. Registration Form Details:

The form captures the following patient information:

- Patient ID – Automatically generated by the system.
- First Name, Last Name
- Date of Birth (DOB) / Age – Mandatory; must not be a future date.
- Gender
- Guardian Name – Required for infants or neonatal patients.
- Contact Number, Email Address (optional; validated format).
- Address
- NICU/Ward Details (if applicable)
- Admission or Visit Date
- Medical History / Notes
- Consent Checkbox – Must be checked before submission.

4. System Validations:

Before saving, the system performs the following checks:

- Mandatory Field Check: Ensures that required fields (First Name, DOB/Age, Contact or Guardian, and Consent) are filled.
- Phone Number Validation: Verifies correct format (e.g., 10-digit number).
- Duplicate Detection: Checks existing records using a combination of Name, DOB, and Contact Number to prevent duplication.

5. Data Submission to Backend (API Call):

If all validations pass, the frontend sends the form data to the backend using:
POST /api/patients

- The Flask API processes the request and creates a new patient record in the database.
- The API returns a system-generated Patient ID as confirmation.

6. Database Storage:

The validated data is securely stored in the MongoDB collection named patients, containing fields such as:

- patient_id
- first_name, last_name
- dob, gender
- guardian_name
- contact, email, address
- admission_date
- medical_history
- consent_flag
- created_at, updated_at

7. System Confirmation:

After successful registration, the user (Receptionist/Admin) receives a confirmation message:

☑ “Patient Registration Successful.”

8. Acceptance Criteria:

- The patient’s record must be retrievable using the Patient ID.
- Registration must not proceed without consent.
- Duplicate entries trigger a warning message, but authorized users may override if necessary.

A. Algorithm (EyeCare – Disease Detection)

Input: Fundus image of the patient's eye
Output: Eye disease classification + Secure patient record storage

Step 1: Image Capture / Upload

- The Fundus Photographer captures or uploads the patient's fundus (retina) image through the web application.
- The image is linked to the patient's unique Patient ID stored in the database.

Step 2: Image Preprocessing

- Resize the image to 224 × 224 pixels.
- Normalize pixel values to standard scale.
- Apply contrast enhancement to highlight retinal details.
- Perform noise removal using filters to improve clarity and accuracy.

Step 3: Feature Extraction (VGG19 Model)

- The preprocessed image is passed through the pre-trained VGG19 model.
- Extract high-level and multi-scale image features from convolutional layers.
- These features represent critical visual patterns for disease detection.

Step 4: Patient Verification (Database-Based)

- Retrieve the patient's record from the MongoDB database using the Patient ID.
- Verify patient details such as name, DOB, and registration consent before analysis.
- If the patient record does not exist → system prompts "Please complete registration."

Step 5: Disease Classification (CNN Head on VGG19)

- The extracted image features are passed to a fine-tuned CNN classifier.
- The model predicts the disease stage as one of the following categories:
    - Normal
    - Mild Retinopathy
    - Moderate Retinopathy
    - Severe Retinopathy
- The output includes both disease stage and confidence score (0–1).

Step 6: Doctor Review and Decision

- The doctor reviews:
    - Original fundus image
    - AI-generated result (stage + confidence)
    - Grad-CAM heatmap for model explainability
- The doctor can:
    - Accept AI diagnosis
    - Modify the diagnosis
    - Request image recapture
- The doctor finalizes and signs the report digitally.

Step 7: System Logging and Storage

- All results and actions are stored securely in MongoDB with fields like:
    - Image ID, Patient ID, Model version, Confidence score, Doctor remarks, Timestamp
- The system also logs failed uploads, login attempts, and report generations for traceability.

Step 8: Clinical Safety & Model Improvement

- If confidence < threshold, the case is flagged for mandatory doctor review.
- Periodic model retraining is performed with newly labeled data to enhance accuracy.
- All audit and inference logs are preserved for accountability and compliance.

4. CONCLUSION

The proposed EyeCare system provides a secure, AI-driven approach to eye disease detection using fundus images. By integrating a VGG19 + CNN model with a robust Flask–MongoDB backend, the system ensures accurate disease classification, reliable data management, and safe clinical decision support.

Unlike decentralized blockchain models, this solution uses encrypted database storage and role-based access control to maintain patient privacy and integrity.

The platform supports doctors and ophthalmologists in early disease diagnosis, digital report generation, and efficient record management — making it ideal for hospitals, clinics, and telemedicine.

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