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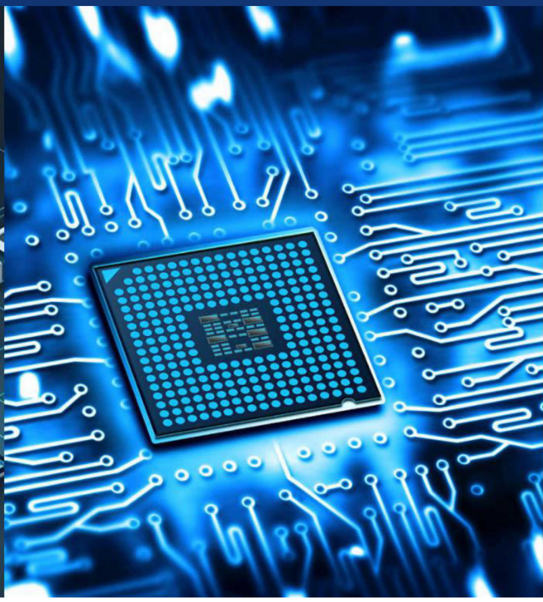

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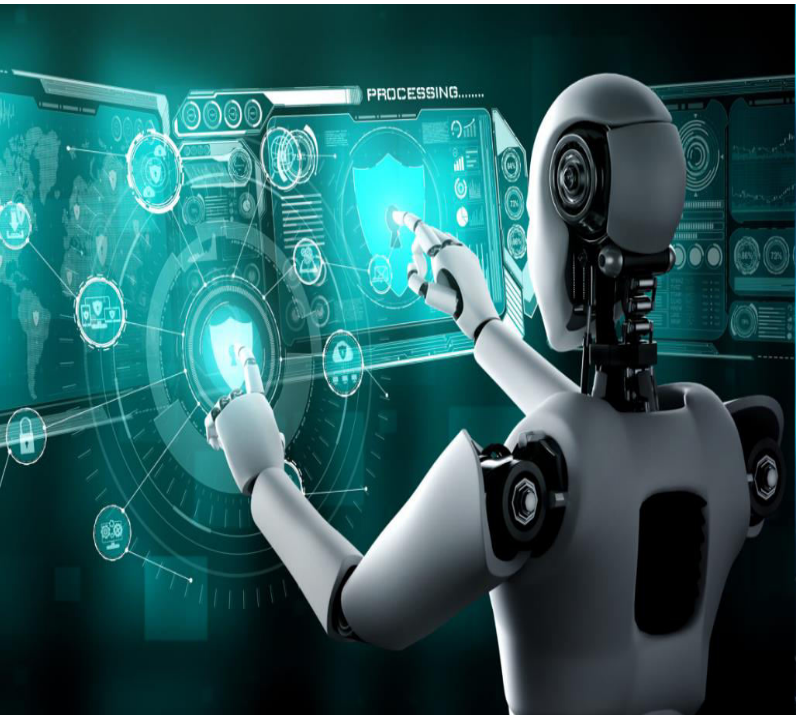


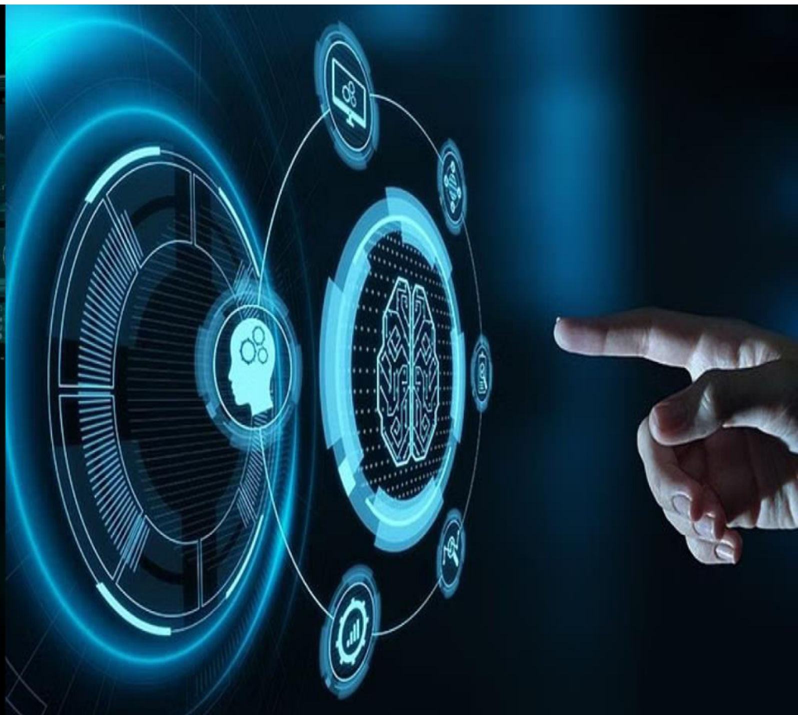

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# Compact and Accurate: Densenet121 for Automated Classification of Crossed and Normal Eyes

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**ABSTRACT:** The early detection of eye disorders such as crossed eyes (strabismus) is essential for timely treatment and prevention of vision impairment. This paper presents an automated system for the classification of crossed eyes and normal eyes using deep learning techniques. A convolutional neural network (CNN), specifically DenseNet121, is employed to extract meaningful features from eye images and perform accurate classification. The proposed model is trained on a labeled dataset consisting of normal and crossed eye images, achieving high accuracy and reliability. Image preprocessing techniques such as resizing, normalization, and augmentation are applied to improve model performance. The results demonstrate that the system can effectively distinguish between crossed and normal eyes, making it suitable for real-time screening applications. This approach can assist healthcare professionals by providing a fast, cost-effective, and non-invasive diagnostic tool, especially in rural and low-resource settings. Automatic eye condition classification plays a crucial role in early diagnosis of vision disorders such as strabismus (crossed eyes). This paper presents a deep learning-based approach using DenseNet121 for automated classification of crossed and normal eyes. DenseNet121, a densely connected convolutional neural network, enhances feature propagation and reduces the vanishing gradient problem by connecting each layer to every other layer. The proposed system utilizes image preprocessing, data augmentation, and transfer learning to improve model performance on limited datasets. The model is trained on labelled eye images and evaluated using metrics such as accuracy, precision, recall, and F1-score. Experimental results demonstrate that the proposed DenseNet121-based model achieves high classification accuracy while maintaining computational efficiency. The compact architecture with fewer parameters makes it suitable for real-time medical applications. This work highlights the effectiveness of DenseNet121 in ophthalmological image classification and provides a reliable solution for automated eye condition screening.

**KEYWORDS**: Crossed Eye, Strabismus, DenseNet121, Deep Learning, Convolutional Neural Network (CNN), Eye Image Classification, Medical Image Analysis, Transfer Learning, Image Preprocessing, Data Augmentation,

## I. INTRODUCTION

Vision disorders such as crossed eyes (strabismus) affect millions of people worldwide and can lead to severe complications if not diagnosed early. Traditional diagnosis methods rely on manual examination by specialists, which can be time-consuming and subjective. Recent advancements in deep learning, particularly convolutional neural networks (CNNs), have enabled automated medical image analysis with high accuracy. DenseNet121 is one such architecture known for efficient feature reuse and reduced parameters compared to traditional CNNs. This paper proposes an automated system for classifying crossed and normal eyes using DenseNet121, aiming to improve diagnostic efficiency and accuracy.

The motivation and significance of using machine learning (ML) for pulmonary cancer detection stem from the critical need to improve early-stage diagnosis, which is the most decisive factor in patient survival. Eye disorders are among the most common health issues affecting people worldwide, and early detection plays a vital role in preventing long-term vision problems. One such condition is crossed eye, also known as strabismus, where the eyes do not align properly and point in different directions.

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If not diagnosed and treated at an early stage, it can lead to serious complications such as amblyopia (lazy eye) and permanent vision loss. Traditionally, the detection of crossed eyes requires examination by skilled ophthalmologists, which may not always be accessible, especially in rural or low-resource areas. Manual diagnosis can also be time-consuming and subject to human error. With advancements in technology, artificial intelligence and deep learning have emerged as powerful tools in the field of medical image analysis. This project focuses on developing an automated.

## II. LITERATURE REVIEW

Recent advancements in deep learning have significantly improved medical image classification, especially in the field of ophthalmology. Convolutional Neural Networks (CNNs) such as VGG, ResNet, and Inception have been widely used for detecting various eye diseases due to their strong feature extraction capabilities.

However, these models often require a large number of parameters and high computational resources. DenseNet121, introduced as a densely connected convolutional network, has gained attention for its efficient architecture, where each layer is connected to every other layer.

This design improves feature reuse, reduces the vanishing gradient problem, and requires fewer parameters compared to traditional CNN models. As a result, DenseNet121 has shown high performance in medical image classification tasks, including retinal disease detection and diabetic retinopathy analysis. Several studies have demonstrated that transfer learning using pre-trained models like DenseNet121 can significantly improve accuracy, especially when working with limited datasets.

## III. SYSTEM OVERVIEW

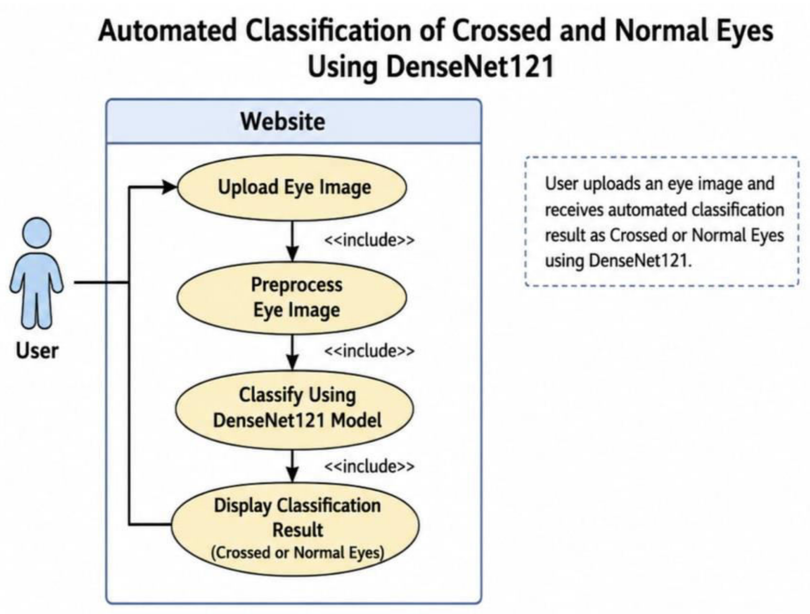


Fig 5.2.1. Use Case Diagram

System analysis focuses on understanding the requirements and structure of the proposed system that uses the DenseNet121 deep learning model to classify eye conditions as either crossed or normal. The system is designed to assist in early detection by providing accurate and automated image-based classification.

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## IV. METHODOLOGY

The proposed system follows a systematic approach to classify crossed and normal eyes using the DenseNet121 deep learning model. Initially, a labeled dataset of eye images is collected and preprocessed by resizing, normalizing, and enhancing the images to improve their quality. Data augmentation techniques are applied to increase the diversity of the training dataset and improve model generalization. The processed images are then used to train the DenseNet121 model using transfer learning, enabling it to learn the distinguishing features of crossed and normal eyes. When a user uploads an eye image through the web application, the trained model analyzes the image and predicts whether it represents a crossed eye (strabismus) or a normal eye. Finally, the prediction result is displayed through a simple and user-friendly interface**.**

**Methodology Steps**
Data Collection: Eye image data is collected from publicly available datasets and reliable sources for training and testing the model.

Image Preprocessing: Images are resized, normalized, enhanced, and augmented to improve model accuracy and reduce overfitting.

**Feature Extraction**: DenseNet121 automatically extracts important visual features from the preprocessed eye images.
**Model Training using DenseNet121**: The DenseNet121 deep learning model is trained using transfer learning to classify crossed and normal eyes accurately.
**Eye Classification**: The trained model analyzes the uploaded eye image and predicts whether it is a Crossed Eye (Strabismus) or a Normal Eye.
**Result Display**: The prediction result is displayed through a simple and interactive web interface along with the classification outcome.

## V. SYSTEM ARCHITECTURE

The proposed system follows a simple client–server architecture that integrates user interaction, image processing, deep learning, and result generation. The user first registers and logs into the application before uploading an eye image. The backend validates and preprocesses the uploaded image, which is then passed to the trained DenseNet121 deep learning model. The model analyzes the eye image and classifies it as either **Crossed Eye (Strabismus)** or **Normal Eye**. Finally, the prediction result is displayed to the user, while user information and prediction history are securely stored in the SQLite database.

**Architecture Components**

- User Interface (Login & Eye Image Upload)
- Flask Backend
- Image Preprocessing
- DenseNet121 Deep Learning Model
- SQLite Database
- Prediction Result Display

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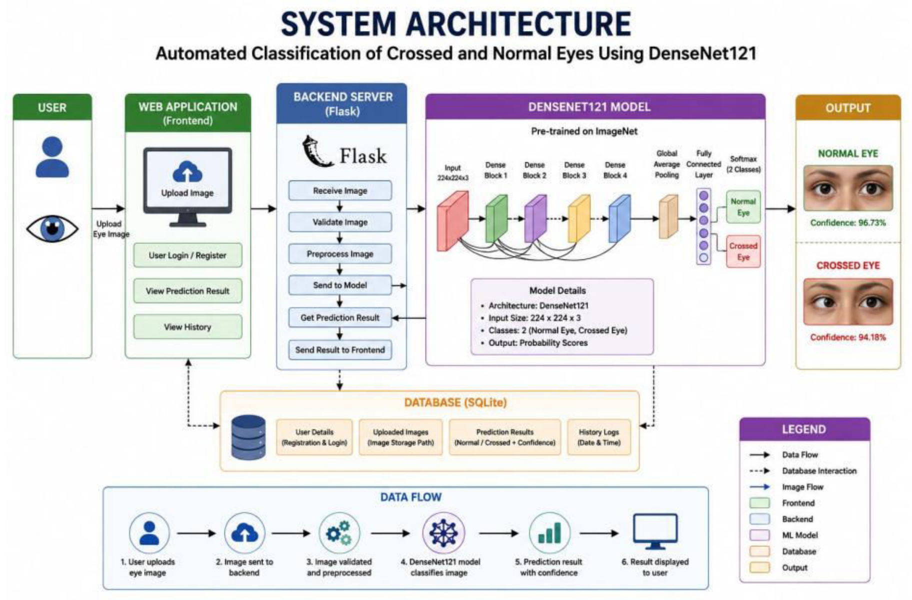


## VI. MODULES

The proposed system consists of the following modules:

### 6.1 User Registration Module
This module allows new users to create an account by providing a username and password. The entered details are validated and securely stored in the SQLite database.

### 6.2 User Login Module
Registered users can log in using their credentials. The system authenticates the user before granting access to the eye classification module.

### 6.3 Eye Image Upload Module
Users upload an eye image through the application interface. The uploaded image is validated for the supported file format and quality before being processed by the system.

### 6.4 Image Preprocessing Module
The uploaded eye image undergoes preprocessing techniques such as resizing, normalization, and enhancement to prepare it for accurate classification by the deep learning model.

### 6.5 Eye Classification Module
The preprocessed image is analyzed using the trained DenseNet121 deep learning model, which classifies the eye as either **Crossed Eye (Strabismus)** or **Normal Eye**.

### 6.6 Result Display Module
The prediction result is displayed in a clear and user-friendly format, showing whether the uploaded eye image is classified as crossed or normal along with the confidence score.

### 6.7 Dashboard and Database Module
The dashboard provides information such as the total number of registered users, uploaded images, and prediction history. The SQLite database securely stores user credentials, image details, and classification results for efficient data management.

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## VII. IMPLEMENTATION DETAILS

### 7.1 Technology Stack
The proposed system is developed using Python and the Flask framework for backend development. The user interface is designed using HTML, CSS, and JavaScript, while SQLite is used for database management. The DenseNet121 deep learning model is implemented using TensorFlow and Keras for automated classification of crossed and normal eyes.

### 7.2 Frontend Implementation
The frontend provides a simple and responsive interface for user registration, login, eye image upload, prediction results, and dashboard visualization. It is designed to ensure easy interaction and provide a user-friendly experience.

### 7.3 Backend Implementation
The backend is developed using Flask, which manages user authentication, image upload, image preprocessing, communication with the DenseNet121 model, and prediction result generation.

### 7.4 Database Design
The SQLite database stores user credentials, login information, uploaded image details, and prediction history. It enables secure storage and efficient retrieval of application data.

### 7.5 Deep Learning Model
The DenseNet121 model is trained using a labeled dataset of crossed and normal eye images after applying image preprocessing and data augmentation techniques. The trained model extracts deep features from eye images and accurately classifies them as either crossed eyes or normal eyes.

### 7.6 Security Measures
The application provides secure user authentication, input validation, session management, and protected database access to ensure user data confidentiality and reliable system performance.

## VIII. EXPERIMENTAL DETAILS AND RESULTS

### 8.1 Experimental Setup
The experimental setup was designed to evaluate the performance of the proposed DenseNet121 model for classifying crossed and normal eyes. A labeled dataset of eye images was collected and preprocessed through resizing, normalization, and data augmentation. The model was implemented using Python with TensorFlow and Keras, and training was performed on a system equipped with standard computing resources. The dataset was divided into training, validation, and testing sets to ensure reliable performance evaluation. Model performance was assessed using metrics such as accuracy, precision, recall, and F1-score.

### 8.2 Test Results

| Test Case | Description | Result Status |
|---|---|---|
| User Registration | Create a new user account | Passed ✓ |
| User Login | Login with valid credentials | Passed ✓ |
| Eye Image Upload | Upload a valid eye image | Passed ✓ |
| Image Preprocessing | Process the uploaded eye image | Passed ✓ |
| Eye Classification | Classify as Crossed Eye or Normal Eye | Passed ✓ |
| Prediction Result Display | Display the classification result | Passed ✓ |
| Model Performance | Generate accurate prediction with DenseNet121 | Passed ✓ |
| Dashboard | Display user history and prediction details | Passed ✓ |

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### 8.3 Performance Evaluation

The performance of the DenseNet121 model was evaluated using standard metrics such as accuracy, precision, recall, and F1-score. The model achieved high classification accuracy in distinguishing crossed eyes from normal eyes. Image preprocessing and transfer learning improved prediction performance and reduced classification errors. The evaluation results indicate that the proposed system is reliable, efficient, and suitable for automated strabismus screening.

### 8.4 Observations

The DenseNet121 model demonstrated effective performance in classifying crossed and normal eyes with high accuracy and reliability. The use of image preprocessing and transfer learning improved feature extraction and overall prediction performance. The system produced consistent results on test images and showed good generalization for unseen data. However, prediction accuracy may decrease when images are blurred, poorly illuminated, or of low quality. Overall, the proposed model is suitable for supporting the early detection of strabismus in clinical and telemedicine applications.

## IX. APPLICATIONS

- Early screening and detection of strabismus.
- Assisting ophthalmologists in eye disease diagnosis.
- Telemedicine and remote healthcare services.
- Eye health screening in schools and hospitals.
- Medical research and clinical studies.
- AI-based healthcare and diagnostic support systems.

## X. LIMITATIONS

- The model's performance depends on the quality and size of the training dataset.
- Poor lighting, blurred images, or incorrect eye positioning may reduce prediction accuracy.
- The system classifies only crossed and normal eyes and does not detect other eye disorders.
- Predictions should support, not replace, professional medical diagnosis.
- The model may require retraining with new data to maintain high accuracy.

## XI. FUTURE ENHANCEMENTS

- Increase the dataset size to improve model accuracy and robustness.
- Extend the system to classify different types of strabismus.
- Develop a real-time web and mobile application for easy access.
- Integrate cloud-based storage for secure data management.
- Improve the model using advanced deep learning architectures and optimization techniques.
- Add multilingual support and a user-friendly interface for wider adoption.

## XII. CONCLUSION

The proposed system uses the DenseNet121 deep learning model to accurately classify crossed eyes and normal eyes from eye images. The model provides fast and reliable predictions, making it useful for early detection of strabismus. This approach can assist healthcare professionals in improving diagnosis while reducing manual effort. Future work can focus on using larger datasets, improving accuracy, and developing a real-time web or mobile application.

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