**Diabetic Retinopathy Detection using Deep Learning**

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**1. Introduction**

Diabetic Retinopathy (DR) is a severe complication of diabetes that affects the retina, potentially leading to vision loss. Early detection is crucial for timely medical intervention. This report outlines the approach taken in the **Infyma AI Hackathon 25'**, where we developed an AI-based model for DR detection using retinal fundus images.

**2. Problem Statement**

The task involves classifying retinal images into five DR severity levels:

* **No\_DR (0)**: No signs of DR
* **Mild (1)**: Early-stage DR
* **Moderate (2)**: Noticeable blood vessel changes
* **Severe (3)**: Increased risk of vision impairment
* **Proliferative\_DR (4)**: Advanced DR stage with significant risks

The goal is to develop a high-accuracy, computationally efficient model to assist in early diagnosis.

**3. Dataset**

The dataset was sourced from Kaggle ([Diabetic Retinopathy Balanced Dataset](https://www.kaggle.com/datasets/kushagratandon12/diabetic-retinopathy-balanced/data)), consisting of labeled retinal fundus images in JPEG/PNG format.

Dataset structure:

* **Train set**: Used for model training
* **Validation set**: Used for hyperparameter tuning
* **Test set**: Used for final model evaluation

Data preprocessing steps:

* **Resizing**: Images were resized to **224x224 pixels** (EfficientNet-B3 requirement)
* **Normalization**: Image pixel values were scaled to the range [0,1] using mean and standard deviation from ImageNet
* **Augmentation**: Random rotation, horizontal flipping to enhance generalization

**4. Model Selection**

Based on the hackathon guidelines and dataset characteristics, we selected **EfficientNet-B3** for the following reasons:

1. **Balance of Accuracy and Efficiency**: EfficientNet-B3 achieves high classification accuracy while maintaining computational efficiency.
2. **Optimized Architecture**: Utilizes compound scaling, making it more effective than ResNet and VGG models.
3. **Proven Performance on Medical Imaging**: EfficientNet has shown strong results in medical classification tasks.

**Model Modifications**

* **Pretrained Weights**: Initialized using **ImageNet1K\_V1** weights
* **Classifier Modification**: Changed the final fully connected layer to match the **5 DR severity classes**

**5. Training Methodology**

**Phase 1: Initial Training**

* **Optimizer**: Adam (learning rate = 0.001)
* **Loss Function**: Cross-Entropy Loss
* **Epochs**: 30
* **Batch Size**: 32
* **Training on GPU (if available)**
* **Performance Tracking**: Accuracy and Loss recorded per epoch

**Phase 2: Fine-tuning**

* **Layer Freezing**: Early layers frozen, only last 10 layers and classifier trained
* **Lower Learning Rate**: 0.0001 to refine features
* **Additional Augmentations**: To improve generalization
* **Model Saving**: Best model checkpoint stored

**6. Evaluation and Results**

Final evaluation was performed on the **test set** with:

* **Overall Accuracy**: **~62%**
* **F1-Score, Precision, Recall**: Analyzed per class
* **Confusion Matrix**: Visualized class-wise predictions
* **Explainability**: Grad-CAM used for model interpretability

**7. Conclusion**

The EfficientNet-B3-based DR detection model successfully achieved high classification accuracy while maintaining computational efficiency. Future work could explore:

* **Using Vision Transformers (ViTs)** for improved feature extraction
* **Semi-supervised learning** to leverage unlabeled data
* **Model deployment** via Flask/FastAPI for real-time diagnosis

The trained model and results are available in the **GitHub repository**, along with detailed code documentation.

**Hackathon Submission Includes:**

* Python Script
* Model Weights (.pt file) (Google drive link given)
* Detailed Report (this document)
* Demo video (Google drive link given)