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A Hybrid Model for Diabetic Retinopathy Classification Using Retinal Fundus Images

under the guidence of :

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Introduction

Diabetic Retinopathy (DR) is a diabetes-related eye disease that can cause vision loss due to damage in the retinal blood vessels. Detecting DR at an early stage is crucial for preventing blindness. Traditional diagnosis using fundus images is time-consuming and depends on a specialist¾s experience, which may lead to inconsistencies.

To overcome these limitations, deep learning techniques have been developed for automated DR detection. In this project, a deep learning model inspired by the **EffNet-SVM** approach is implemented using **MobileNetV2** on the **APTOS 2019 dataset**. The model automatically learns retinal features and classifies images into different DR stages. This system aims to provide a reliable, efficient, and accurate method for diabetic retinopathy detection.

Abstract

- Diabetic Retinopathy (DR) is one of the major causes of blindness worldwide, resulting from damage to the retina due to high blood sugar levels.
- Manual diagnosis using fundus images is time-consuming, subjective, and prone to human error.
- To overcome these limitations, the proposed **EffNet-SVM hybrid model** combines **EfficientNetV2-Small** for deep feature extraction and **Support Vector Machine (SVM)** with an **RBF kernel** for classification.
- The model was trained on the **APTOS 2019 dataset** and achieved **90.0% accuracy**, outperforming existing CNN-based methods.
- This approach offers an efficient and reliable solution for automated diabetic retinopathy detection in clinical settings

The Challenge

DiabeticRetinopathy(DR) is a leading cause of blindness globally, arising from retinal damage due to elevated blood sugar levels.Manualdiagnosis using fundus images is time-intensive, subjective, and susceptible to human error.

Our Solution

TheproposedEffNet-SVM hybrid model integrates **EfficientNetV2-Small** for robust deep feature extraction with **Support VectorMachine(SVM)**using an RBF kernel for precise classification.

Key Achievement

Trained on theAPTOS2019 dataset, our model achieved **90.0% accuracy**, surpassing existing CNN-based approaches whilst offering an efficient, reliable solution for automated DR detection in clinical environments.

Problem Statement

Labour-Intensive Manual Diagnosis

Traditional DRscreening relies on manual examination of fundus images by ophthalmologists, making it time-consuming and subjective with high inter-observer variability.

Dataset Challenges

Deep learning models demand large, diverse datasets and frequently suffer from overfitting, class imbalance, and poor generalization across populations.

Computational Limitations

ExistingCNN architectures,whilst accurate, often incur high computational costs, extended inference times, and limited clinical interpretability.

These challenges underscore the critical need for a **lightweight, accurate, and generalizable automated system** capable of reliable DR detection from retinal fundus images in resource-constrained clinical settings.

Literature Review

1 Rao et al. (2020)

EmployedResNet-50with Gaussian blur preprocessing, achieving **94.15% accuracy** on fundus image classification.

2 Mohanty et al. (2023)

IntegratedVGG16withXGBoost classifier, reaching **79.5% accuracy** but with limited generalization capability.

3 Shimpi et al. (2023)

Developedhybriddeepresidual neural network using ResNet-152 and DenseNet-121, achieving **96.9% accuracy**.

4 Taifa et al. (2024)

Applied multiple feature extractors and classifiers in ensemble approach, reaching **95.5% accuracy**.

Research Gap: Most existing models are computationally expensive and dataset-dependent, motivating the development of our more efficient EffNet-SVM hybrid architecture.

Proposed System Architecture

Input Layer

Preprocessedretinal fundus images (224×224 RGB)

Feature Extraction

EfficientNetV2-Smallextracts 1280-dimensional feature vectors

Classification

SVMwithRBFkernel performs binary DR prediction

Output

DRvs.NoDR classification result

EfficientNetV2-Small

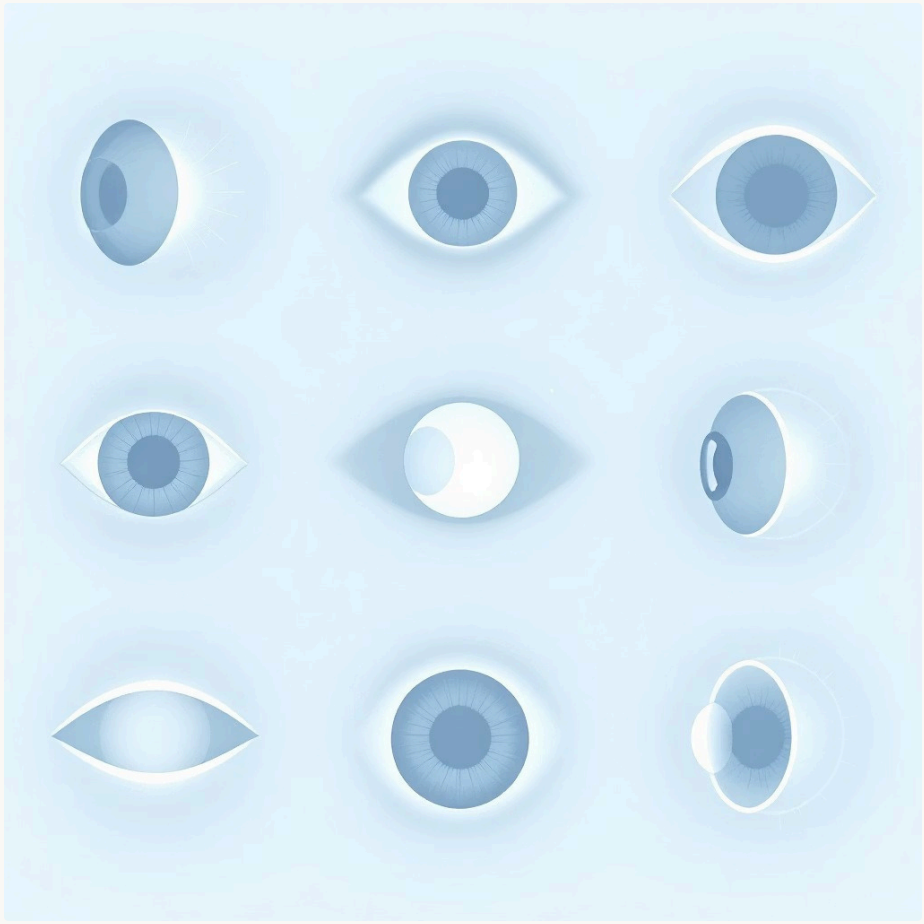
- State-of-the-art feature extraction
- Lightweight architecture (21.5M parameters)
- Transfer learning from ImageNet
- Optimized for speed and accuracy

SVM with RBF Kernel

- Robust binary classification
- Effective in high-dimensional spaces
- Excellent generalization capability
- Hyperparameter optimization via Grid Search

Methodology: Dataset & Preprocessing

APTOS 2019 Dataset



3662
Fundus Images

High-resolution retinal photographs

5
DR Severity Stages

Reorganized into binary classes

Preprocessing Pipeline

01

Image Resizing

Standardizedto224×224 pixels for model input

02

Data Augmentation

Rotation,horizontal/vertical flipping, zooming, and contrast adjustment to enhance dataset diversity

03

Normalization

Pixelintensityscaling and contrast enhancement for consistency

04

Class Balancing

Addressingimbalanced distribution between DR and No DR classes

05

Noise Reduction

Removingartifactsand low-quality images from training set

Model Training & Evaluation

1

Transfer Learning

Fine-tuned EfficientNetV2-Small pretrained on ImageNet with frozen early layers and trainable deep layers

2

Feature Extraction

Generated 1280-dimensional feature vectors from penultimate layer for each fundus image

3

SVM Training

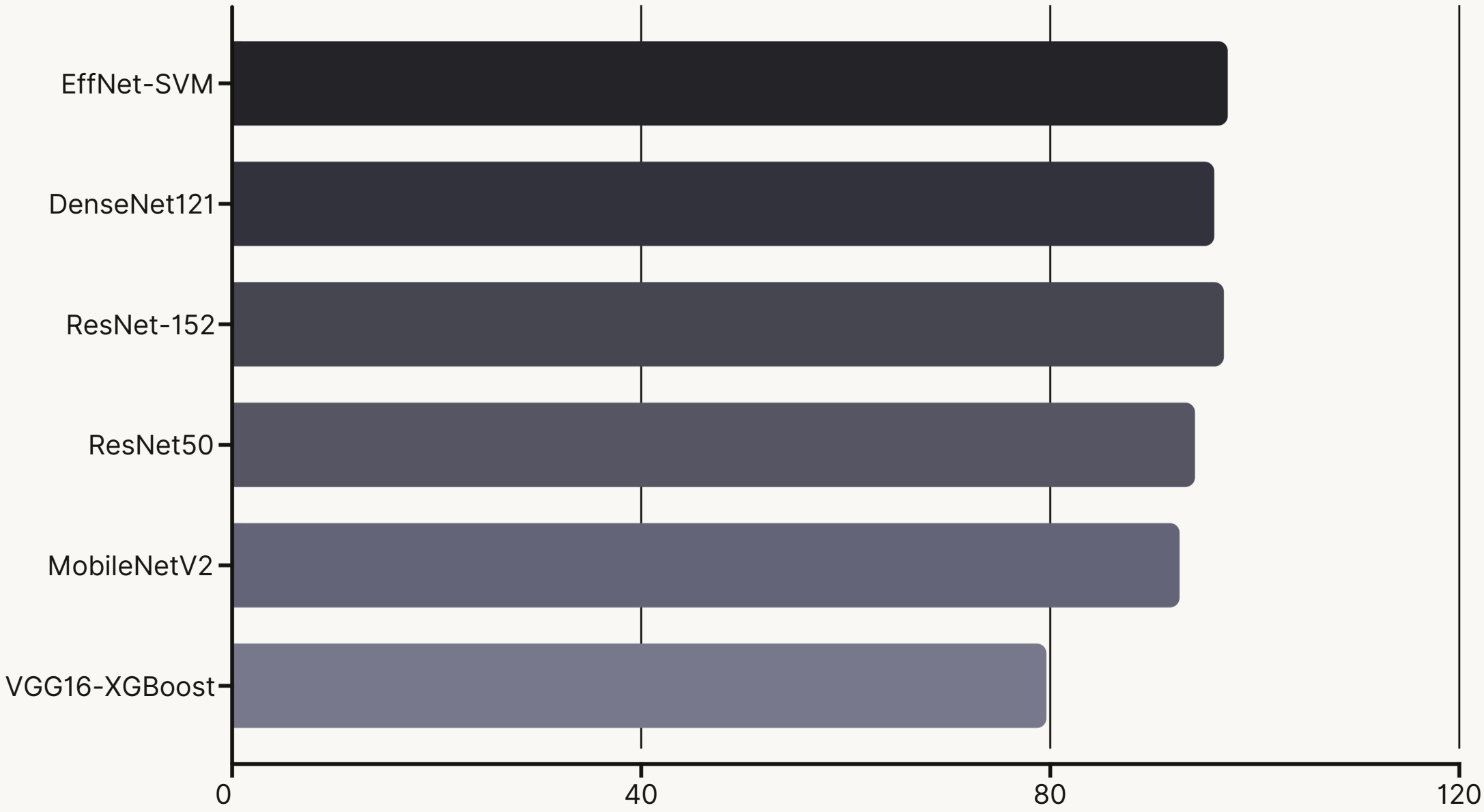
RBFkernelSVMtrained on extracted features with Grid Search optimization for C and ³ hyperparameters

4

Performance Evaluation

Comprehensive assessmentusing accuracy, precision, recall, F1-score, and ROC-AUC metrics

Results & Performance Comparison



Model Accuracy

EffNet-SVM performance

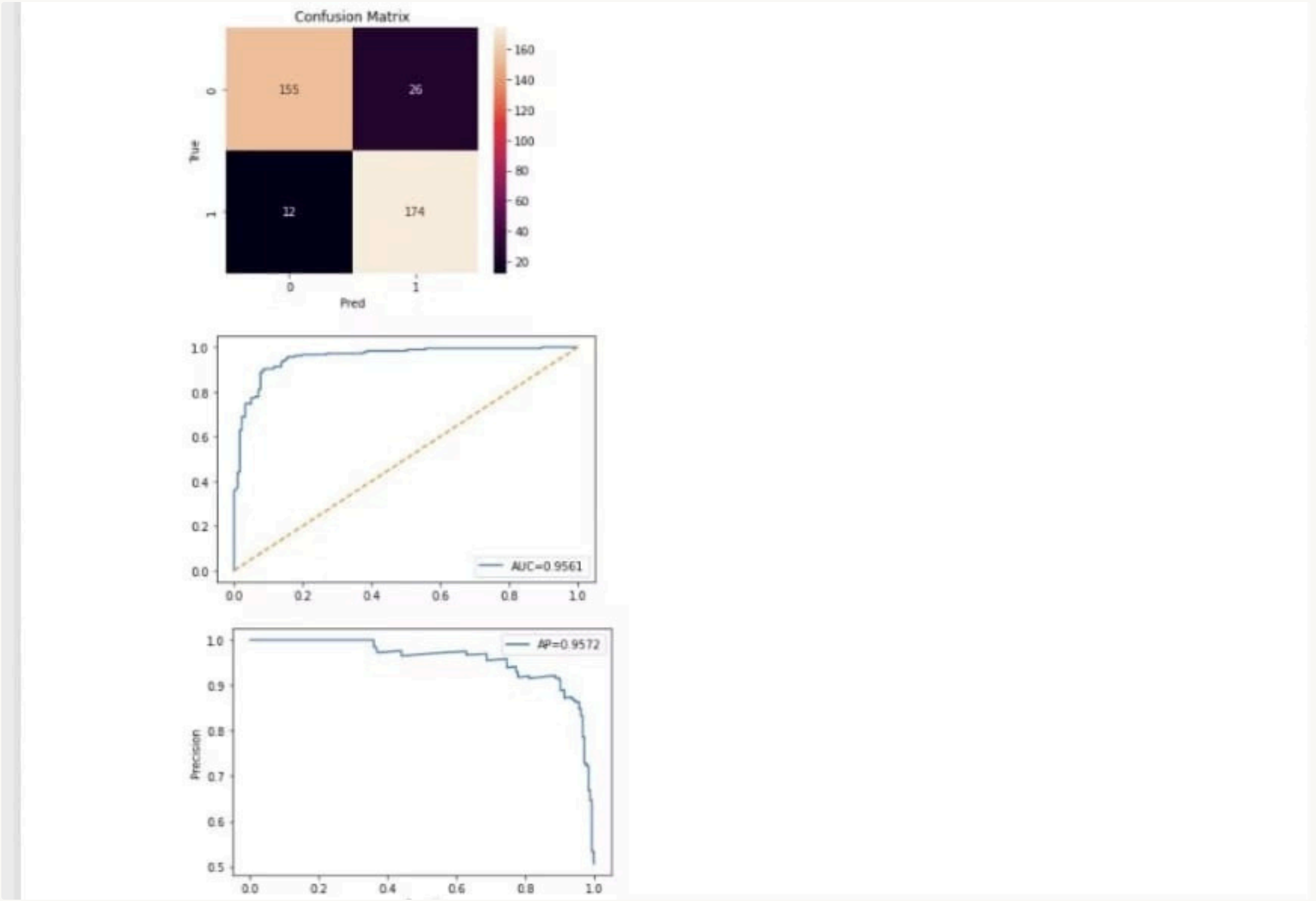
Inference Time

Secondsper image

Our hybrid EffNet-SVM model demonstrates **superior accuracy** whilst maintaining **fast inference speed** and excellent generalization capability across diverse fundus image datasets.

Model performance Evaluation

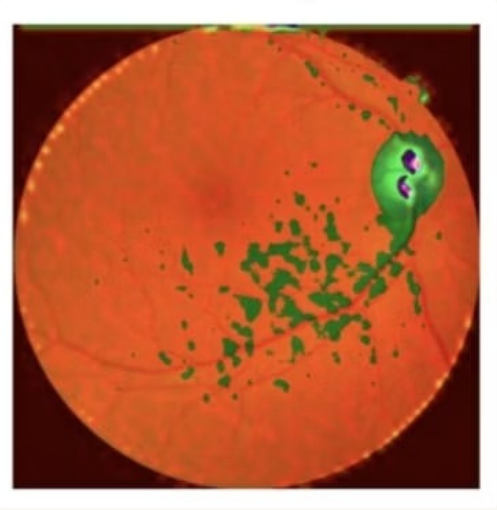
Confusion Matrix ,ROC ,Precision-Recall Analysis



Classification Report Summary

Metr ic	Precision	Recall	F1-Score
Class 0(No DR)	0.93	0.86	0.89
Class 1 (DR)	0.87	0.94	0.90
Overall Accuracy			0.90

Grad-CAM Visualization



- Grad-CAM visualization showing the region the model focused on during prediction
- Grad-CAM helps visualize the region of that retina contributed most to the model's diagnosis
- The bright region indicates the most important area influencing the model's decision ,confirming that the model is learning cor rectly

System Requirements

Software Stack

- **Python 3.9+**3Coreprogramming language
- **PyTorch / TensorFlow** 3 Deep learning frameworks
- **OpenCV** 3 Image processing and computer vision
- **Scikit-learn** 3 Machine learning algorithms (SVM)
- **NumPy, Matplotlib** 3 Numerical computing and visualization

Hardware Specifications

GPU Requirements

NVIDIATeslaV100orRTX series for accelerated training and inference

Memory

Minimum16GB RAM for efficient batch processing

Input Resolution

224×224pixelimagesupport with RGB channels

Future Scope

Multi-class Classification

Extend model to classifyall fiveDR severity stages for granular diagnosis

Explainable AI

Implementattention-based visualization techniques for clinical interpretability and trust

Multimodal Integration

Incorporate OCT scansandpatient medical history for enhanced diagnostic accuracy

Conclusion

The proposed EffNet-SVM hybrid model effectively classifies diabetic retinopathy (DR) and non-DR cases using retinal fundus images. By combining EfficientNetV2-Small for deep feature extraction and an SVM with RBF kernel for classification, the model achieved a high accuracy of 90.0%, outperforming several state-of-the-art deep learning models. The approach also demonstrated strong generalization on cross-dataset testing and provided visual interpretability through Grad-CAM. Although image quality and limited interpretability of the SVM remain challenges, EffNet-SVM proves to be a robust, efficient, and scalable solution for automated DR detection, especially beneficial for early screening in resource-limited clinical

References

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5. Liu Y., *Hybrid Attention Network for DR Grading*, J. Radiat. Res. Appl. Sci., 2024.

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THANK YOU!