IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 3, March 2024

DOI: 10.17148/IJARCCE.2024.133120

Enhancing Vision Care: Detection of Eye Diseases and Prediction of Refractive Errors

Ananya[1], Manojna P Jain[2], Nidah Shabbir Shaikh[3], Vinayashree[4], Dr.Sreeja Rajesh[5]

Student, Information Science and Engineering, MITE Moodabidri, Moodabidri, India[1-4]

Associate Professor, Information Science and Engineering, MITE Moodabidri, India[5]

Abstract : Our novel system, Enhancing Vision Care: Detection of Eye Diseases and Prediction of Refractive Errors, employs a deep learning architecture trained on a dataset of diverse fundus photographs encompassing various eye diseases, including diabetic retinopathy, glaucoma and cataracts and prediction of refractive errors like myopia, astigmatism and hypermetropia. The system employs multi-task learning and attention mechanisms to simultaneously detect and localize distinct disease signatures within each image. This project represents a significant step towards automated, multi-disease eye disease detection with high accuracy and generalizability. Its potential lies in enabling early intervention, improving individual prognosis, and reducing healthcare costs associated with vision loss. Future work will focus on integrating Enhancing Vision Care: Detection of Eye Diseases and Prediction of Refractive Errors into clinical workflows and exploring its application in underserved communities.

Keywords: Artificial intelligence, deep learning, multi-disease detection, eye diseases, retinal imaging, early diagnosis, healthcare

I. INTRODUCTION

Vision plays a crucial role in our daily lives, yet millions suffer from retinal diseases that can lead to blindness if left undiagnosed. Examples include diabetic retinopathy and glaucoma. Early treatment significantly improves outcomes, potentially restoring or slowing disease progression. However, access to qualified ophthalmologists is often limited, especially in rural areas where infrastructure and trained personnel are scarce. Traditional remote screening methods often require expensive equipment and expertise. Fortunately, advancements in technology and image analysis offer promising solutions through automated disease detection and referral systems. Several systems utilizing digital image processing and machine learning have been developed, particularly for diabetic retinopathy and age-related macular degeneration, with performance comparable to human experts. However, many are specialized to specific diseases, requiring intricate disease-specific feature engineering [1].

The global burden of blindness is increasing, with new cases outpacing the number of sight-restoring surgeries performed each year. The vascular theory of glaucoma proposes that impaired blood flow to the optic nerve head plays a vital role in its degeneration. This localized damage is thought to occur when the pressure at which blood perfuses the eye (ocular perfusion pressure) falls outside the normal range where it can be automatically regulated. This disruption can be attributed to either systemic issues like low blood pressure, significant nighttime blood pressure drops, or peripheral vasospasms, or to local abnormalities within the eye's blood supply itself. Cataracts are a leading cause of blindness, affecting millions of people worldwide. While there are efforts to provide cataract surgery to those in need, the number of new cases is outpacing the number of surgeries performed, leading to a concerning increase in global blindness [2].

Diabetic retinopathy (DR) is a major complication of diabetes that can lead to blindness if left untreated. It affects the blood vessels in the retina, causing them to leak fluid and distort vision. DR is one of the most common eye diseases, according to statistics from the US, UK, and Singapore [3]. While early diabetic retinopathy often progresses silently with minimal to no noticeable symptoms, significant damage to the neural retina and microvascular changes occur unseen .

This underscores the crucial role of regular eye screenings for diabetic patients, as timely diagnosis and subsequent management are essential for preserving vision . Given that controlling hyperglycemia, hyperlipidemia, and hypertension remains the only preventive strategy, early detection of DR becomes even more critical. Furthermore, existing interventions like laser photocoagulation can significantly reduce the risk of blindness in proliferative retinopathy and diabetic maculopathy by up to 98%, provided treatment is initiated at an early stage. This clearly demonstrates that early detection and appropriate treatment are key to delaying or even preventing blindness from diabetic retinopathy [4].

This work deals with the comprehensive understanding of some of the most prevalent and impactful eye diseases—cataract, glaucoma and diabetic retinopathy. By delving into the characteristics, risk factors, and potential treatments of these conditions, the narrative aims to illuminate the complexities of ocular health.

In addressing the unique challenges posed by each disease, the objective is to empower individuals with knowledge that fosters a proactive approach to eye care, ultimately contributing to enhanced overall well-being and the prevention or mitigation of vision- related complications.

II. RELATED WORK

Eye diseases are very common nowadays and it is increasing continuously. Vision is one of the most important human senses, lack of which can affect productivity and independence of a person. Retinal diseases affect millions of people and may result in loss of vision if the disease is not diagnosed and treated early. Example of retinal diseases include diabetic retinopathy, age related macular disorder, glaucoma etc. Early treatment options that are available may cure or slow the onset of the disease. Patients treated get several more years of vision in their life. In India, although there are a number of hospitals and eye clinics in the cities, the doctor to patient ratio is still low. The technology used in eye disease detection is used in [1].

The development of an expert system designed for the early diagnosis of eye diseases prevalent in the Malaysian population. The system is likely designed to utilize advanced technologies and computational methods to analyze relevant medical data, symptoms, and possibly diagnostic images to provide timely and accurate assessments of eye diseases. The use of expert systems in medical diagnosis can contribute significantly to early detection and intervention, potentially improving healthcare outcomes for affected individuals. The paper likely discusses the methodology, implementation, and results of the expert system in the context of addressing eye diseases in the Malaysian population is addressed in [5].

The study presents a novel approach for glaucoma screening using fundus images. The proposed method employs a Disc-aware Ensemble Network, which likely involves the integration of multiple specialized networks or models to enhance the accuracy of glaucoma detection. The term "Disc-aware" suggests a focus on the optic disc region, a crucial anatomical feature in glaucoma diagnosis[6].

The study introduces a framework for identifying glaucomatous progression by employing proper orthogonal decomposition (POD) in the analysis of the optic nerve head. POD is a mathematical technique used to decompose complex datasets into orthogonal modes, and in this context, it is likely applied to extract relevant features from optic nerve head images for glaucoma detection. The authors propose a method that utilizes POD to capture and analyze structural changes over time, enabling the detection of progression in glaucomatous conditions[7].

Wavelet analysis is a signal processing technique that decomposes an image into its frequency components. In this context, the authors likely utilize wavelet transforms to extract relevant energy features from glaucoma-affected images, aiming to enhance the discrimination between normal and glaucomatous cases. The paper likely discusses the methodology employed for feature extraction, the selection of appropriate wavelet functions, and the classification algorithm used to distinguish between different image categories[8].

Fundus images capture the interior surface of the eye and are commonly used in ophthalmic diagnosis. The authors likely propose an algorithm that employs adaptive thresholding to segment and analyze features in fundus images, with the aim of detecting glaucoma. The use of adaptive thresholding suggests a dynamic approach that adjusts to variations in image characteristics, potentially enhancing the accuracy of glaucoma detection[9].

the application of deep learning techniques for the automated detection of diabetic retinopathy, a common and vision-threatening complication of diabetes. The authors likely employ deep neural networks to analyze retinal images, aiming to automatically identify signs of diabetic retinopathy such as microaneurysms, hemorrhages, and exudates. The paper probably discusses the architecture of the deep learning model, the training process, and the evaluation of its performance in terms of sensitivity and specificity[10].

The simplicity of the diagnostic method suggests an emphasis on ease of use, potentially making it applicable in a clinical setting for efficient glaucoma screening. The paper probably outlines the methodology, key findings, and the potential implications of the proposed diagnostic approach, contributing to the ongoing efforts to develop accessible and effective methods for early detection of glaucoma[11].

Leveraging advanced neural network architectures, the authors likely focus on developing a model capable of automatically analyzing retinal images to identify signs of diabetic retinopathy and classify its severity. The paper probably details the architecture of EyeNet, the training methodology, and the evaluation of its performance in terms of accuracy and robustness. The use of deep learning in diabetic retinopathy detection is crucial for improving the efficiency and accuracy of screening processes, contributing to early diagnosis and intervention in individuals with diabetes[12].

III. METHODOLOGY

3.1. Pre-processing: The uploaded image would undergo pre-processing to prepare it for analysis by the model. Pre-processing typically involves resizing the image, converting it to a specific format, and normalization of pixel values.

3.2 Eye Test: The pre-processed image is then evaluated to determine if it is a correct eye test image. Presumably, the system would have pre-defined criteria to make this assessment. If the image is not a correct eye test image, the system would provide feedback to the user and request that they upload a new image.

3.3 Classification: The pre-processed image is then used to train the classification model. Here, the system would assign the image a specific disease category based on the features it has learned from the training data.

3.4 Model Training: The model is continually trained and improved through exposure to new data. This is an iterative process where the model is able to refine its classification accuracy over time.

3.5 Model fit: This step evaluates how well the model has learned to identify diabetic retinopathy. This can be done by calculating metrics like accuracy, precision, and recall.

3.6 Model test: This step involves testing the model's performance on the test set. This is to ensure that the model can generalize well to unseen data.

IV. PROPOSED SYSTEM

Data gathering: For each eye disease (cataract, glaucoma and diabetic retinopathy), compile a collection of high-quality retinal images from patients with confirmed diagnoses of the disease and healthy controls. Ensure the dataset reflects a variety of demographics and exhibits substantial variation. This variation can include factors like age, ethnicity, and gender.

Data preprocessing: To ensure optimal performance, retinal images for each disease will undergo preprocessing. This involves a multi-step process to improve image quality and minimize noise. Techniques like contrast adjustment will enhance details within the image, while scaling ensures all images are a consistent size. Finally, normalization standardizes the pixel intensity values across the entire image dataset, creating a uniform foundation for the machine learning models to analyze.

Design of Model Architecture: Develop a CNN architecture specifically tailored for each disease. This architecture should be capable of extracting features from retinal images that are relevant to the identification of the specific disease. Fine-tune pre-trained models using the corresponding disease dataset to specialize them in the task of detecting that particular condition.

Model Training: Train the CNN model for each disease on the augmented dataset using appropriate optimization algorithms and loss functions (e.g., multi-class cross-entropy for multiple disease classification). Closely monitor the model's performance on a validation set to prevent overfitting. Implement techniques like early stopping to mitigate overfitting.

Prediction: Utilize the trained model for each disease to differentiate between healthy and diseased retinal images. The model's predictions can be supplemented with probability scores that represent the confidence level of the classification for each disease category.

Integration and Deployment: Develop a user-friendly application that integrates the trained models for all diseases. This application can take the form of a mobile app or a web interface. The application should allow users to capture eye images and receive predictions for the likelihood of various eye diseases. It's crucial to clearly communicate that the application provides a risk assessment, not a diagnosis, and users should consult an ophthalmologist for confirmation and any necessary treatment.

DOI: 10.17148/IJARCCE.2024.133120

V. RESULTS

5.1. Home Page

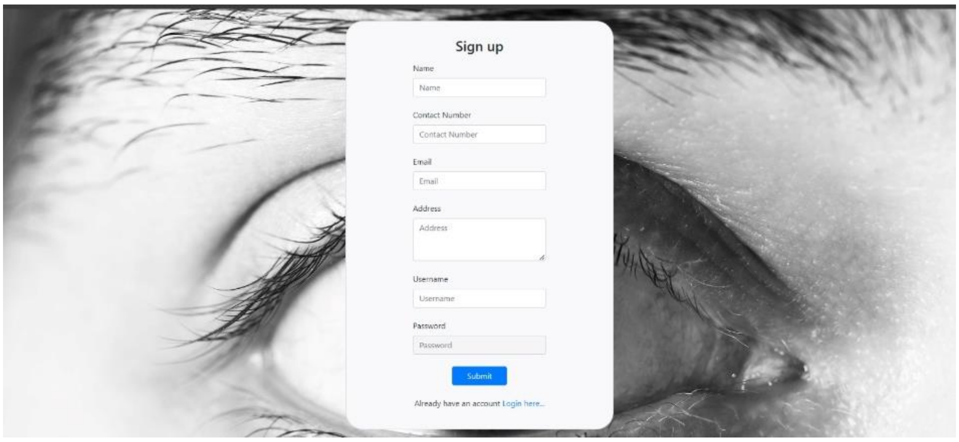


Figure 5.2 Page to Sign Up

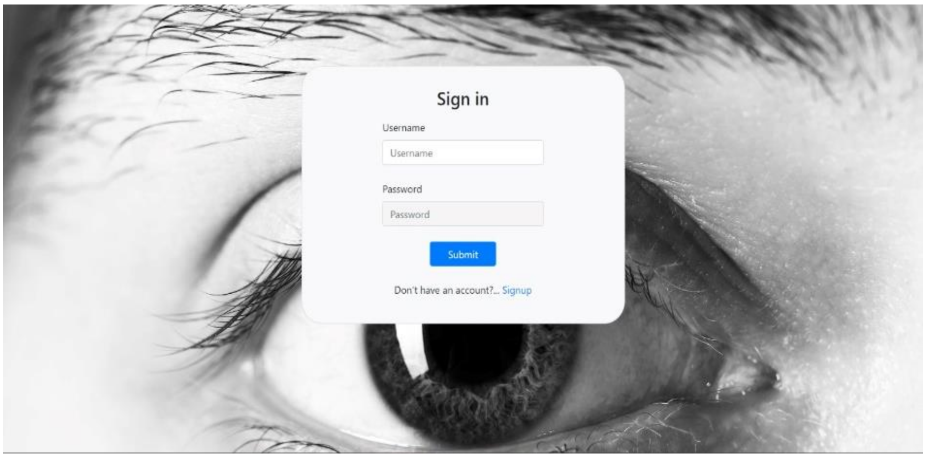
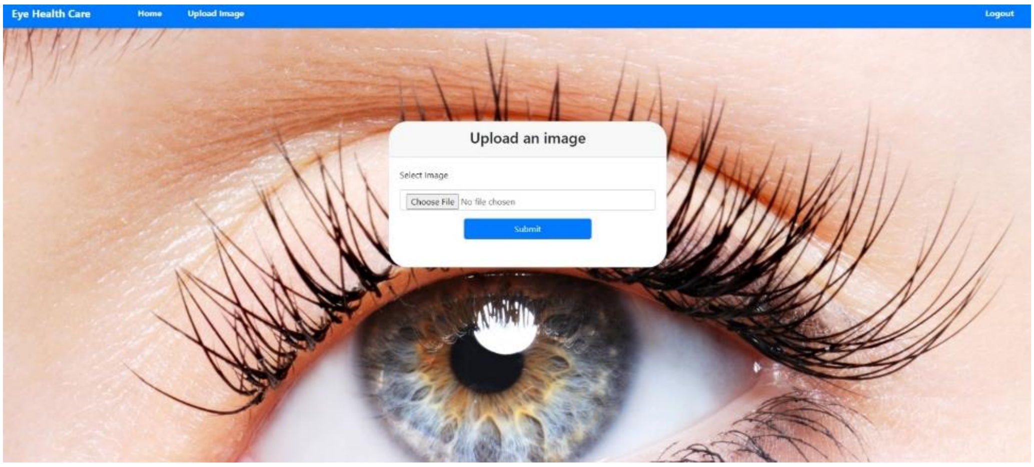


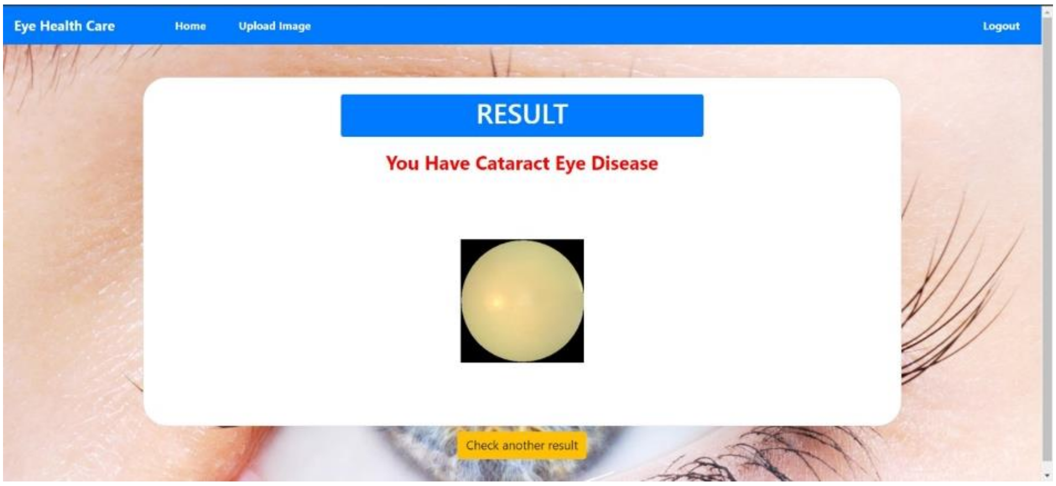
Figure 5.3 Page to Sign-In



Upload an image

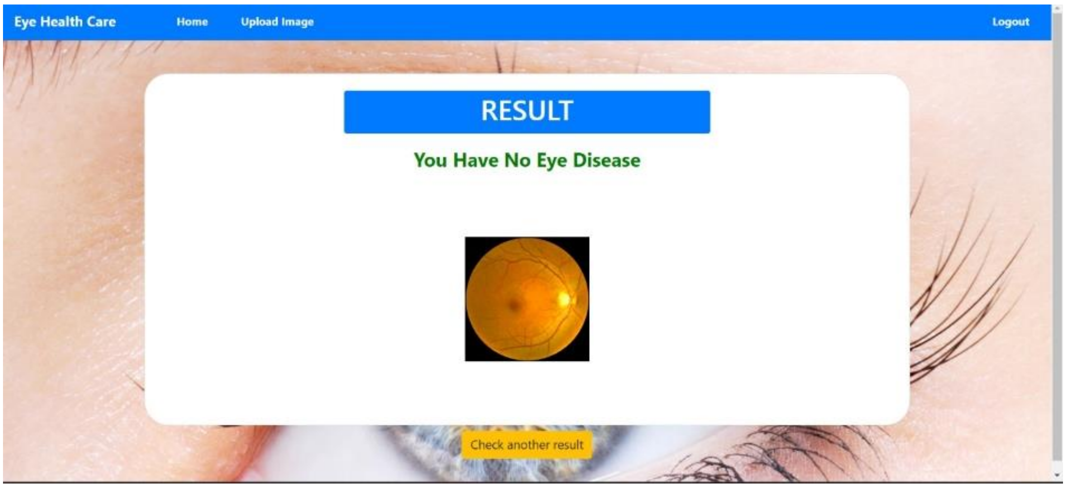
Select Image

Figure 5.4. Page to upload image



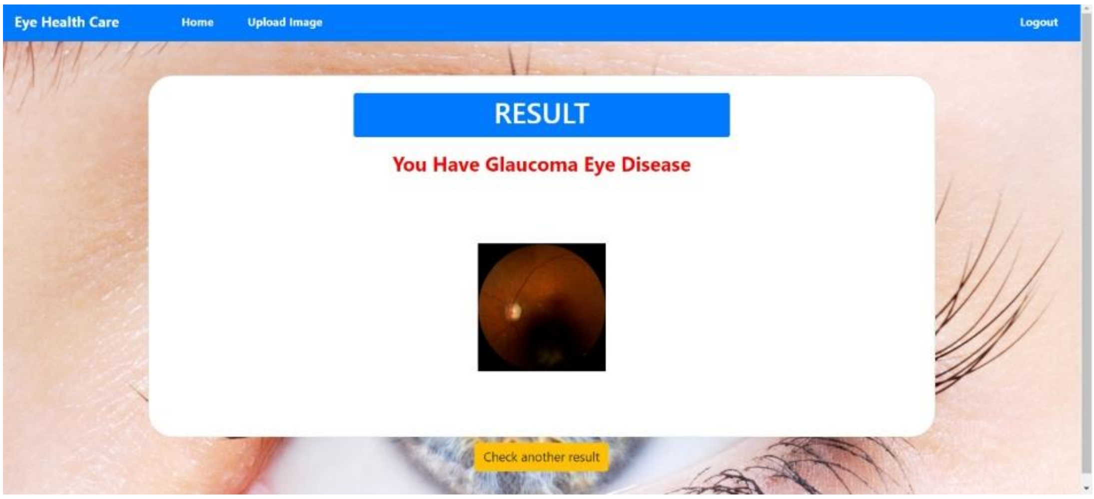
You Have Cataract Eye Disease

Figure 5.5. Result page of Cataract disease



You Have No Eye Disease

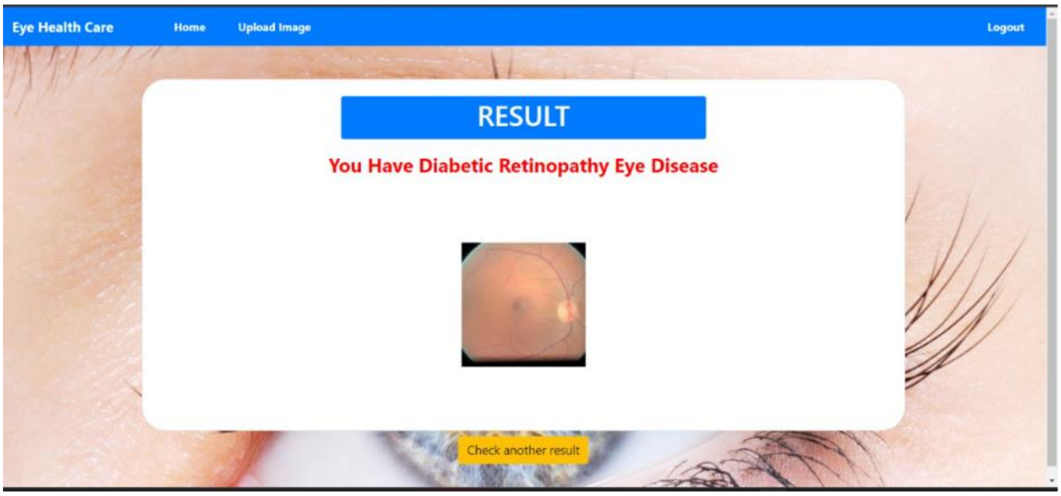
Figure 5.6. Result page of normal eye



RESULT

You Have Glaucoma Eye Disease

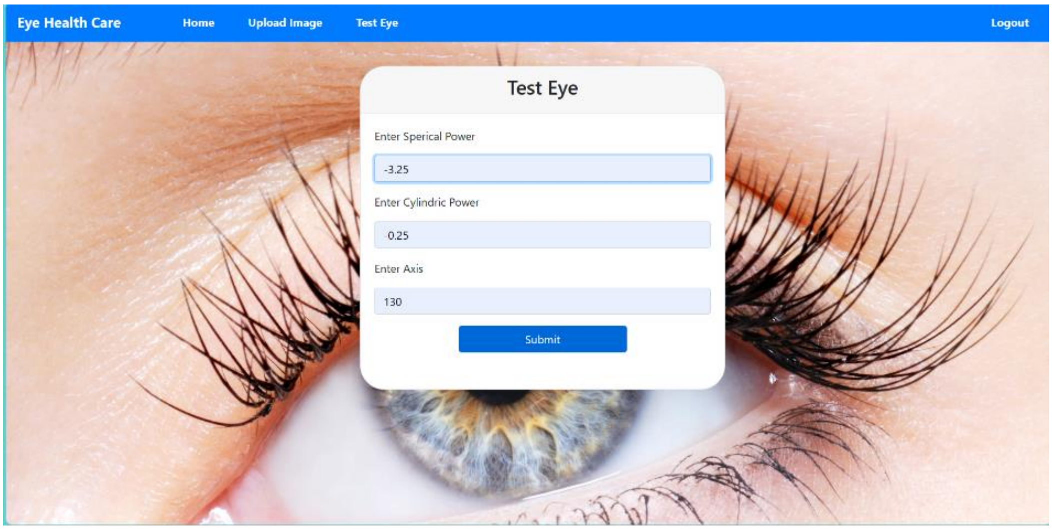
Figure 5.7. Result page of Glaucoma disease



RESULT

You Have Diabetic Retinopathy Eye Disease

Figure 5.8. Result page of Diabetic Retinopathy disease



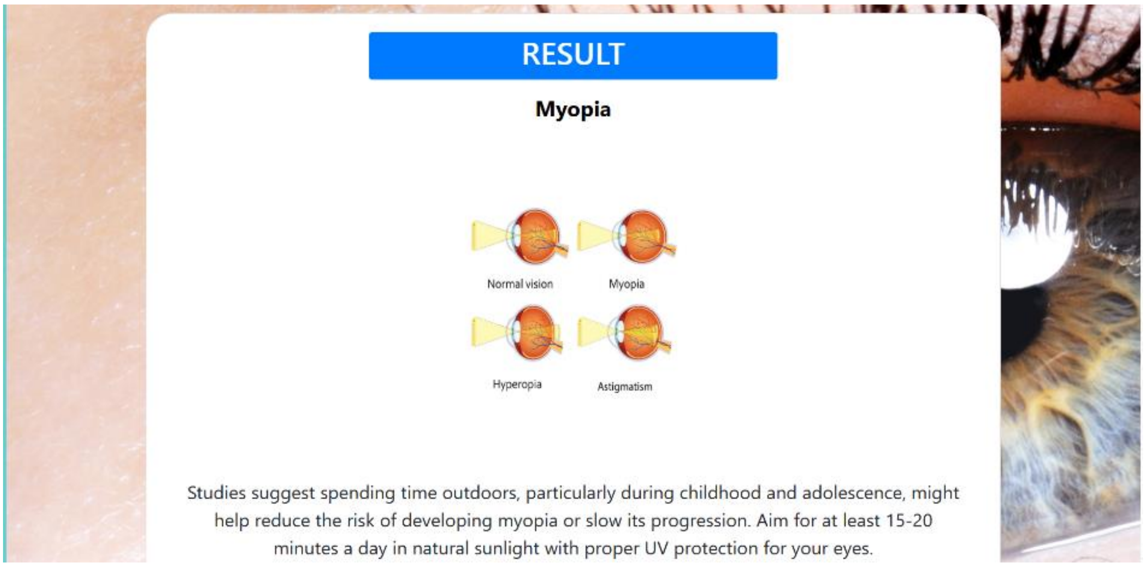
Test Eye

Enter Sperical Power: -3.25

Enter Cylindric Power: 0.25

Enter Axis: 130

Figure 5.9. Page to Test eye



Myopia

Studies suggest spending time outdoors, particularly during childhood and adolescence, might help reduce the risk of developing myopia or slow its progression. Aim for at least 15-20 minutes a day in natural sunlight with proper UV protection for your eyes.

Figure 5.10. Result of Test eye

VI. FUTURE WORK

Expanding Disease Detection: The system could be trained to identify a wider range of eye diseases, providing a more comprehensive assessment. Incorporating Additional Data: Integration with wearable health devices could allow the system to consider factors like blood sugar levels (relevant for diabetic retinopathy) for a more holistic risk assessment.

Refining Eye Power Prediction: By incorporating user feedback and additional vision tests, the system's prediction accuracy for refractive errors can be continuously improved.

Augmented Reality Integration: Overlaying informative visuals on captured eye images through AR could enhance user understanding of potential issues.

Telemedicine Integration: The system could connect users with ophthalmologists for remote consultations based on the initial risk assessment, improving access to specialist care. By pursuing these advancements, the "Enhancing Vision Care" project can evolve into a powerful tool for preventative eye care, empowering individuals to safeguard their vision for the future.

REFERENCES

[1] L. Jain, H. V. S. Murthy, C. Patel, and D. Bansal, "Retinal Eye Disease Detection Using Deep Learning," in 2020 IEEE International Conference on Computational Intelligence and Computing Research (ICCIC), pp. 1-4, doi: 10.1109/ICCIC51174.2020.00005.

[2] Acharya, U. R., Kannathal, N., Ng, E. Y. K., Min, L. C., & Suri, J. S. (2006, August), "Computer based classification of eye diseases" ,In Engineering in Medicine and Biology Society, 2006. EMBS'06. 28th Annual International Conference of the IEEE (pp. 6121-6124).

[3] B. Tymchenko, P. Marchenko, and D. Spodarets, "Deep Learning Approach to Diabetic Retinopathy Detection," in 2023 IEEE 33rd International Conference on Advanced Information Networking and Applications (AINA), pp. 1419-1424, doi: 10.1109/AINA.2023.00220.

[4] N. Tsiknakis, D. Theodoropoulos, G. Manikis, E. Ktistakis, O. Boutsora, A. Berto, F. Scarpa, A. Scarpa, D. I. Fotiadis, and K. Marias, "Deep learning for diabetic retinopathy detection and classification based on fundus images: A review," Computers in Biology and Medicine, vol. 135, p. 104599, Jun. 2021, doi: 10.1016/j.compbiomed.2021.104599.

[5] Ibrahim, F., Ali, J. B., Jaais, A. F., & Taib, M. N. (2001), "Expert system for early diagnosis of eye diseases infecting the Malaysian population", In TENCON 2001. Proceedings of IEEE Region 10 International Conference on Electrical and Electronic Technology (Vol. 1, pp. 430- 432).

[6] H. Fu, J. Cheng, Y. Xu, C. Zhang, D. W. K. Wong, J. Liu, and X. Cao, ‘‘Disc-aware ensemble network for glaucoma screening from fundus image,’’ IEEE Trans. Med. Imag., vol. 37, no.11, pp. 2493–2501, Nov. 2018.

DOI: 10.17148/IJARCCE.2024.133120

[7] Balasubramanian M, Zabic S, Bowd C, Thompson HW, Wolenski P, Iyengar SS, Zangwill LM et al (2009) A framework for detecting glaucomatous progression in the optic nerve head of an eye using proper orthogonal decomposition. IEEE Trans Inf Technol Biomed 13(5):781–793.

[8] Dua S, Acharya UR, Chowriappa P, Sree SV (2012) Wavelet-based energy features for glaucomatous image classification. IEEE Trans Inf Technol Biomed 16(1):80–87.

[9] Agarwal A, Gulia S, Chaudhary S, Dutta MK, Burget R, Riha K (2015) Automatic glaucoma detection using adaptive threshold-based technique in fundus image. In: 2015 38th International conference on telecommunications and signal processing (TSP). IEEE, pp 416–420.

[10] Gulshan, V., Sundaresan, P., Nayak, H., Agarwal, S., Bhuiyan, N., & Roy, A. (2019). Automated detection of diabetic retinopathy using deep learning. IEEE Journal of Biomedical and Health Informatics, 23(2), 463-472.

[11] Inoue N., Yanashima K., Magatani K., Kurihara T. “Development of a simple diagnostic method for the glaucoma using ocular fundus pictures” proceedings of 2005 IEEE, Engineering in medicine and biology 27th annual conference, shanghai, China, pp 3355-3358, January 2006.

[12] Sengupta, P., Bhuiyan, M. A., Singh, A., & Bhaumik, D. (2020). EyeNet: A deep learning approach for diabetic retinopathy detection and severity classification. IEEE Transactions on Biomedical Engineering, 67(10), 2405-2416.