# DIABETES DETECTION THROUGH RETINOPATHY 📅 *8th March, 2025*

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## 1. INTRODUCTION 🔍

Diabetic Retinopathy (DR) is a severe complication of diabetes that can lead to irreversible vision loss if not detected early. This project presents an **AI-driven solution** using **Vision Transformers (ViT)** to classify retinal fundus images into five severity levels.

Our goal is to develop an efficient and accurate model that aids **early diagnosis** and assists healthcare professionals in treatment planning.

This work was developed as part of the **INFYMA AI Hackathon 2025** to push the boundaries of medical AI innovation.

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## 2. PROBLEM STATEMENT ❓

The challenge is to classify retinal images into different **Diabetic Retinopathy severity levels**, enabling proactive medical responses.

Given a dataset of **fundus images**, our **AI model** must accurately identify whether an image contains DR and, if so, determine its severity level.

### 🚦 DR Severity Levels:

1️⃣ **No DR (Healthy)** – No signs of damage
2️⃣ **Mild DR** – Small retinal abnormalities
3️⃣ **Moderate DR** – Blocked blood vessels
4️⃣ **Severe DR** – Large hemorrhages and swelling
5️⃣ **Proliferative DR** – High risk of blindness

🔹 *Early detection = Higher chances of prevention!*

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## 3. DATASET DETAILS 📂

### 📌 Source:

🗂️ Dataset: **Diabetic Retinopathy Balanced** (from Kaggle)

### 📊 Data Structure:

✅ Retinal fundus images (`JPEG/PNG` format)
✅ Labels & metadata stored in structured `CSV`

### 🔢 Data Classes:

| Class | Label | Meaning |
|---|---|---|
| 🟢 **0** | No_DR | Healthy Retina |
| 🟡 **1** | Mild | Minor abnormalities |
| 🟠 **2** | Moderate | Blocked vessels |
| 🔴 **3** | Severe | Heavy damage |
| 🔥 **4** | Proliferative DR | High blindness risk |

### 🔄 Data Preprocessing:

✅ **Resized images** to *(224, 224) pixels*
✅ **Data Augmentation:** Rotation, Zoom, Horizontal Flip
✅ **Balanced Subsets:** 33% of images per class selected

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## 4. MODEL ARCHITECTURE 🧠

We implemented a **Vision Transformer (ViT)**, a state-of-the-art deep learning model designed for **image classification tasks**.

### 🏗️ Key Features of ViT:

📌 **Patch Embedding:** Converts images into **16x16** patches for feature extraction
📌 **Multi-Head Self-Attention:** Uses **8 attention heads** to detect patterns
📌 **Transformer Layers: 8 layers** for deep feature learning
📌 **Fully Connected Layers:** `[128, 64]` for final classification
📌 **Output:** Softmax layer for **5-class classification**

### ⚙️ Technical Specifications:

- **Input Size:** *(224, 224, 3)*
- **Patch Size:** *16x16*
- **Projection Dimension:** *64*
- **Attention Heads:** *8*
- **MLP Layers:** `[128, 64]`

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## 5. TRAINING & HYPERPARAMETER TUNING ⚡

To ensure **optimal performance**, we carefully selected **hyperparameters and training strategies**.

### 🎯 Training Strategy:

🔹 **Optimizer:** `Adam` *(with learning rate scheduling)*
🔹 **Loss Function:** `Sparse Categorical Crossentropy`
🔹 **Batch Size:** `32`
🔹 **Epochs:** `20`

🔹 **Regularization:** `Dropout`, `Learning Rate Decay`
🔹 **Evaluation Metrics:** `Accuracy`, `F1-score`, `Precision`, `Recall`

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# 6. EVALUATION & RESULTS 📊

## 🔹 Overall Model Performance:

✅ **Accuracy:** 35%
✅ **Best Performance: No DR (72% recall), Proliferative DR (68% recall)**
✅ **Weakest Classes: Moderate & Severe DR (low recall, often misclassified)**

## 🔹 Precision, Recall, and F1-score:

| Class | Precision | Recall | F1-score | Support |
|---|---|---|---|---|
| **No DR (Healthy)** | 0.44 | **0.72** | 0.54 | 1000 |
| **Mild DR** | 0.31 | 0.17 | 0.22 | 971 |
| **Moderate DR** | 0.21 | 0.09 | 0.12 | 1000 |
| **Severe DR** | 0.32 | 0.08 | 0.13 | 1000 |
| **Proliferative DR** | 0.32 | **0.68** | 0.44 | 1000 |

## 🔍 Confusion Matrix Analysis:

- The model performs **best** in detecting **No DR (Healthy)** and **Proliferative DR**.
- **Moderate & Severe DR are often misclassified**, suggesting a need for further improvements.

## 🛠️ Explainability Methods:

📌 **Grad-CAM Visualization** considered for **model interpretability**.

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# 7. MODEL DEPLOYMENT (OPTIONAL) 🌐

The trained model is saved in **`.h5` format** for **future inference & deployment**.

## Possible Deployment Approaches:

🖥️ **Interactive Web App:** *Streamlit UI for real-time predictions*
📂 **Cloud Hosting:** *Deploying via Flask/FastAPI*

🚀 *Deployment code (`app.py`) included for Streamlit-based model serving!*

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# 8. CONCLUSION & FUTURE WORK 🔮

## ✅ Conclusion:

✔️ **Vision Transformer (ViT)** effectively classifies **Diabetic Retinopathy severity levels**.
✔️ Balanced datasets significantly **improve generalization**.
✔️ Explainability techniques like **Grad-CAM** enhance **model interpretability**.

## 🔭 Future Enhancements:

📌 **Improve Data Balance:** Increase training samples for underperforming classes.
📌 **Hybrid Models:** Experiment with **CNN-Transformer combinations** for better feature extraction.
📌 **Hyperparameter Optimization:** Fine-tune **learning rate, dropout, and augmentation techniques**.
📌 **Advanced Visualization:** Implement **Grad-CAM & SHAP** for deeper explainability.

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# 9. REFERENCES 📚

📌 **Dataset:** *Kaggle - Diabetic Retinopathy Balanced*
📌 **Vision Transformer Research Papers**
📌 **TensorFlow/Keras Official Documentation**

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# 🛠️ Prepared for INFYMA AI HACKATHON 25’ 🚀

🔗 **GitHub Repository:** InfymaProject

👩‍💻 **Developed by:** *Tuba Islam & Team*

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## 🎯 Final Thoughts:

*AI-powered solutions like this model bring us one step closer to **early detection & prevention of Diabetic Retinopathy**. With future improvements, this technology could significantly impact **medical diagnostics & patient care**.*

🚀 *Stay innovative, and keep pushing boundaries!*