MODULE 2: To develop a hybrid deep learning architecture which combines CNN (Convolutional Neural Network) and LSTM (Long Short Term Memory) for improving DR detection performance.

Project Overview

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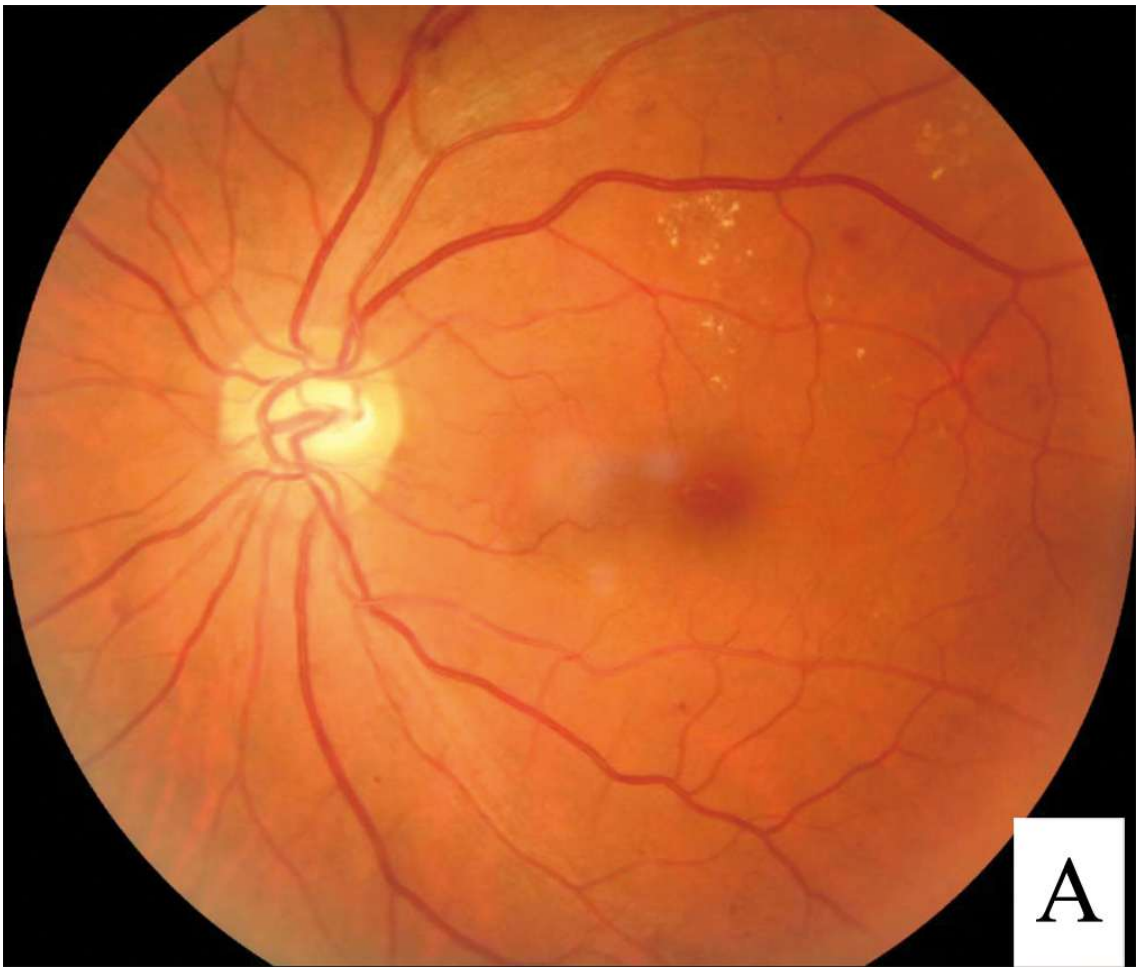

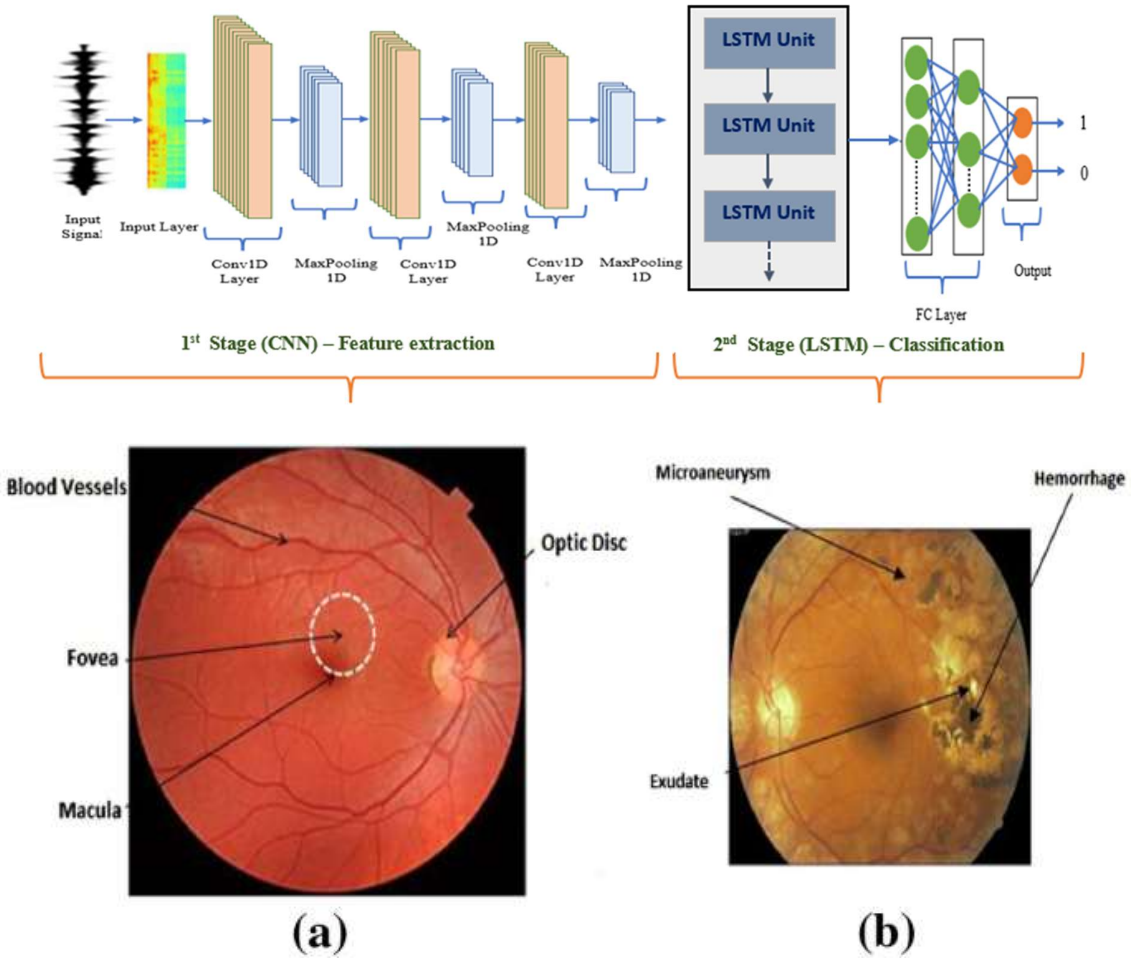

Problem Statement

Diabetic Retinopathy (DR) is a progressive eye disease caused by prolonged diabetes and is one of the leading causes of preventable blindness. While Convolutional Neural Networks (CNNs) are highly effective in extracting spatial features from retinal fundus images, they are limited in modeling sequential and contextual relationships among these features. This limitation affects accurate classification, especially in early and intermediate stages of DR.

Objective

To develop a **hybrid deep learning architecture combining CNN and Long Short-Term Memory (LSTM)** networks that improves DR detection and

classification accuracy by capturing both **spatial features** and **sequential dependencies** present in retinal images.

Proposed Hybrid Architecture

1. CNN-Based Feature Extraction

- CNN layers extract high-level spatial features such as:
  - Microaneurysms
  - Hemorrhages
  - Exudates
- Convolution, pooling, and normalization layers reduce dimensionality while preserving critical lesion information
- Output feature maps represent structured spatial patterns of retinal abnormalities

2. Feature Sequencing

- Extracted CNN feature maps are reshaped into sequential vectors
- These sequences represent ordered spatial dependencies across retinal regions

3. LSTM-Based Temporal Modeling

- LSTM layers process the sequential feature vectors
- Capture long-term dependencies and contextual relationships among extracted features
- Improve discrimination between visually similar DR severity stages

4. Classification Layer

- Fully connected layers followed by Softmax activation
- Multi-class classification of DR stages:
  - No DR
  - Mild
  - Moderate

- Severe
- Proliferative DR

Methodology

Data Preprocessing

- Image resizing and normalization
- Contrast enhancement to highlight lesions
- Data augmentation to improve generalization

Model Training

- Loss Function: Categorical Cross-Entropy
- Optimizer: Adam
- Regularization using Dropout and Batch Normalization
- Model trained using stratified train-test split

Evaluation Metrics

- Accuracy
- Precision
- Recall
- F1-score
- Confusion Matrix

Advantages of CNN–LSTM Hybrid Model

- CNN efficiently extracts spatial features from retinal images
- LSTM captures sequential and contextual relationships ignored by standalone CNNs
- Improved detection of early-stage DR
- Reduced false positives and misclassification

- Better generalization on unseen data

Applications

- Automated DR screening systems
- Clinical decision support tools
- Telemedicine-based ophthalmology platforms
- Large-scale population screening programs

Conclusion

The proposed CNN–LSTM hybrid deep learning architecture significantly enhances Diabetic Retinopathy detection performance by integrating spatial feature extraction with sequential dependency modeling. This approach improves classification accuracy, particularly in early and borderline cases, making it a reliable and scalable solution for automated retinal disease diagnosis.