OCUSCAN : RETINAL FUNDUS CLASSIFICATION

ACM40960-Projects in Maths Modelling

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Introduction

OcuScan is a deep learning pipeline for multi-class classification of retinal fundus images. It combines preprocessing, model training and evaluation into a deployable system. **Inception-ResNet-v2 achieved the best performance (94.08% accuracy)** among several architectures. The pipeline includes image enhancement, class-balanced training and mixed-precision optimization. A Streamlit GUI enables real-time single-image diagnosis with confidence scores, making OcuScan suitable for clinical and research use.

Data & Preprocessing

The dataset contains 4,728 fundus images across five classes: diabetic retinopathy, normal, cataract, glaucoma and ARMD. The first four classes are relatively balanced, while ARMD is under-represented, making class-weighted loss or macro-averaged metrics suitable for evaluation.

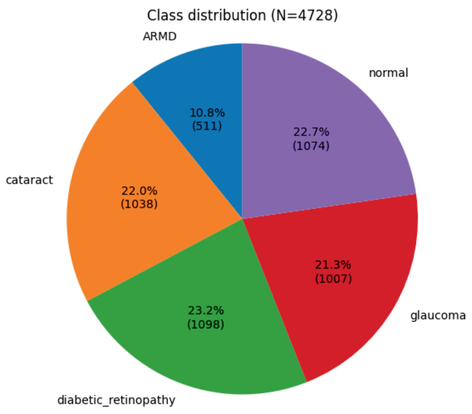

Figure 1. Pie Chart showing Class Distribution

Each image is cropped to the fundus region, corrected for illumination and color, enhanced using CLAHE and gamma adjustment, sharpened and resized with square padding. Processing is parallelized for speed and robustness.

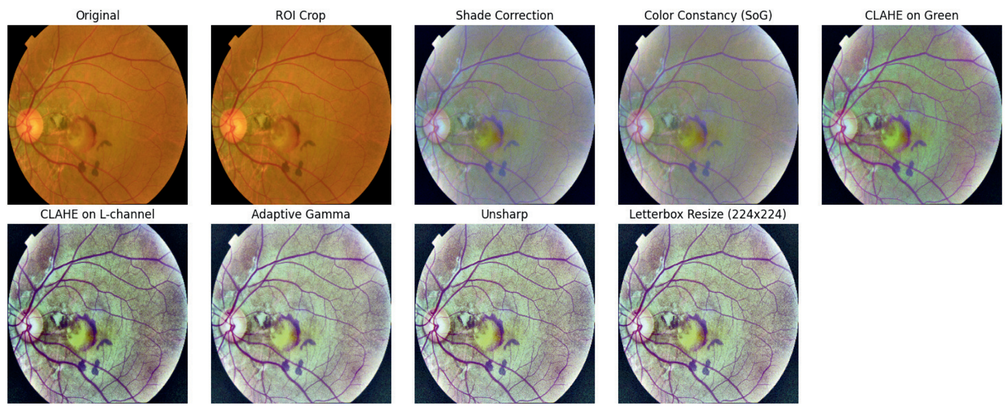

Figure 2. Preprocessing Steps on Image

Model Training

Models:

- ResNet, DenseNet, MobileNetV3 (224×224)
- EfficientNet-B1 (240×240)
- InceptionV3, Inception-ResNet-v2 (best) (299×299)
- ConvNeXt (384×384)

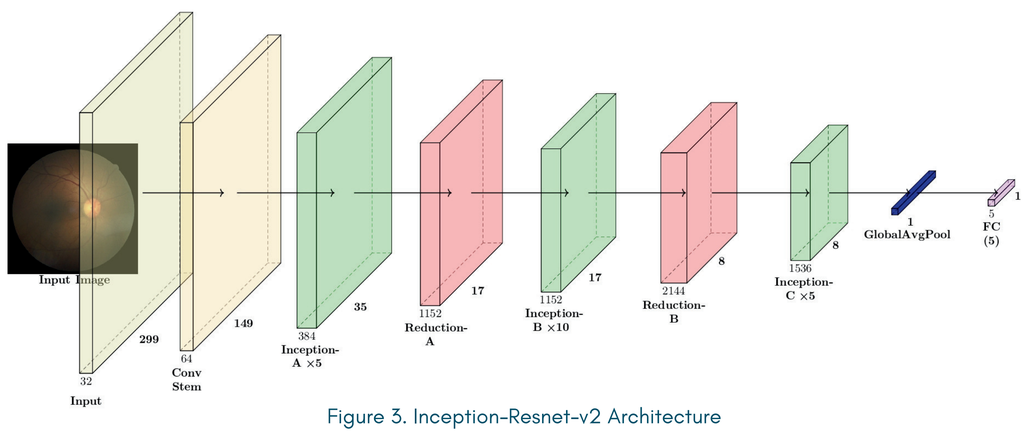

Figure 3. Inception-Resnet-v2 Architecture

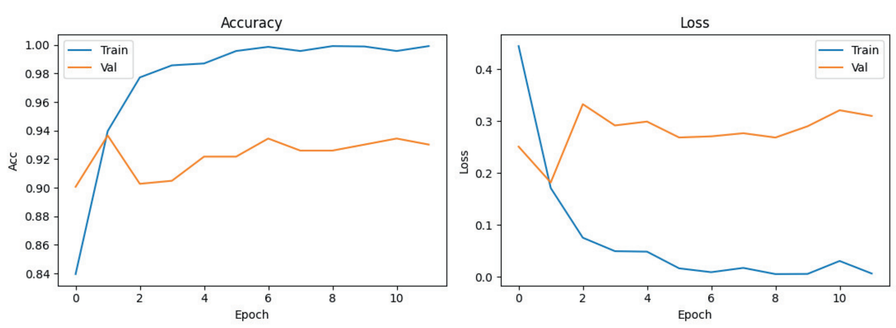

Figure 4. Training and Validation curves for Inception-Resnet-v2

References

1. Y. Li, Q. Lao, Q. Kang, Z. Jiang, S. Du, S. Zhang, and K. Li, "Self-supervised anomaly detection, staging and segmentation for retinal images," Medical Image Analysis, vol. 87, p. 102805, 2023.
2. A. Bhati, N. Gour, P. Khanna, and A. Ojha, "Discriminative kernel convolution network for multi-label ophthalmic disease detection on imbalanced fundus image dataset," Computers in Biology and Medicine, vol. 153, p. 106519, 2023.
3. O. Sivaz and M. Aykut, "Combining efficientnet with ml-decoder classification head for multi-label retinal disease classification," Neural Computing and Applications, vol. 36, no. 23, pp. 14251–14261, 2024.

Methodology

- **Data Collection:** 4,728 retinal fundus images across 5 disease classes.
- **Preprocessing:** ROI crop, illumination correction, color normalization, contrast enhancement, resizing.
- **Modeling:** Multiple CNN architectures trained (e.g., Inception-ResNet-v2, ResNet, ConvNeXt).
- **Training:** Stratified splits, class-balanced loss, AMP, Adam optimizer, learning rate scheduling.
- **Evaluation:** Accuracy, AUC, ROC, confusion matrix.
- **Deployment:** Streamlit app for real-time diagnosis and confidence visualization.

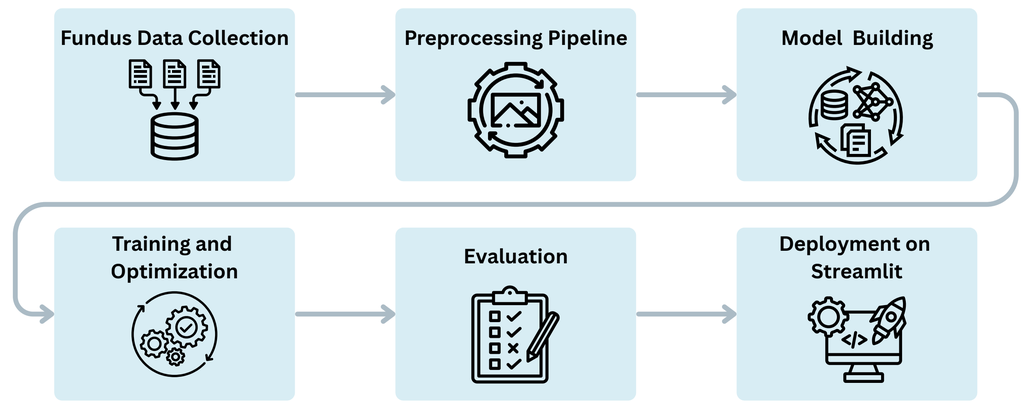

Figure 5. Flow of The Project

Results

Model	Input	Test Accuracy	Precision	Recall	F1-Score	Macro AUC
Inception-ResNet-v2	299	**0.9408**	0.9444	0.9457	0.9448	0.9910
DenseNet-121	224	0.9307	0.9376	0.9359	0.9358	**0.9936**
DenseNet-169	224	0.9305	0.9371	0.9362	0.9363	0.9914
InceptionV3	299	0.9302	**0.9402**	0.9355	0.9353	0.9904
ConvNeXt-T/S/B	384	0.9302	0.9367	0.9357	0.9354	0.9859

Table 1. Top 5 Performing Models (Test Accuracy)

- **Inception-ResNet-v2** achieved the **highest test accuracy (94.08%)** and strong overall metrics.
- DenseNet-121 had the best Macro AUC (0.9936), indicating strong class-wise discrimination.
- Other top models (DenseNet-169, InceptionV3, ConvNeXt) performed around 93% accuracy.

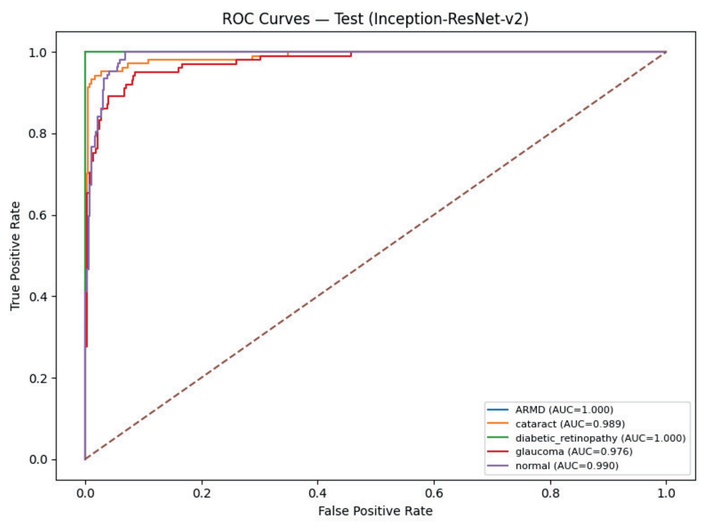

Figure 6. ROC (Inception-Resnet-v2)

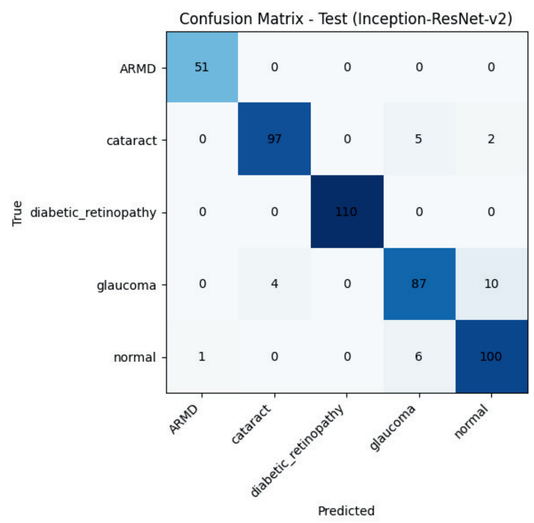

Figure 7. Confusion Matrix (Inception-Resnet-v2)

- **ROC Curve:** The ROC curve for Inception-ResNet-v2 demonstrates excellent class-wise separability, with all AUC scores exceeding 0.96, including perfect AUCs for ARMD and diabetic_retinopathy.
- **Confusion Matrix:** Inception-ResNet-v2 shows strong per-class accuracy with minimal misclassifications, especially perfect detection of ARMD and diabetic_retinopathy.
- **GUI:** The Streamlit-based GUI enables real-time single-image diagnosis with automatic preprocessing and class-wise confidence scores.

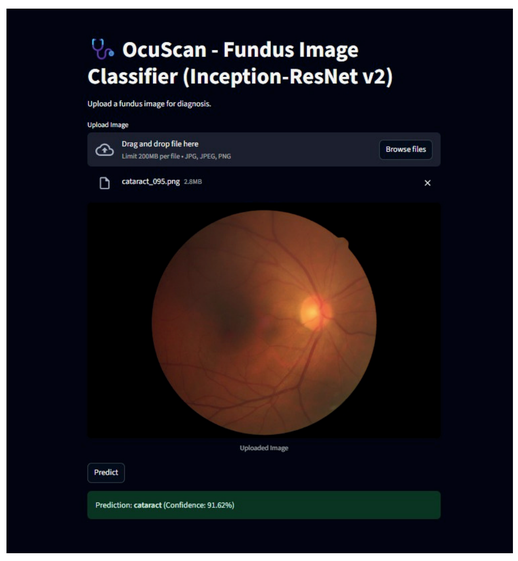

Figure 8. Streamlit GUI

Conclusion & Future Scope

- **OcuScan** delivers a robust and accurate deep learning pipeline for **multi-class retinal disease classification**, achieving **94.08% accuracy** with **Inception-ResNet-v2** and demonstrating strong per-class performance through **ROC** and **confusion matrix** analysis.
- The system's strong performance highlights its clinical potential, with future directions including **dataset expansion** for under-represented diseases, integration of **explainable AI tools** (e.g., **Grad-CAM**) for interpretability and **deployment in real-world screening environments for clinical validation and feedback.**