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

Project ID: TMP-23-162

Project Proposal Report

Muthukumarana M.W.A.N.C

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

Muthukumarana M.W.A.N.C

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 my 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 my 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.

Name	Student ID	Signature
Muthukumarana M.W.A.N.C	IT20227890	

The above candidate is carrying out research for the undergraduate Dissertation under my supervision

Signature of the supervisor Date

……………………………… ………………………..

(Mrs. Devanshi Ganegoda)

Signature of the co-supervisor Date

……………………………… ………………………..

(Mr. Jeewaka Perera)

ABSTRACT

Age-related macular degeneration (AMD) is a severe eye condition that can lead to significant loss of vision in people fifty or older. Optical coherence tomography (OCT) is an effective imaging modality for diagnosing AMD. However, manual analysis of OCT images can be time-consuming, leading to a need for automated methods for AMD detection.

This study proposes a deep learning algorithm for the automated detection of AMD from OCT images. Our approach combines two existing models and includes preprocessing techniques to enhance the image quality. The deep learning algorithm was trained and validated on a diverse dataset of OCT images, including both normal and AMD cases.

We will also develop an application that allows clinicians to upload and scan OCT images for AMD detection, integrating the trained model for real-time analysis. The application's performance was evaluated in a clinical setting involving ophthalmologists and patients. Our outcomes show that the proposed algorithm achieved high accuracy and sensitivity in classifying OCT images as normal or AMD. The application was user-friendly, efficient, and secure and received positive feedback from clinicians and patients.

Overall, this research provides a promising method for the automated detection of AMD using OCT imaging, which can enhance the efficiency and accuracy of diagnosis and treatment for this debilitating disease.

TABLE OF CONTENTS

DECLARATION 3
ABSTRACT 4
1. INTRODUCTION 8
1.1. Literature survey 9
1.2 Research Gap 11
2. RESEARCH PROBLEM 12
3. RESEARCH OBJECTIVES 13
3.1. Main Objectives 13
3.2. Sub Objectives 13
4. METHODOLOGY 14
4.1. System Diagram 15
5. REQUIREMENTS 16
5.1. Functional requirements 16
5.2. Non-Functional requirements 16
6. GANTT CHART 17
7. WORK BREAKDOWN STRUCTURE 18
8. BUDGET AND BUDGET JUSTIFICATION 19
REFERENCE LIST 20
Appendices 21

LIST OF FIGURES

Figure 1 : System Diagram 15
Figure 2 : Gantt Chart... 17
Figure 3 : Work Breakdown Structure 18
Figure 4: Similarity score.. 21

LIST OF TABLES

Table 1 : Budget and Budget Justification.. 19

1. INTRODUCTION

Eye diseases have become a significant global public health concern due to their high prevalence and impact on people's quality of life. Age-related macular degeneration (AMD) and diabetic retinopathy are numerous debilitating eye diseases. Diabetic retinopathy is a factor of diabetes that impacts the retina and causes blindness. At the same time, AMD is a progressive degeneration of the macula, which is liable for central vision.

Age-related macular degeneration is an eye disease impacting the macula, a tiny area at the retina's centre liable for sharp, central vision. Age-related macular degeneration is the major reason for vision loss in individuals over 50 in developed countries. Early detection and intervention are critical to delay the progression of AMD and can prevent vision loss. OCT imaging is a non-invasive, high-resolution imaging approach that can provide detailed retina images, including macula.

Early detection and timely treatment of these conditions are essential to prevent irreversible damage to the eyes and preserve vision. However, traditional diagnosis and monitoring methods are time-consuming, expensive, and often require highly skilled ophthalmologists. Therefore, there is an acute need for more efficient and accurate tools to detect and annotate eye diseases, especially in low-resource settings where access to specialist care is limited.

Machine learning has emerged as an excellent approach to addressing these challenges by enabling automated analysis and interpretation of retinal images. Recently, machine-learning algorithms have been used to detect and annotate diabetic retinopathy and age-related macular degeneration. These algorithms have demonstrated high accuracy and speed, making them suitable for large-scale screening programs and clinical settings.

In this research, I will develop and evaluate a deep-learning algorithm that can accurately classify OCT images as usual or showing signs of Age-related macular degeneration. Specifically, we will investigate using deep-learning based algorithms like convolutional neural networks (CNN) to analyze retinal images and automatically identify symptoms of these diseases.

1.1. Literature survey

Eye diseases, particularly diabetic retinopathy and age-related macular degeneration are the significant causes of blindness worldwide. Treatment and Early detection of these diseases are vital for preventing vision loss and improving the quality of life of affected individuals. In recent years, medical imaging technology and machine learning have provided new opportunities for efficient and accurate screening and diagnosis of eye diseases. This literature survey aims to provide an overview of the current knowledge on machine learning for detecting and annotating eye diseases using retinal images, explicitly focusing on classifying OCT images as usual or showing signs of age-related macular degeneration.

The literature survey identified several machine-learning approaches for detecting and annotating eye diseases using retinal images. Specifically, deep-learning models like convolutional neural networks (CNN) have shown optimistic results for classifying OCT images as usual or showing signs of age-related macular degeneration. Those models are trained on large datasets of annotated OCT images and can accurately detect subtle changes in the retinal layers that indicate the existence of age-related macular degeneration.

In recent studies, detecting and classifying ocular diseases using deep learning algorithms, such as age-related macular degeneration, has shown great potential. Lee et al. (2018) [1] found that deep-learning models were highly influential in classifying normal and AMD OCT images. The study used a fine-tuned VGG16 convolutional neural network [2] as the deep-learning model to achieve an accuracy of 86.64% with a sensitivity of 83.64% and a specificity of 92.54%.

In a study presented in 2020, Srivastava et al [3] focused on the role of the choroid [4] in automated age-related macular degeneration detection from OCT images. The study investigated choroid layer impact on the accuracy of deep learning models and found that incorporating the choroid layer improved the performance of the model in detecting AMD. The study proposed ResNet50 as the deep learning model to achieve an accuracy of 95.82% with a sensitivity of 95.45%, a specificity of 95.91%, and an AUC of 0.9942.

Moreover, Govindaiah et al. (2018) [5] proposed a new method for automated screening of AMD using ensemble deep neural networks. They developed a multi-stage screening algorithm that uses multiple CNNs [2], [6], [7] to detect and classify AMD in OCT images. Their proposed method achieved high accuracy and sensitivity in detecting AMD and outperformed other state-of-the-art techniques. Their study suggests that a multi-stage approach to AMD detection can improve the accuracy and reliability of clinical diagnosis.

1.2 Research Gap

Age-related macular degeneration (AMD) is an adequate public health concern. Early detection and treatment of AMD are critical to preserving visual function and preventing vision loss, as late-stage AMD is irreversible and leads to permanent vision impairment. Optical coherence tomography (OCT) [8] has appeared as a non-invasive, reliable, and widely used imaging technique for diagnosing and monitoring AMD. Various research approaches have been attempted using machine learning to build systems to detect and identify eye diseases.

However, existing approaches [9], [10] for analyzing OCT images for AMD detection are computationally intensive, requiring high-end computing resources, and are therefore not feasible for use in clinical settings or resource-limited areas.

Our proposed study aims to develop a novel approach to detect AMD using OCT images by combining two existing models. The novelty of this approach is to create a lightweight model that reduces computational requirements while maintaining high accuracy, making it feasible to develop a mobile app for AMD detection in clinical settings and resource-limited areas. By developing a more efficient and accurate model for AMD detection using OCT images, this study aims to improve the feasibility and accessibility of AMD screening, diagnosis, and management, leading to earlier detection and improved patient outcomes.

2. RESEARCH PROBLEM

Age-related macular degeneration (AMD) impacts millions worldwide, particularly those over fifty. AMD is an adequate reason for vision loss and blindness, potentially severely impacting patients' quality of life. Currently, the diagnosis of AMD involves a manual examination of retinal images by trained specialists, which is expensive and time-consuming.

Optical coherence tomography imaging has appeared as a promising tool for AMD detection, offering high-resolution and non-invasive visualization of retinal structures. OCT imaging produces cross-sectional retina images that can reveal abnormalities and changes in the macular region characteristic of AMD. However, accurate interpretation of OCT images remains challenging due to the complexity and variability of retinal features and limitations in current analysis methods.

The current methods for OCT image analysis involve manual measurement of retinal thickness and identification of characteristic features such as drusen, pigment changes, and neovascularization. These methods are time-consuming, leading to delayed or incorrect diagnoses. Furthermore, manual OCT image analysis is limited by the subjective nature of the research and the need for extensive training to develop the necessary expertise.

Therefore, the research problem for this component is to develop automated image analysis algorithms to improve the accuracy and efficiency of AMD detection using OCT images. The algorithms should address technical challenges such as image segmentation, feature extraction, and algorithm reliability to ensure robust and consistent performance. This research aims to develop a tool that can assist optical specialists in accurately and efficiently diagnosing AMD, leading to improved patient outcomes and reduced healthcare costs

3. RESEARCH OBJECTIVES

3.1. Main Objectives

This study's main objective is to develop and validate a machine-learning algorithm that can accurately detect AMD using OCT images. Moreover, using an extensive dataset of OCT images, the algorithm will be trained and utilize advanced deep-learning techniques to learn distinctive features indicative of AMD. The goal is to achieve high accuracy in detecting AMD while minimizing false positive and false negative rates. The algorithm will be evaluated using a separate test dataset to measure its sensitivity, specificity, precision, and accuracy performance. The aim is to provide a reliable and automated tool for early detection and diagnosis of AMD, which can assist ophthalmologists in making clinical decisions and improve patient outcomes.

3.2. Sub Objectives

- To collect a dataset of OCT images for training the machine learning model.
- Preprocess and clean OCT images to ensure high-quality input data.
- Develop a machine learning model for accurate detection of AMD using deep learning.
- Optimize the machine learning model for fast and accurate AMD detection with minimal computational resources.

4. METHODOLOGY

In this component, we aim to develop a deep learning algorithm to detect age-related macular degeneration in OCT images. Moreover, the proposed methodology consists of several key steps: data collection, preprocessing, model development, training and validation, application development, model integration, and evaluation.

Data collection is crucial in building a robust and diverse dataset of OCT images. We plan to collect OCT images from multiple sources, including public databases. The dataset will include images of patients with and without AMD, covering a range of ages, races, and disease severities. This diverse dataset will enable our model to be more robust and accurate. After collecting the dataset, we will preprocess the OCT images using normalization, denoising, and segmentation techniques. This preprocessing step will help enhance the images' quality and facilitate feature extraction. We will also clean the dataset by removing low-quality or corrupted images to ensure our model is trained on high-quality data.

The next step is model development, where we will combine two existing models to develop a deep learning-based algorithm for AMD detection in OCT images. The model will be trained to classify OCT images as usual or AMD with high accuracy and sensitivity. To ensure the optimal performance of the model, we will fine-tune the hyperparameters and test different architectures. Once the model is developed, we will divide the dataset into training, validation, and test sets. We will train the model utilizing the training set and validate model performance with the validation set. We will use sensitivity, accuracy, specificity metrics to evaluate the model's performance.

The next step is application development, where we will develop an application that allows clinicians to upload and scan OCT images for AMD detection. The application will be user-friendly, efficient, and secure. It will also have features that allow clinicians to visualize and interpret the results. Next, we will integrate the trained model into the application to scan and analyze OCT images. We will ensure the model is compatible with different OCT devices and settings and can handle many images in real-time. This step will involve testing the model on a large independent dataset of OCT images.

Lastly, we will evaluate the performance of the developed application in a clinical setting involving ophthalmologists and patients. We will validate the accuracy and reliability of the application using the same independent dataset of OCT images. This iterative process will ensure that the application is optimized for clinical use.

4.1. System Diagram

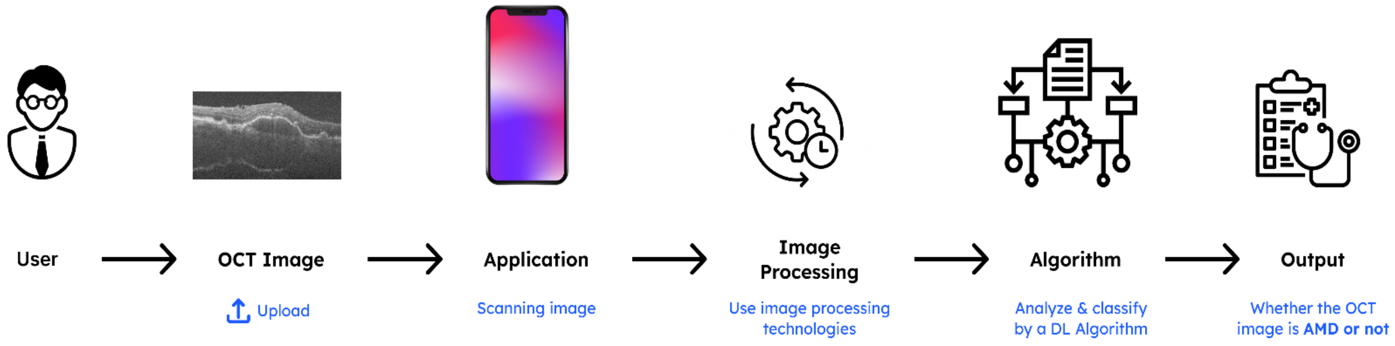

Figure 1 : System Diagram

5. REQUIREMENTS

5.1. Functional requirements

- The system should be able to import OCT images for analysis.
- The system should be able to identify AMD from OCT images.
- The system should provide a user interface for the input and output of OCT images.
- The system should be able to generate reports of AMD detection results.

5.2. Non-Functional requirements

- The system should have high accuracy in AMD detection from OCT images.
- The system should be able to process OCT images quickly and efficiently.
- The system should be user-friendly and easy to use for healthcare professionals

6. GANTT CHART

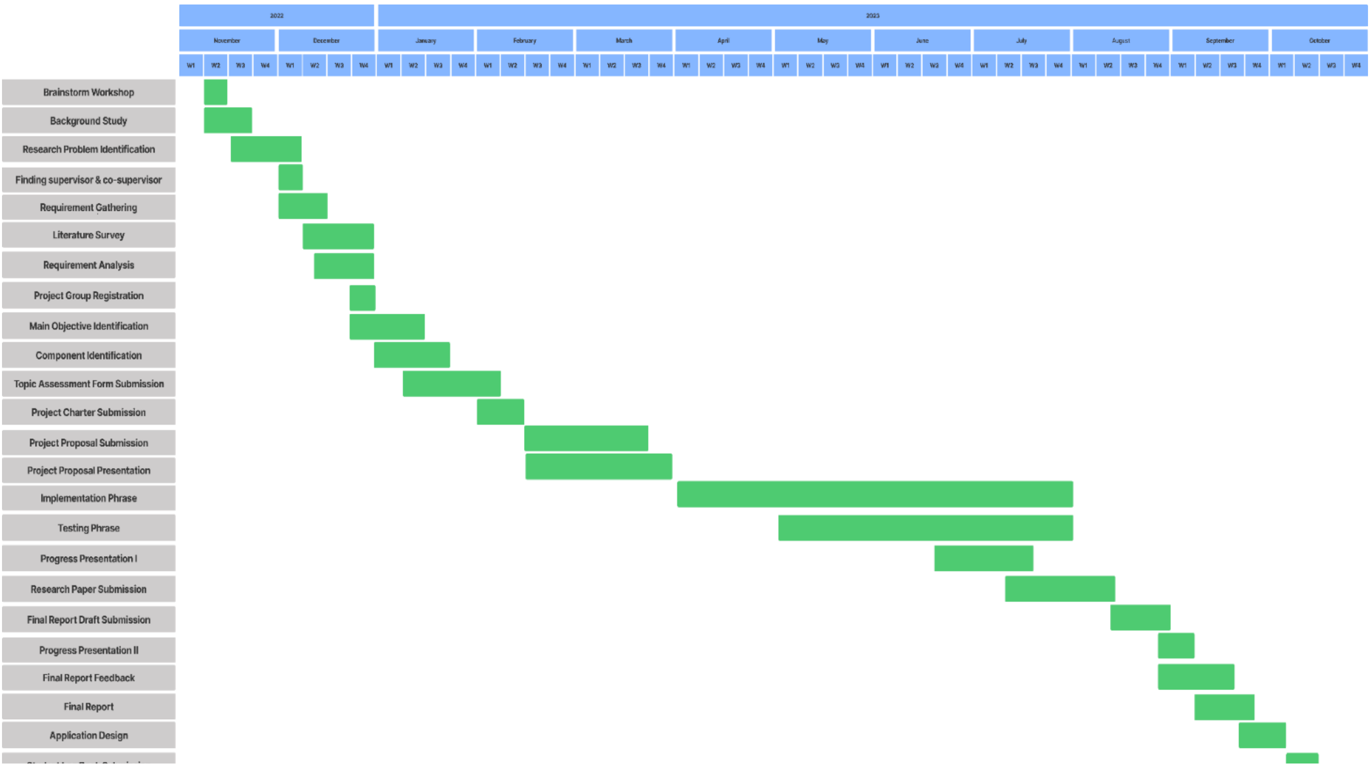

Figure 2 : Gantt Chart

7. WORK BREAKDOWN STRUCTURE

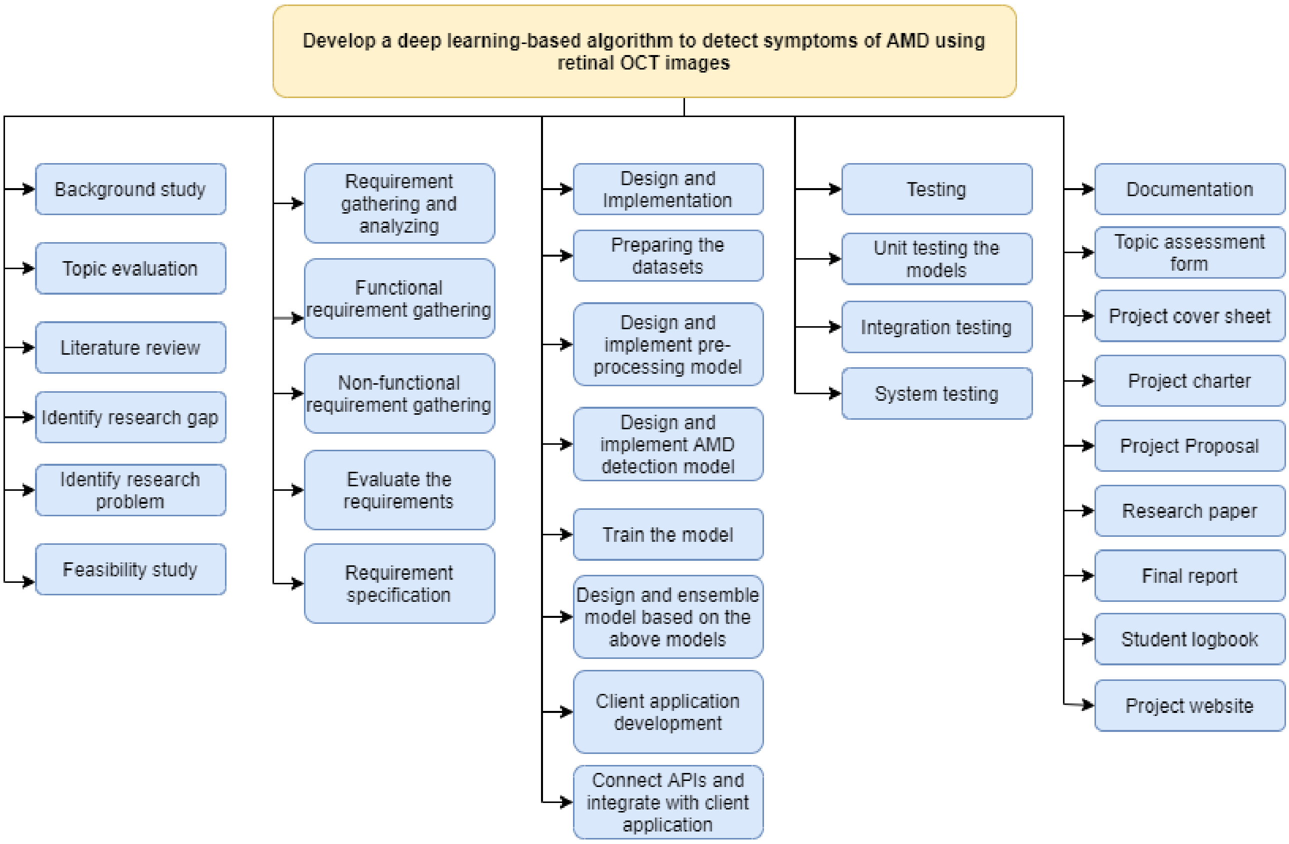

Figure 3 : Work Breakdown Structure

8. BUDGET AND BUDGET JUSTIFICATION

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

Table 1 : Budget and Budget Justification

REFERENCE LIST

[1] C. S. Lee, D. M. Baughman, and A. Y. Lee, "Deep Learning Is Effective for Classifying Normal versus Age-Related Macular Degeneration OCT Images," *Ophthalmol Retina*, vol. 1, no. 4, pp. 322–327, Jul. 2017, doi: 10.1016/j.oret.2016.12.009.

[2] K. Simonyan and A. Zisserman, "Very Deep Convolutional Networks for Large-Scale Image Recognition," Sep. 2014.

[3] R. Srivastava, E. P. Ong, and B.-H. Lee, *Role of the Choroid in Automated Age-related Macular Degeneration Detection from Optical Coherence Tomography Images; Role of the Choroid in Automated Age-related Macular Degeneration Detection from Optical Coherence Tomography Images*. 2020. doi: 10.0/Linux-x86_64.

[4] M. Farazdaghi and K. Ebrahimi, "Role of the choroid in age-related macular degeneration: A current review," *J Ophthalmic Vis Res*, vol. 14, no. 1, p. 78, 2019, doi: 10.4103/jovr.jovr_125_18.

[5] A. Govindaiah, R. T. Smith, and A. Bhuiyan, "A New and Improved Method for Automated Screening of Age-Related Macular Degeneration Using Ensemble Deep Neural Networks," in *2018 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, IEEE, Jul. 2018, pp. 702–705. doi: 10.1109/EMBC.2018.8512379.

[6] C. Szegedy, S. Ioffe, V. Vanhoucke, and A. Alemi, "Inception-v4, Inception-ResNet and the Impact of Residual Connections on Learning," *Proceedings of the AAAI Conference on Artificial Intelligence*, vol. 31, no. 1, Feb. 2017, doi: 10.1609/aaai.v31i1.11231.

[7] F. Chollet, "Xception: Deep Learning with Depthwise Separable Convolutions," in *2017 IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, IEEE, Jul. 2017, pp. 1800–1807. doi: 10.1109/CVPR.2017.195.

[8] D. Huang *et al.*, "Optical Coherence Tomography," *Science (1979)*, vol. 254, no. 5035, pp. 1178–1181, Nov. 1991, doi: 10.1126/science.1957169.

[9] R. R. Slavescu, Universitatea Tehnică din Cluj-Napoca. Computer Science Department, IEEE Romania Section, and Institute of Electrical and Electronics Engineers, *Proceedings, 2018 IEEE 14th International Conference on Intelligent Computer Communication and Processing (ICCP) : Cluj-Napoca, Romania, September 6-8, 2018*.

[10] C. H. Lin *et al.*, "Denoising Performance Evaluation of Automated Age-Related Macular Degeneration Detection on Optical Coherence Tomography Images," *IEEE Sens J*, vol. 21, no. 1, pp. 790–801, Jan. 2021, doi: 10.1109/JSEN.2020.3014254.

Dataset - https://www.kaggle.com/datasets/obulisainaren/retinal-oct-c8

Appendices

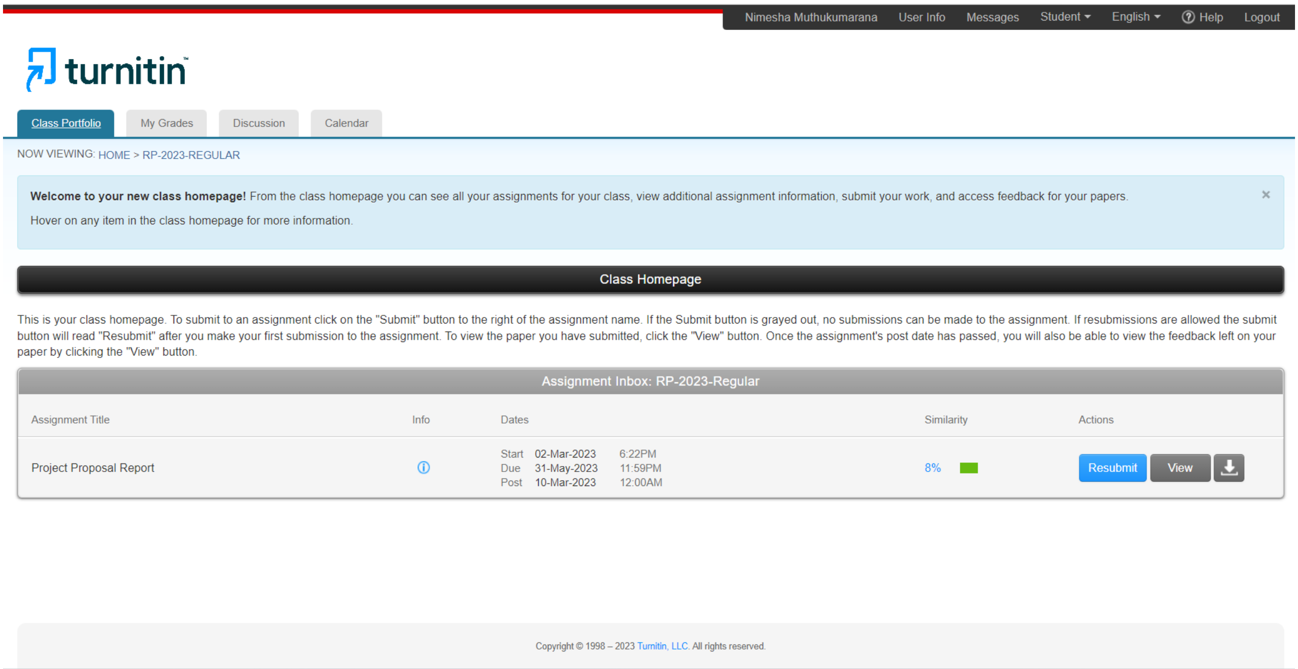

Figure 4: Similarity score