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Faculty of Engineering, Environment and Computing School of Computing, Electronics and Mathematics

MSc. Data Science and Computational Intelligence
7151CEM
Computing Individual Research Project

Diabetic Retinopathy Detection Using Deep Learning

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I declare that a proposal for this project has been submitted to the Coventry University ethics monitoring website (https://ethics.coventry.ac.uk/) and that the application number is listed below (Note: Projects without an ethical application number will be rejected for marking)

Signed :

{AleenaAlby} Date:

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Last Name: Alby Student ID number Ethics Application Number 1st Supervisor Name Prof James Brusey 2nd Supervisor Name

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Introduction

One of the major causes of eye vision loss is diabetes. While delayed examination would have a higher effect on the retinal area of the eye, early detection of diabetes is crucial. The key factors affecting the rise in the occurrence of this disease are people's lifestyles and other contributing factors, and it is anticipated that this trend will continue. According to Tien Y Wong et al, among the 285 million diabetics worldwide, 33 percent of those individuals exhibit DR symptoms(R, Ty, and C 2015). Nearly 90% of individuals can be diagnosed, and long-term effects can be reduced, with thorough screening and regular checkups. The significant issue here is that DR is primarily an asymptomatic eye condition that does not manifest distinctive symptoms until a late stage is reached. The manual examination of retinal image features is a challenging and taxing task, nevertheless. Many automated diagnostic technologies have been created recently to help ophthalmologists examine retinal abnormalities, which has helped to solve this problem.

Background to the Project

Project Objectives

Can DL outperform other methods such as SVM, Logistic Regression, Decision Tree in producing a high performing classifier for DR on unseen data?

Overview of This Report

Literature Review

In recent years, numerous deep learning based automatic DR detection systems have emerged. In this section, some of the recent research projects have been addressed.

Using transfer learning, Esra Kaya and Ismail Saritas created CNN for the identification of diabetic retinopathy (Kaya and Saritas 2022). To find the best effective architecture, photographs from the DRIVE (Digital Retinal Images for Vessel Extraction) dataset of DR patients and healthy people were classified using Convolutional Neural Network (CNN) architectures as a transfer learning technique. They utilised contrast-limited adaptive histogram equalisation to improve the clarity of the image. They assessed the ResNet18, GoogleNet, and SqueezeNet CNN architectures' performances as feature extraction techniques and classifiers. For ResNet18 and squuezeNet, they employed adam optimizer, while for googleNet, they used sgdm. There are 71 layers in ResNet18, 144 layers in GoogleNet, and 68 layers in SqueezeNet. ResNet18 was discovered to be the most effective architecture as a classifier with 100% accuracy.

Fundus images from the Kaggle opensource dataset were used by Nikhil Sathya Kumar and Dr. B. Ramaswamy Karthikeyan to identify DR using CNNs, Transformers, and MLPs (Kumar and Ramaswamy Karthikeyan 2021). The dataset includes more than 3600 photographs with a resolution of 2416*1736. ResNet and EfficientNet based on CNN, Vision-Transformer and SwinTransformer based on Transformer, and MLP-Mixer based on MLP architecture were the models chosen for this study.The findings show that, in comparison to CNN and MLP based models, Transformer based models were more accurate. All models underwent 15 epochs of training. The most accurate Transformer-based model was Swin with 92.49% accuracy.

ImageNet model was proposed by Jayakumari.C et.al (Jayakumari, Lavanya, and Sumesh 2020). Here the TensorFlow framework is used to build a convolutional neural network model in Python. The size of each image has been reduced to 224 X 224 X 3. The model trained the network using the Adam optimizer and categorical cross-entropy as a loss function. The model was executed 100 epochs. The model accuracy in training was 98.8%, and in validation accuracy was 98.5%.

A CNN method was suggested by Frans Coenen et.al to diagnose DR with a sensitivity of 95 % and accuracy of 75% (Pratt et al. 2016).They train the network using a high-end graphics processor unit (GPU) on the publicly available Kaggle dataset.

Pathak et.al classified early-stage DR using a deep learning method (Pathak et al. 2021). They have employed a variety of classifier-based techniques, including SVM (Support Vector Machine), CNN (Convolution Neural Network), DCNN (Deep Convolution Neural Network), ANN (Artificial Neural Network), NB (Naive Bayes), and threshold-based strategies. The model achieved 90% accuracy for the SVM, 91% for the ANN, 92.9% for the NB, 97% for the Thresholding-Based, and 96.5% for the DCNN. They concluded that the DCNN technique is highly accurate and productive.

Table 2: DR detection methods

Methods & Ref	Datasets Used	Techniques	Performance metrics
CNN (Kaya and Saritas 2022)	DRIVE dataset (40 images in the database were chosen randomly from 400 images)	They assessed the ResNet18, GoogleNet, and SqueezeNet	ResNet18 - 100 %, GoogleNet - 68.2 %, SqueezeNet - 67.4 %
CNN, **MLP & Transfomer** (Kumar and Ramaswamy Karthikeyan 2021)	Aptos dataset from Kaggle (6590 Images)	EfficientNet, ResNet, MLP-Mixer, ViT , ViT+MLP, Swin and Swin+ViT	EfficientNet -91.18 %, ResNet - 89.63%, MLP-Mixer - 94.47%, ViT - 91.13 %, ViT+MLP - 89.73%, Swin - 92.49%, Swin+ViT - 91.91 %
ImageNet (Jayakumari, Lavanya, and Sumesh 2020)	Kaggle Dataset	ImageNet	98.6%
CNN (Pratt et al. 2016)	Kaggle Dataset (80,000 Images)	CNN	75%
SVM classifier-Based technique, CNN classifier, DCNN classifier, ANN classifier, NB classifier, Thresholding Based techniques.(Pathak et al. 2021)	Indian Diabetic Retinopathy Image Dataset (IDRiD), High-Resolution Fundus (HRF) Image Database, Kaggle dataset	Using a classifier-based SVM (Support Vector Machine) method, Convolution neural network classifiers, DCNN (deep convolution neural network) classifiers, artificial neural network classifiers, naive bayes classifiers, and threshold-based methods are examples of classifiers.	SVM - 90% CNN - Best ANN - 91% NB - 92.6% Thresholding Based -97% DCNN - 96.5%

Methodology

The software development life cycle involves using common business procedures for creating software applications. After carefully examining a few well-known models, including Waterfall, Iterative, V-Model, and Agile approach, I have chosen to adopt the Agile model in this study.

Agile Methodology

Agile is a method of software development that aims to provide functional software consistently through rapid iterations ("What Is Agile Methodology?" 2022). An agile methodology emphasizes a cooperative, iterative, and incremental approach to project management.

1. **Better quality**
2. **Speed and flexibility**
3. **cost management**

   The team consider the budget when making decisions after each stage.This is a crucial component of project management since it enables teams to comprehend the expenses associated with each feature, which will be taken into consideration when making strategic decisions.
4. **Project's progress is fully visible and updated in real-time**
5. **stakeholders' participation**

Dataset

This study using dataset available at Kaggle("Diabetic Retinopathy Detection" 2015). This Retinal images were provided by EyePACS. The dataset containing large set of high-resolution retina images taken under a variety of imaging conditions. For each image, a left and right field is provided. Images are identified by a image id and either the left or right eye (for example, 1 left.jpeg represents the patient number 1's left eye).

Table 3: ("Diabetic Retinopathy - Stages" 2017)

DR classes	Level	Description
No DR	0	Healthy Retina (Normal)
Mild	1	Retina with tiny bulges (microaneurysms)
Moderate	2	Retina with microaneurysms, higher risk of developing vision problems in the future
Severe	3	Retina with severe and widespread microaneurysms, including bleeding into the retina
Proliferative	4	New blood vessels and scar tissue have formed on your retina, which can cause significant bleeding and lead to retinal detachment

Data pre-processing

Image pre-processing was performed with the aim to decrease unclear image and reduce image size. The plot below illustrates the class imbalance in the original dataset.

The dataset consist of 35,126 set of images. The orginal image have 1944 * 2592 * 3 size, and all images are jpeg format. The classes have an uneven distribution of images.

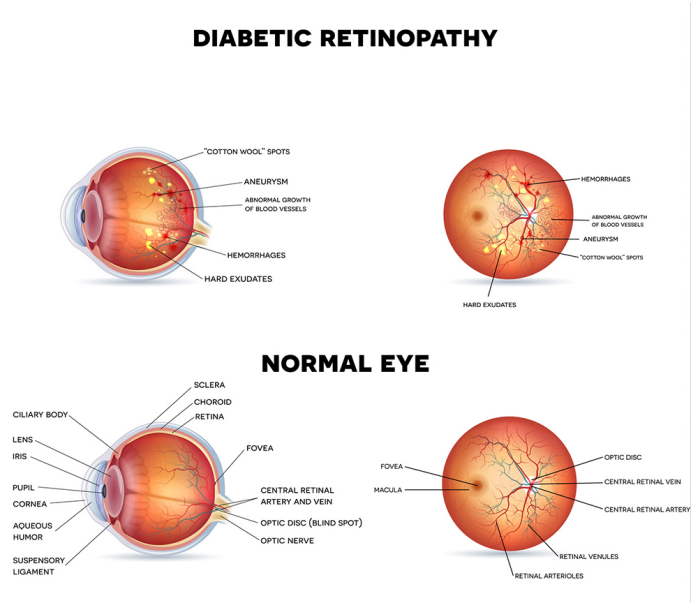

Figure 1: Normal Retina Vs Diabetic Retinopathy Retina ("Diabetic Retinopathy Vs Normal," n.d.)

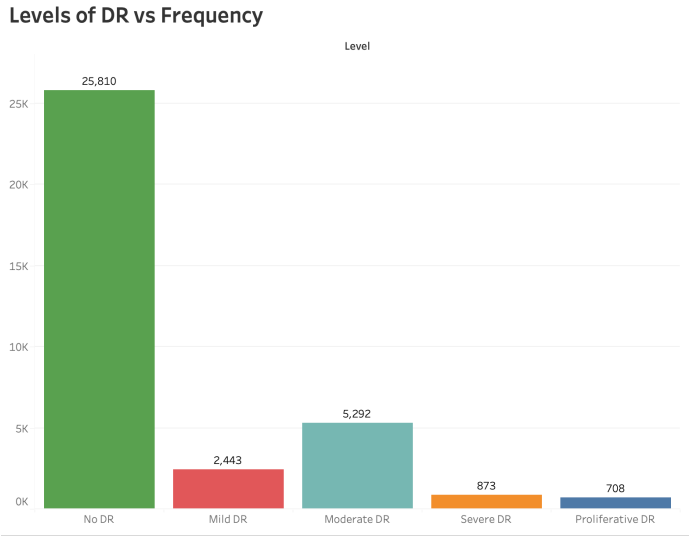

Figure 2: Sum of number of records for each level

1. Image Resizing

   Due to the enormous size of the dataset, it was drastically downsized before being sent to the network. Each input image is 256 * 256 in size after resizing.

2. Removing Unclear Image

   Some images have a blackish or white tint. Because it might affect the outcome, this type of image cannot be fed into the network. The removal of an unclear image is a crucial step that must be taken.

3. Dividing images into classes

   Images are classified into 5 folders based on the DR levels.

This section reviews numerous approaches and methods for various classifiers.

Requirements

System Requirements

Table 4: System Configuration

System Type	64 bit
OS Name	Mac os mojave
Processor	Intel Core i5
Installed Physical Memory (RAM)	8 GB

Analysis

Design

Implementation

Testing

Project Management

Project Schedule

Risk Management

Quality Management

Social, Legal, Ethical and Professional Considerations

Critical Appraisal

Conclusions

Achievements

Future Work

Student Reflections

References

"Diabetic Retinopathy - Stages." 2017. https://www.nhs.uk/conditions/diabetic-retinopathy/stages/.

"Diabetic Retinopathy Detection." 2015. https://kaggle.com/competitions/diabetic-retinopathy-detection.

"Diabetic Retinopathy Vs Normal." n.d. https://www.advancedretinaassociates.com/patient-education/diabetic-retinopathy/.

Jayakumari, C., Vidhya Lavanya, and E P Sumesh. 2020. "Automated Diabetic Retinopathy Detection and Classification Using ImageNet Convolution Neural Network Using Fundus Images." In *2020 International Conference on Smart Electronics and Communication (ICOSEC)*, 577–82. https://doi.org/10.1109/ICOSEC49089.2020.9215270.

Kaya, Esra, and Ismail Saritas. 2022. "Performances of CNN Architectures on Diabetic Retinopathy Detection Using Transfer Learning." In *2022 57th International Scientific Conference on Information, Communication and Energy Systems and Technologies (ICEST)*, 1–4. https://doi.org/10.1109/ICEST55168.2022.9828576.

Kumar, Nikhil Sathya, and B. Ramaswamy Karthikeyan. 2021. "Diabetic Retinopathy Detection Using CNN, Transformer and MLP Based Architectures." In *2021 International Symposium on Intelligent Signal Processing and Communication Systems (ISPACS)*, 1–2. https://doi.org/10.1109/ISPACS51563.2021.9651024.

Pathak, Ketki C., Riddhi B. Shah, Reshma R. Tharakan, Bhavya N. Patel, and Dhruvi C. Jariwala. 2021. "Diabetic Retinopathy Diagnosis and Categorization Using Deep Learning - a Review." In *2021 5th International Conference on Intelligent Computing and Control Systems (ICICCS)*, 1063–69. https://doi.org/10.1109/ICICCS51141.2021.9432312.

Pratt, Harry, Frans Coenen, Deborah M Broadbent, Simon P Harding, and Yalin Zheng. 2016. "Convolutional Neural Networks for Diabetic Retinopathy." *Procedia Computer Science* 90: 200–205.

R, Lee, Wong Ty, and Sabanayagam C. 2015. "Epidemiology of Diabetic Retinopathy, Diabetic Macular Edema and Related Vision Loss." *Eye and Vision (London, England)* 2 (September). https://doi.org/10.1186/s40662-015-0026-2.

"What Is Agile Methodology?" 2022. https://www.redhat.com/en/topics/devops/what-is-agile-methodology.

Appendix A – Project Specification

Appendix B – Interim Progress Report and Meeting Records

Appendix C – Requirements Specification Document

Appendix D – User Manual

Appendix E – Project Presentation

Appendix F – Certificate of Ethics Approval