EffNet-SVM A Hybrid Model for Diabetic Retinopathy Detection Using Retinal Fundus Images

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Abstract—**Diabetic Retinopathy (DR) is a severe complication of diabetes and one of the leading causes of blindness worldwide. Early detection is critical to prevent vision loss, but manual diagnosis is time-consuming and dependent on expert availability. This paper proposes a hybrid model named EffNet-SVM for automated detection of diabetic retinopathy using retinal fundus images. The system integrates EfficientNetV2-S for feature extraction and Support Vector Machine (SVM) for classification. EfficientNet extracts high-level visual features, while SVM ensures robust and accurate classification using an RBF kernel. To improve interpretability, the model incorporates explainable AI techniques such as Grad-CAM and LIME. The system is deployed using Streamlit, enabling real-time prediction and visualization. Experimental results show that the proposed approach achieves high accuracy with reduced computational complexity, making it suitable for real-world healthcare applications.**

Index Terms—**Diabetic Retinopathy, EfficientNet, SVM, Deep Learning, Explainable AI, Medical Imaging**

I. INTRODUCTION

Diabetic Retinopathy (DR) is a progressive eye disease caused by prolonged diabetes, leading to damage in retinal blood vessels. It is one of the major causes of vision impairment globally. Early detection plays a crucial role in preventing severe complications, but traditional diagnosis methods rely heavily on manual analysis by ophthalmologists.

Manual screening of retinal images is time-intensive and requires specialized expertise, making it difficult to scale for large populations. Additionally, human interpretation may vary, leading to inconsistencies in diagnosis.

Recent advancements in Artificial Intelligence (AI) and Machine Learning (ML) have enabled automated medical image analysis. Deep learning models, especially Convolutional Neural Networks (CNNs), have shown strong performance in image classification tasks. However, these models often require large datasets and high computational resources.

To overcome these limitations, this paper proposes a hybrid approach that combines deep learning and classical machine learning. EfficientNetV2-S is used for feature extraction due to its efficiency and accuracy, while Support Vector Machine (SVM) is used for classification due to its strong generalization ability.

The proposed system aims to provide a fast, accurate, and interpretable solution for diabetic retinopathy detection.

II. LITERATURE SURVEY

Several studies have explored automated diabetic retinopathy detection using machine learning and deep learning techniques.

Traditional methods relied on image processing and handcrafted features, which were limited in performance due to variations in image quality. Classical machine learning algorithms such as SVM, Random Forest, and KNN improved classification but depended heavily on feature engineering.

Deep learning models such as VGGNet, ResNet, and DenseNet introduced automatic feature extraction, significantly improving accuracy. EfficientNet further enhanced performance by optimizing model scaling.

Recent research focuses on hybrid approaches that combine deep learning feature extraction with machine learning classifiers. These models achieve better accuracy while reducing computational complexity.

Explainable AI techniques like Grad-CAM and LIME have also gained importance, as they provide transparency in model predictions, which is essential in medical applications.

III. PROPOSED SYSTEM

A. System Overview
The proposed system is a hybrid model combining EfficientNetV2-S and SVM for diabetic retinopathy detection.

B. Methodology
The workflow includes:
1. Image preprocessing (resizing and normalization)
2. Feature extraction using EfficientNetV2-S
3. Feature scaling using StandardScaler
4. Classification using SVM (RBF kernel)
5. Explainability using Grad-CAM and LIME

C. Workflow
1. Input retinal image
2. Preprocessing
3. Feature extraction (1280-dimension vector)
4. Classification using SVM
5. Output prediction (DR / No DR)
6. Visualization using Grad-CAM and LIME

D. Advantages
- High accuracy with reduced computation
- Works with limited datasets
- Provides explainable results
- Suitable for real-time applications

IV. IMPLEMENTATION

A. Tools and Technologies
- Python
- PyTorch
- Scikit-learn
- Streamlit

B. Dataset
APTOS 2019 dataset(resized) is used, converted into binary classification:
- $0 \rightarrow$ No DR
- $1\text{–}4 \rightarrow$ DR

C. Model Development
- EfficientNetV2-S used as frozen feature extractor
- SVM used for classification
- Features scaled using Standard Scaler

D. Deployment
The model is deployed using Streamlit, allowing users to upload retinal images and receive predictions instantly.

V. RESULTS AND DISCUSSION

The proposed system was evaluated based on performance, accuracy, and efficiency.

A. Performance
- EfficientNet provides strong feature extraction
- SVM improves classification accuracy

B. Benefits
- Faster processing compared to full deep learning models
- Reduced computational requirements
- Suitable for real-time applications

C. Interpretability
- Grad-CAM highlights important regions
- LIME explains model decisions

The results indicate that the hybrid model performs efficiently and reliably.

VI. CONCLUSION

This paper presents a hybrid model for diabetic retinopathy detection using EfficientNet and SVM. The system achieves high accuracy while maintaining efficiency and interpretability. The integration of explainable AI techniques enhances trust and usability in medical applications.

The proposed solution can assist healthcare professionals in early detection and reduce manual workload.

VII. FUTURE SCOPE

- Multi-class classification for DR severity
- Integration with mobile applications
- Deployment on cloud platforms
- AI-based healthcare systems

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