

Enhanced ODIRnet: Attention-Driven And Explainable Deep Neural Network For Robust Diabetic Retinopathy Detection

Prof. N. K. Patil¹, Rushikesh Patil², Sohel Khan³, Chaitanya Gangarde⁴, Shivam Kale⁵

^{1, 2, 3, 4, 5} Dept of Computer Engineering

^{1, 2, 3, 4, 5} Savitribai Phule Pune University, Sinhgad Institute of Technology Lonavala, India

Abstract- Diabetic Retinopathy (DR) is a significant global health concern, especially in areas with high rates of diabetes. Early detection via automated systems can reduce the risk of blindness. This paper introduces ODIRNet, a compact deep convolutional neural network that efficiently classifies retinal fundus images. ODIRNet is developed from the ground up, incorporating advanced feature extraction techniques such as blue-channel emphasis and attention modules. The model was trained and tested on the Ocular Disease Intelligent Recognition (ODIR) dataset, which contains 6392 images. Results show that ODIRNet achieves an accuracy of 89.70%, surpassing models like VGG16, ResNet50, and MobileNet. Furthermore, the model is integrated into a web-based platform for real-time diagnostic screening, making it a practical and accessible solution for clinics with limited resources.

Keywords: Diabetic Retinopathy, Deep Learning, CNN, ODIRNet, Fundus Imaging, Medical Image Classification

I. INTRODUCTION

Diabetic Retinopathy (DR) represents a serious complication of diabetes and is a primary cause of vision loss worldwide [1]. Detecting DR at an early stage is essential for preventing blindness and improving patient outcomes [7], [11]. Conventional diagnosis involves manual examination of retinal images, a process that is both labour-intensive and error-prone [6], [15].

Recent progress in deep learning has made it possible to automatically detect eye diseases with high accuracy [2], [8], [14]. Despite this, many current models are resource-intensive and depend on transfer learning techniques [4], [10]. Additionally, advanced approaches such as graph neural networks and transformer-based models have been explored, but they often introduce higher computational complexity [12], [13].

A. Contributions

The main contributions of this work are summarized as follows:

- A lightweight deep convolutional neural network (ODIRNet) designed for efficient retinal image classification.
- A novel blue-channel based feature enhancement technique to improve detection of disease-specific patterns [3], [6].
- Integration of an attention mechanism to focus on clinically relevant regions in fundus images [8], [11].
- Development of a real-time web-based diagnostic system suitable for deployment in resource-constrained environments [2], [5].

II. LITERATURE REVIEW

Diabetic Retinopathy (DR) is a major cause of vision loss, and early detection is essential to prevent severe complications [1]. Traditional diagnosis relies on manual examination of retinal images, which is time-consuming and prone to errors [6].

Recent advancements in deep learning have significantly improved automated DR detection. Convolutional Neural Networks (CNNs) have shown high accuracy in classifying retinal images and grading disease severity [8], [14]. Additionally, deep neural networks have been successfully applied for early-stage detection, enabling timely medical intervention [11].

Transfer learning techniques have been widely used to enhance performance, especially when labeled data is limited. Models combining transfer learning with architectures such as U-Net have demonstrated improved detection capabilities [4], [10]. However, these approaches often require high computational resources, limiting their applicability in real-time systems.

More recent approaches, including Graph Neural Networks (GNNs) and transformer-based models, have further improved feature representation and classification performance [12], [13]. Despite their effectiveness, they introduce increased model complexity.

III. RELATED WORK

Models like VGG16, ResNet50, and DenseNet are commonly applied for DR detection tasks. While transfer learning strategies offer high accuracy, they also demand substantial computational power. Recent research has investigated the use of attention mechanisms and hybrid models to boost performance. Nonetheless, issues like high model complexity and insufficient support for real-time use persist. This study tackles these challenges by proposing a more lightweight and efficient architecture.

IV. METHODOLOGY

A. Dataset

The ODIR dataset consists of 6392 retinal fundus images, each labeled with various ocular diseases. For experimentation, the data is divided into 80% for training and 20% for testing.

B. Preprocessing

Preprocessing steps include:

- Image resizing
- Normalization
- Blue-channel extraction
- Data Augmentation (rotation, flipping, zoom)

C. Proposed Model

ODIRNet is a 20-layer CNN consisting of:

- Convolutional layers with ReLU activation
- Batch normalization
- Max pooling
- Attention mechanism
- Fully connected layers
- Softmax classifier

D. Training Details

- Optimizer: Adam
- Loss Function: Categorical Cross-Entropy
- Batch Size: 32

- Epochs: 25

E. Mathematical Formulation

$$Y(i, j) = \sum_m \sum_n X(i - m, j - n) \cdot K(m, n) \quad (1)$$

$$f(x) = \max(0, x) \quad (2)$$

F. Experimental Setup

The experiments were conducted using Python with TensorFlow on a system equipped with an Intel i7 processor, 16GB RAM, and NVIDIA GPU. The model was trained for 25 epochs with a batch size of 32 using the Adam optimizer.

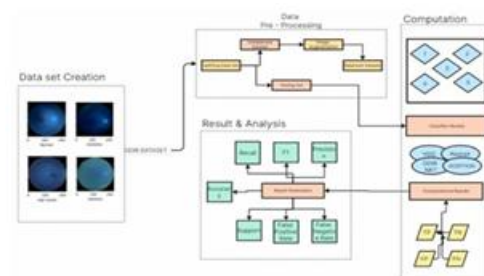


Fig. 1. Workflow of ODIRNet

V. SYSTEM DESIGN

Retinal fundus photos are taken directly from Digital Retinal Scanner (DRS) devices and uploaded to the ODIRNet web portal for processing. For easy integration with current clinical processes, the system accommodates standard medical image formats, such as JPEG, PNG, and DICOM. This compatibility ensures easy interoperability with a broad variety of ophthalmic imaging devices and electronic health record (EHR) systems, which facilitates straightforward adoption in clinical environments.

VI. MODEL ARCHITECTURE

ODIRNet is built on a lightweight and efficient convolutional neural network framework customized for ophthalmic image classification. The architecture enhances feature extraction by combining optimized convolutional layers with attention mechanisms that focus on clinically important regions in retinal images. This design significantly improves classification accuracy across multiple disease categories. By keeping the architecture streamlined, the model achieves faster inference with strong detection capabilities, making it suitable for low-resource clinical settings. Additionally, preprocessing steps like channel normalization and data augmentation are integrated into the training process

to boost generalization and robustness to the kinds of image variation commonly seen in real-world retinal datasets.

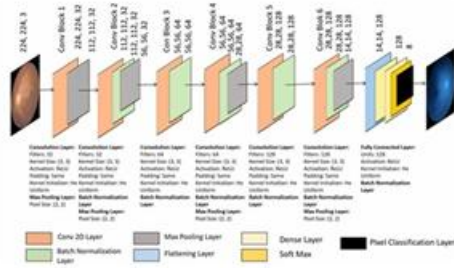


Fig. 2. ODIRNet Architecture

VII. RESULTS

The performance of the model is evaluated using standard metrics such as Accuracy, Precision, Recall, and F1-score.

TABLE I

PERFORMANCE COMPARISON

Model	Accuracy	Precision	Recall	F1-score
VGG16	86.2%	85.5%	84.8%	85.1%
ResNet50	87.5%	86.9%	86.2%	86.5%
MobileNet	88.1%	87.6%	87.0%	87.3%
ODIRNet	89.7%	89.1%	88.6%	88.8%

A. Evaluation Metrics

- Accuracy
- Precision
- Recall
- F1-score

B. Performance Comparison

ODIRNet surpasses conventional models in performance while keeping computational demands low. The attention mechanism further improves feature extraction by directing focus toward key retinal areas.

C. Observations

ODIRNet achieves higher accuracy with reduced computational complexity. The attention mechanism improves detection of critical features, and the model is suitable for real-time applications.

VIII. CONCLUSION

This work introduces ODIRNet, a compact deep learning model with attention mechanisms for automated Diabetic Retinopathy detection. The model achieves strong classification accuracy and operates efficiently, making it practical for use in settings with limited resources. Integrating ODIRNet into a web-based diagnostic platform increases its real-world usefulness in clinical practice.

The results indicate that ODIRNet can serve as an effective tool for early detection and screening of ocular diseases, thereby contributing to improved patient outcomes.

IX. FUTURE WORK

Future improvements include:

- Integration of Explainable AI (Grad-CAM)
- Larger dataset training
- Mobile deployment
- Vision Transformer integration

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