MACHINE LEARNING APPROACH TO DETECT & ANNOTATE EYE DISEASES USING RETINAL IMAGES

Project ID: TMP-23-162

Project Proposal Report

Perera H. A. N. S

B. Sc. (Hons) Degree in Information Technology

(Specialization in Software Engineering)

Department of Information Technology

Sri Lanka Institute of Information Technology

Sri Lanka

March 2023

MACHINE LEARNING APPROACH TO DETECT & ANNOTATE EYE DISEASES USING RETINAL IMAGES

Project ID: TMP-23-162

Project Proposal Report

Perera H. A. N. S – IT20166106

Supervised by: Mrs. Devanshi Ganegoda

Co-supervised by: Mr. Jeewaka Perera

B. Sc. (Hons) Degree in Information Technology

(Specialization in Software Engineering)

Department of Information Technology

Sri Lanka Institute of Information Technology

Sri Lanka

March 2023

DECLARATION

I declare that this is our own work, and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. Also, I hereby grant to Sri Lanka Institute of Information Technology, the nonexclusive right to reproduce and distribute my dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

Name	Student ID	Signature
Perera H. A. N. S	IT20166106	

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

Signature of the supervisor Date

…… ……..

(Ms. Devanshi Ganegoda)

ABSTRACT

Preventing irreversible vision loss and improving patient outcomes depend on the early detection and accurate diagnosis of eye diseases. Machine learning has recently become a promising tool for examining retinal images to find conditions and assist in diagnosis.

This report presents a novel method for classifying retinal images that show signs of diabetic retinopathy. To increase the correctness and dependability of the existing model, the proposed method optimizes its parameters and adds new functionalities. The study trains and validates the algorithm's performance using a significant dataset of labeled retinal images.

The difficulty of resource-intensive continuous monitoring of DR is also covered in the report. To lessen the strain on healthcare systems and enhance patient outcomes, the study explores the potential of healthcare and mobile health technologies for remote screening and monitoring of DR.

Overall, this research provides a more effective and reliable machine-learning method to detect diabetic retinopathy at early stages. The suggested approach will significantly impact how well people with diabetes live their lives and how much of a financial burden diabetic retinopathy is on healthcare systems. It can also act as a base for creating scalable and solutions for continuous DR monitoring.

TABLE OF CONTENTS

DECLARATION 3

ABSTRACT 4

1. INTRODUCTION 8

1.1. Literature Survey 10

1.2. Research Gap 12

1.3. Research Problem 13

2. OBJECTIVES 14

2.1. Main Objectives 14

2.2. Sub Objectives 14

3. METHODOLOGY 15

3.1. The System Overview Diagram 16

4. REQUIREMENTS 17

4.1. Functional Requirements 17

4.2. Nonfunctional Requirements 17

5. GANTT CHART 18

6. WORK BREAKDOWN STRUCTURE 19

7. BUDGET AND BUDGET JUSTIFICATION 20

8. APPENDICES 21

REFERENCE LIST 22

LIST OF FIGURES

Figure 1: System Overview Diagram 16
Figure 2: Gantt Chart 18
Figure 3 : Work Breakdown Structure 19
Figure 4: Similarity Score 21

LIST OF TABLES

Table 1: Results of former research..... 11
Table 2 : Budget for the proposed system..... 20

1. INTRODUCTION

The human eye is a key organ in processing visual information by detecting and interpreting light stimuli. In addition to being vital, this sensory organ is also delicate and needs gentle handling. It is likely to be impacted from a wide range of diseases and disorders, causing irreversible damages to the eye. Thus, early diagnosis is crucial in coping these diseases, prevent its progression and to preserve the patient's vision. Eye conditions like Diabetic Retinopathy (DR) and Age-related Macular Degeneration (AMD) are prevalent conditions that lead to significant vision loss and, in some cases, visual impairments. However, the focus of this report will be on a modified approach to detect signs of DR with higher accuracy in retinal fundus image using machine learning.

Diabetic retinopathy is one of most dangerous complication of diabetes. Also, the fourth foremost cause of blindness and the fifth most common cause of visual impairment worldwide[1]. The condition occurs when the blood vessels in the retina are damaged because of increasing levels of sugar in the bloodstream. It may eventually result in vision loss, if poorly controlled. A survey carried out by the World Health Organization found 4.2 million people around earth have diabetic retinopathy as a main cause of their visual impairment. Type 1 or type 2 diabetes patients are at risk to getting diabetic retinopathy, and the risk rises with duration of diabetic diagnosis and deficient blood glucose control.

Manual inspection of retinal fundus image to recognize diabetic retinopathy by eye specialists is complex and time-consuming process that demands highly trained and experience. Also, since the manual inspection process is depending on the availability of resources, it can be restricted to certain geographical areas as well as entities with more financial capabilities. Specially, as third world countries like Sri Lanka have limited public healthcare services, manual inspection process can increase the workload on specialists, prevent them from focusing on severe cases.

To overcome the challenges in the process of manual inspection, several research studies have been carried out to automate the process of diabetic retinopathy detection using various approaches. In recent years, the field of medical imaging has seen auspicious developments in the use of machine learning (ML), especially in automating the process

of detection and diagnosis of eye diseases such as diabetic retinopathy. Therefore, it is vital to develop algorithms that are more precise and credible for accurately detecting early indicators of diabetic retinopathy.

The proposed study aims to develop a novel method for classifying retinal images that show signs of diabetic retinopathy. We hope to achieve a more accurate and reliable method for detecting early signs of diabetic retinopathy by incorporating additional functionalities and optimizing the existing model's parameters.

This section discusses the key points of the literature survey related to diabetic retinopathy, current detection algorithms, research conducted on the area, research gaps in the conducted research by analyzing them, and the main research problem that is being addressed by developing the proposed system.

1.1. Literature Survey

Diabetic retinopathy is a significant cause of blindness globally, affecting millions of people. Therefore, early detection and diagnosis are crucial for preventing further deterioration of vision. Over the past few years, the application of machine learning models has demonstrated significant potential in the accurate identification and diagnosis of diabetic retinopathy using retinal images. In this literature survey, we will review the most relevant research studies on the development of novel methods for classifying retinal images that show signs of diabetic retinopathy.

In the year 2019, S M Asiful Huda, Ishrat Jahan Ila, Shahrier Sarder, Md. Shamsujjoha, Md. Nawab Yousuf Ali proposed an improved machine learning & feature importance algorithms for detection of Diabetic Retinopathy [2]. Decision Tree, Logistic Regression, & SVM is used in their proposed system. A dataset containing nearly 15945 retinal fundus images along with 66 features associated were collected for developing the model. The model achieved a precision of 97% and a recall of 92%, which shows a notable contrast with respect to existing results, 72% and 63% outcome.[3]–[5].

Akanksha Soni et al. (2021) in their paper "A Novel Approach for the Early Recognition of Diabetic Retinopathy using Machine Learning" developed a multi-task deep learning model that use k-mean clustering, Support Vector Machine (SVM) & Random Forest classification algorithm to recognize diabetic retinopathy using retinal images [6]. The model achieves a recognition rate of 96.2% that is a competent & stable outcome compared to SVM.

Qomariah D U N et al. in year 2019 presented a deep learning approach to extracting features & classification using SVM & CNN [7]. The proposed approach is tested on 77 retinal images from Messidor's base 12 and 70 retinal images from base 13 databases. Alexnet, VggNet, InceptionNet, GoogleNet, DenseNet, and Resnet was used in this tudy to gain the feature vector for classification. The result of the experiment shows 95.83% & 95.24% as the highest accuracy values for base 12 & 13 respectively.

Mahendran Gandhi and Dr. R. Dhanasekara in their research paper "Diagnosis of Diabetic Retinopathy Using Morphological Process and SVM Classifier" published in year 2013

used SVM classifier along with Morphological processes to access the severity of diabetic retinopathy [8]. This paper presents an accuracy of 96.67% in classifying the severity of DR.

Table below depicts some of the percentages of sensitivity, specificity and accuracy acquired using different approaches.

Method	**Sensitivity (%)**	**Specificity (%)**	**Accuracy (%)**
FCM clustering and SVM [9]	97.5	97.8	97.7
Feature fusion from Inception-v3, ResNet-50, and VGGNet-19 models [10]	-	-	98.91
DCNN Feature + SVM [11]	-	-	86.1
Adaptive histogram equalization, Gabor, Top-hat, 1iterative thresholding approach [12]	96.7	91.4	94.1
Custom convolutional neural network [13]	90	87	-
R-sGAN technique [14]	79.01	97.95	-
Handcraft feature, CNN and Random Forest classifier [15]	97.2	-	93.4
CNN architecture [16]	-	93.65	83.68

Table 1: Results of former research

1.2. Research Gap

Even though various research has been conducted in this field and a few technologies have been implemented, the improvements of the outcomes are crucial since the research is based on medical industry. However, the existing research have some limitations in terms of accuracy, sensitivity, specificity, false-positive rates and so on. Additionally, some research were conducted using complex feature engineering methods, which is time-consuming and not generalize well to new datasets. Furthermore, methods that can give priority to Diabetic Retinopathy early detection are needed.

The need for more reliable and scalable methods that can deal with variations in image quality, such as low resolution, noise, and artifacts, is another research gap. Several approaches currently use to produce high-quality images, which may not be accessible in practical situations. As a result, methods are required that can handle noisy or poor-quality images without reducing accuracy.

An accurate and trustworthy tool is required for detecting early signs of DR can significantly improve patient outcomes by enabling early detection and lowering the risk of blindness. The proposed system can also aid healthcare providers in resource optimization and increased DR screening program effectiveness. The workload of healthcare professionals can also be reduced, freeing them up to concentrate on other important tasks. As a result, incorporating the developed tool into the medical field may offer significant practical benefits, including better patient outcomes, lower healthcare costs, and more efficient use of available resources. Additionally, the incorporation of such a tool can help to standardize DR screening, ensuring that patients get consistent, high-quality care regardless of where they live or how many resources are available to them.

1.3. Research Problem

Despite the fact that there have been various attempts to automate the process of diabetic retinopathy detection using machine learning, a more accurate and reliable method for early recognition of diabetic retinopathy is still required in order to enable early diagnose and treatment. In order to increase the accuracy and reliability of automated detection and diagnosis of the condition, the research aims to produce a novel approach for classifying retinal images that exhibit symptoms of diabetic retinopathy. The method will include additional functionalities and optimize the existing model's parameters to improve its outcomes.

The significance of the proposed study is that it has the ability to offer a more effective and reliable method of identifying early indicators of diabetic retinopathy. Automated diagnosing using machine learning can help in achieving this goal by reducing the risk of severe vision loss and blindness through early detection and intervention.

For early detection, continuous monitoring of diabetic retinopathy is essential, particularly in patients who have a high risk of the condition progressing. However, this requires a significant investment of time, workforce, and resources. It is difficult to implement continuous monitoring of DR in all diabetic patients due to the constrained resources of the current healthcare system. As a result, many DR cases go undiagnosed, which causes severe vision loss and eventual blindness.

2. OBJECTIVES

The aim of the proposed research is to implement a novel machine learning algorithm to detect the symptoms of Diabetic Retinopathy using retinal images in order to improve the accuracy of outcomes for better diagnosis.

2.1. Main Objectives

The motive of this component is to improve the diagnosis process and optimize the outcomes to aid both ophthalmologists and patients. Since DR diagnose process requires continuous monitoring, this approach will reduce the resource usage and expertise workload at a high level. Therefore, the main aim of the research study is to overcome the drawbacks of recent research and come up with a accurate and effective approach.

2.2. Sub Objectives

In addition to the main objectives, there are some specific objectives related to the implementation.

- Preprocess retinal fundus image
- Noise Removal and standardization of the image
- Extract features of the retina to identify the signs
- Analyze the features
- Prepare datasets of retinal fundus images
- Select a model architecture (Ex: SVM, CNN)
- Train the model
- Evaluate the performance of the model
- Analyze the metrics such as precision, accuracy, training time, resource allocation etc.

3. METHODOLOGY

Based on the outcomes of the literature survey conducted, it is important to automate the detection process of Diabetic Retinopathy to minimize the risk of the patients. Diabetic patients have to undergo continuous monitoring to determine they have a risk of Diabetic Retinopathy. The proposed system has three main stakeholders: Diabetic patients and eye specialists and healthcare providers such as private and state hospitals.

The research study aims on developing a system to provide early and easy detection of DR using machine learning and image processing techniques. Here, the image data will be pre-processed before extracting the features. This component of the system performs its process in several steps. Such as

- Image – orientation
- Resizing
- Convert the image into a Grayscale image
- Contrast Enhancement
- Remove noise, if any

Feature Extraction component is used to obtain the Region of Interest (ROI) from the retinal image. Technologies like Convolutional Neural Networks (CNN), Local Binary Patterns (LBP), Gabor Wavelets, Scale-Invariant Feature Transform (SIFT), and Histogram of Oriented Gradients (HOG) are commonly used in extracting features from retinal images over the past years. Various studies that used deep learning approaches, mainly Convolutional Neural Networks (CNNs), have achieved high accuracy in detecting DR in retinal images.

Machine learning Algorithms like Random Forest (RF) and Support Vector Machine (SVM) can be used to train and evaluate the performance od the classification model. These algorithms have shown promising results in medical image analysis, including Diabetic Retinopathy.

3.1. The System Overview Diagram

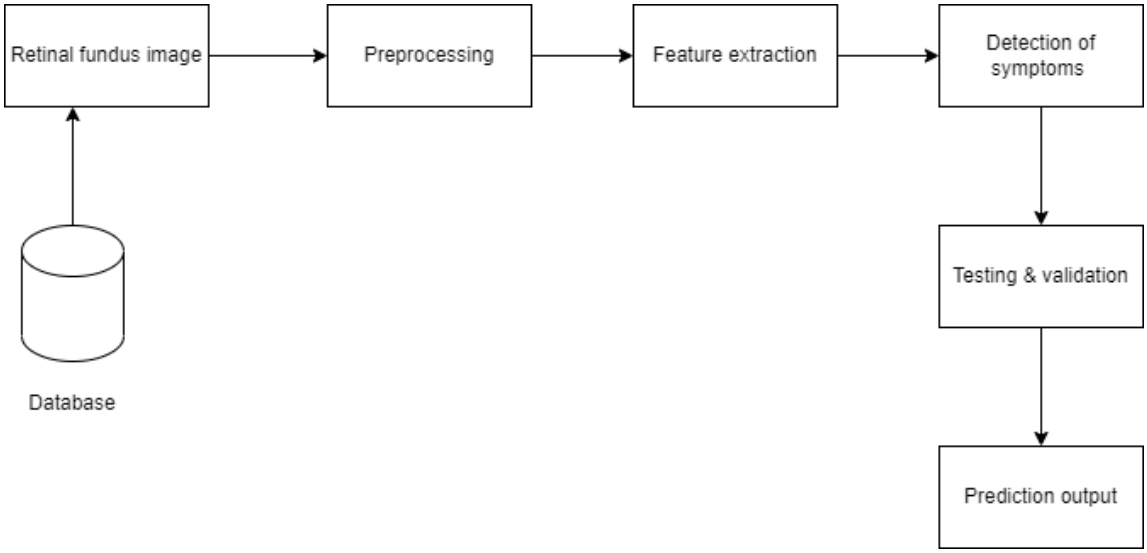

Figure 1: System Overview Diagram

4. REQUIREMENTS

4.1. Functional Requirements

- Preprocessing retinal fundus image
- Accurate classification of Diabetic Retinopathy
- Feature extraction
- Low resource consumption

4.2. Nonfunctional Requirements

- Accuracy
- Accessibility
- Usability
- Performance
- Data Security

5. GANTT CHART

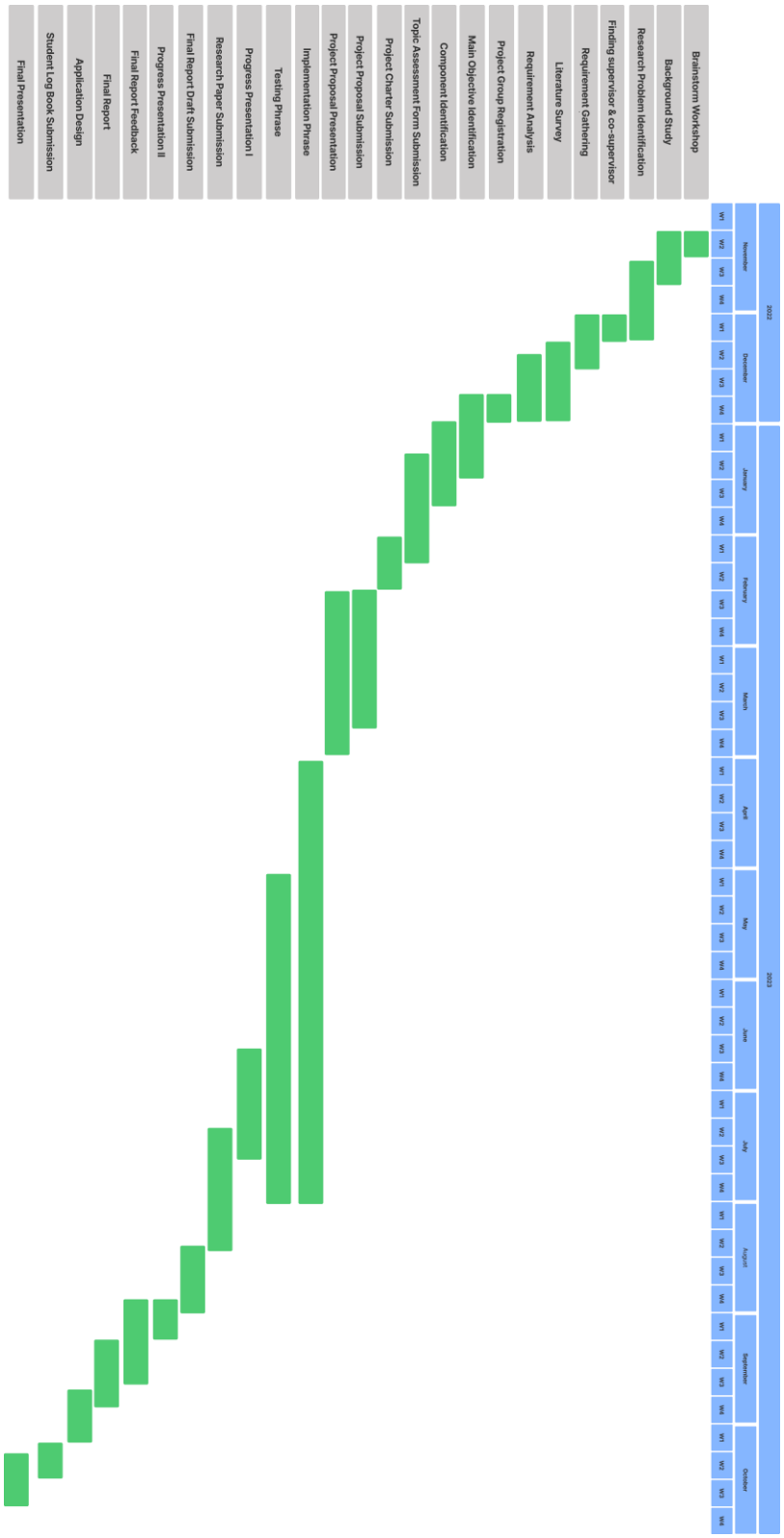

Figure 2: Gantt Chart

6. WORK BREAKDOWN STRUCTURE

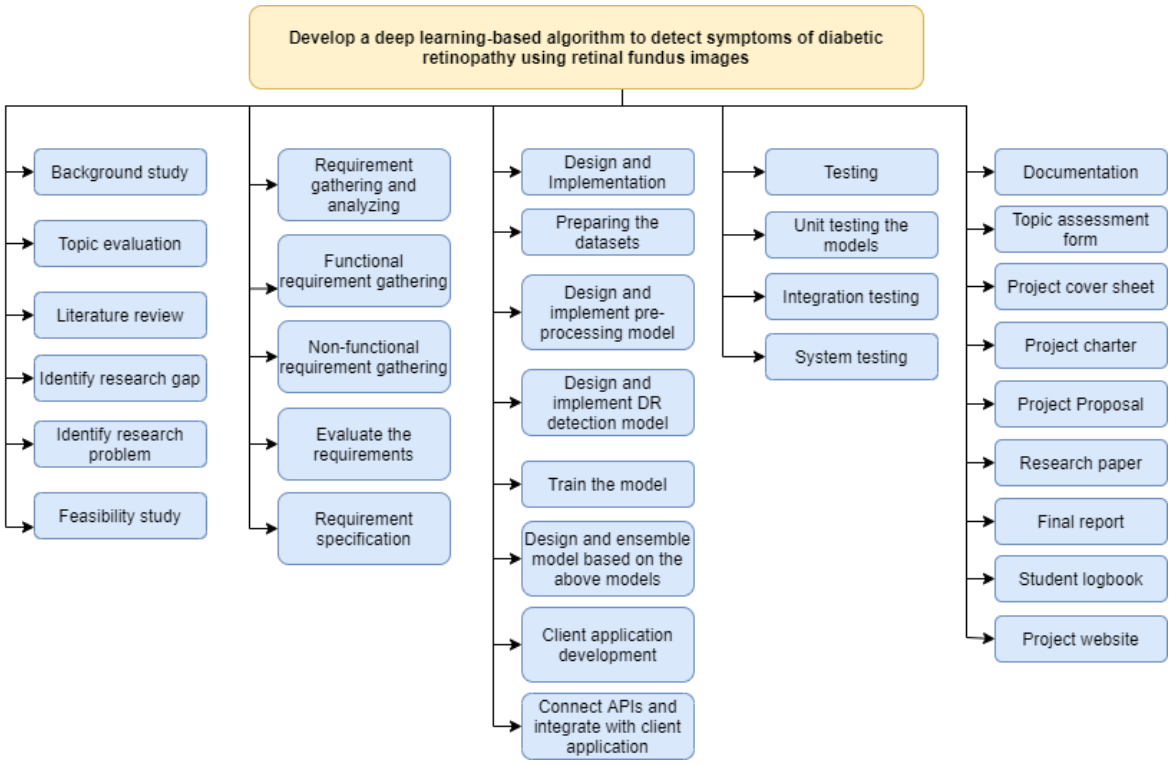

Figure 3 : Work Breakdown Structure

7. BUDGET AND BUDGET JUSTIFICATION

The budget allocation for various resource types according to the requirements of the research are listed below.

Task	**Cost (Rs.)**
Hosting	7000
Backups	5000
Testing	2000
Marketing	5000
Other	2000
Total Cost	**21000**

Table 2 : Budget for the proposed system

8. APPENDICES

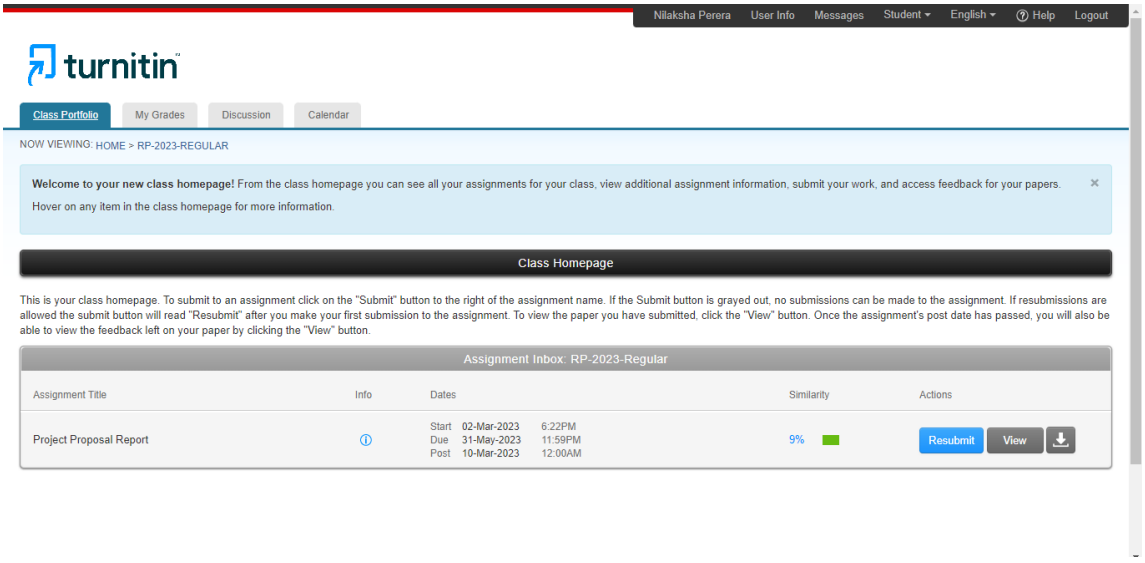

Figure 4: Similarity Score

REFERENCE LIST

[1] *Tool for the assessment of diabetic retinopathy and diabetes management systems*. 2015. [Online]. Available: www.who.int

[2] Institute of Electrical and Electronics Engineers, *2019 7th International Conference on Smart Computing & Communications (ICSCC).*

[3] M. Bihis and S. Roychowdhury, "A generalized flow for multi-class and binary classification tasks: An Azure ML approach," in *Proceedings - 2015 IEEE International Conference on Big Data, IEEE Big Data 2015*, Institute of Electrical and Electronics Engineers Inc., Dec. 2015, pp. 1728–1737. doi: 10.1109/BigData.2015.7363944.

[4] S. C. Lee, E. T. Lee, Y. Wang, R. Klein, R. M. Kingsley, and A. Warn, "Computer Classification of Nonproliferative Diabetic Retinopathy." [Online]. Available: https://jamanetwork.com/

[5] R. Acharya U *et al.*, "Automated Identification of Diabetic Type 2 Subjects with and without Neuropathy Using Wavelet Transform on Pedobarograph," *J Med Syst*, vol. 32, no. 1, pp. 21–29, 2008, doi: 10.1007/s10916-007-9103-y.

[6] A. Soni and A. Rai, "A Novel Approach for the Early Recognition of Diabetic Retinopathy using Machine Learning," in *2021 International Conference on Computer Communication and Informatics, ICCCI 2021*, Institute of Electrical and Electronics Engineers Inc., Jan. 2021. doi: 10.1109/ICCCI50826.2021.9402566.

[7] I. F. of I. and C. Technology. D. of I. Institut Teknologi 10 Nopember (Surabaya and Institute of Electrical and Electronics Engineers, *Proceedings of 2019 International Conference on Information & Communication Technology and Systems (ICTS) : Surabaya, July 18th, 2019*.

[8] M. Gandhi and R. Dhanasekaran, "Diagnosis of diabetic retinopathy using morphological process and SVM classifier," in *International Conference on Communication and Signal Processing, ICCSP 2013 - Proceedings*, 2013, pp. 873–877. doi: 10.1109/iccsp.2013.6577181.

[9] S. Long, X. Huang, Z. Chen, S. Pardhan, D. Zheng, and F. Scalzo, "Automatic detection of hard exudates in color retinal images using dynamic threshold and SVM classification: Algorithm development and evaluation," *Biomed Res Int*, vol. 2019, 2019, doi: 10.1155/2019/3926930.

[10] M. Mateen, J. Wen, M. Hassan, N. Nasrullah, S. Sun, and S. Hayat, "Automatic Detection of Diabetic Retinopathy: A Review on Datasets, Methods and Evaluation Metrics," *IEEE Access*, vol. 8, pp. 48784–48811, 2020, doi: 10.1109/ACCESS.2020.2980055.

[11] Y. H. Li, N. N. Yeh, S. J. Chen, and Y. C. Chung, "Computer-Assisted Diagnosis for Diabetic Retinopathy Based on Fundus Images Using Deep Convolutional Neural Network," *Mobile Information Systems*, vol. 2019, 2019, doi: 10.1155/2019/6142839.

[12] K. Adem, M. Hekim, and S. Demir, "Detection of hemorrhage in retinal images using linear classifiers and iterative thresholding approaches based on firefly and particle swarm

optimization algorithms," *Turkish Journal of Electrical Engineering and Computer Sciences*, vol. 27, no. 1, pp. 499–515, 2019, doi: 10.3906/elk-1804-147.

[13] G. T. Zago, R. V. Andreão, B. Dorizzi, and E. O. Teatini Salles, "Diabetic retinopathy detection using red lesion localization and convolutional neural networks," *Comput Biol Med*, vol. 116, p. 103537, Jan. 2020, doi: 10.1016/J.COMPBIOMED.2019.103537.

[14] H. Zhao, H. Li, S. Maurer-Stroh, Y. Guo, Q. Deng, and L. Cheng, "Supervised segmentation of Un-annotated retinal fundus images by synthesis," *IEEE Trans Med Imaging*, vol. 38, no. 1, pp. 46–56, Jan. 2019, doi: 10.1109/TMI.2018.2854886.

[15] J. I. Orlando, E. Prokofyeva, M. del Fresno, and M. B. Blaschko, "An Ensemble Deep Learning Based Approach for Red Lesion Detection in Fundus Images," Jun. 2017, [Online]. Available: http://arxiv.org/abs/1706.03008

[16] G. García, J. Gallardo, A. Mauricio, J. López, and C. Del Carpio, "Detection of Diabetic Retinopathy Based on a Convolutional Neural Network Using Retinal Fundus Images," 2017, pp. 635–642. doi: 10.1007/978-3-319-68612-7_72.