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Eye Tech Solutions: An Innovative Application for the Visually Impaired

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Abstract:-The use of digital devices in modern culture has increased the number of vision-related health problems that affect people of all ages, from infants to adults. Acknowledging the pressing nature of this public health issue, this study presents "EyeTech Solutions," a cutting-edge web program aimed at transforming eye care through integrated comprehensive treatment pathways and early detection of vision impairments. The main functions of the software, such as self-assessment tools, a tracking system for vision progress, and a feature that links users with experts, are explained in detail in this paper. A comprehensive literature study highlights the shortcomings of current mobile vision applications and emphasizes the need for a more comprehensive and user-friendly solution. The program uses the MERN stack as a methodology, which guarantees efficiency and scalability. The app's potential to increase user participation in eye health management is demonstrated by the results. The conclusion emphasizes the app's contribution to early vision problem detection and underscores the necessity for ongoing updates to integrate the latest technological advancements.

Keywords*: visual acuity, convolutional neural networks, ishihara test, vision progress detector*

1. Introduction

The human eye is a remarkable and intricate organ, serving as a window to the world and playing a pivotal role in shaping individuals' experiences. In the modern age of rapid technological advancements and the widespread use of digital devices, one cannot overstate the importance of maintaining optimal eye health. Unfortunately, the way many people lead their lives today, with extended screen time and insufficient attention to potential eye issues, has led to a significant global increase in vision-related health conditions. This concerning trend affects not only adults but is increasingly affecting newborns and young children.

Early detection of these eye abnormalities and swift intervention are crucial in slowing their progression, as untreated visual impairments can ultimately result in permanent blindness. However, in a fast-paced society

filled with numerous commitments, the significance of maintaining excellent eye health often takes a backseat. Today's hectic parental environment compounds oversight, emphasizing the need for more attention to children's eye health. Failing to schedule regular eye checkups during a child's critical developmental stages can lead to severe vision problems later in life. It is concerning to note that over 2.2 billion individuals worldwide (as per the World Health Organization) are currently grappling with vision-related difficulties shockingly, nearly half of these cases are preventable.

Furthermore, the high costs associated with vision tests pose a significant barrier, making it difficult for many individuals to access timely and affordable eye care. These challenges underscore the pressing need for an accessible and effective solution to address the growing concerns surrounding vision health.

The primary objectives of this research include:

- Facilitating the early identification of vision anomalies through a comprehensive range of self-assessment tools.
- Implement a vision progress tracking system that enables users to monitor changes in their vision over time, empowering them to make informed decisions about their eye care routines and interventions.
- Create an integrated feature that connects users with eye care specialists, enabling convenient scheduling of in-person appointments and facilitating the provision of customized eyeglass prescriptions based on individual visual needs.

Some Research Questions that are addressed:

- How effectively does the app's vision progress tracking system capture and represent changes in users' vision over time, and what impact does this information have on user behavior towards eye care?
- How accurately can the app's vision testing module assess visual acuity and other key visual parameters when compared to traditional clinical methods?

“EyeTech Solutions” is a cutting-edge web app designed to change eye care and bridge gaps in vision health management. EyeTech Solutions intends to be user-friendly and accessible, allowing users to actively monitor their eye health, identify problems early, and take appropriate action regardless of time, location, or expense constraints. This ground-breaking web program includes self-administered vision tests and quizzes, a progress detector that tracks the user's visual progress, 24/7 online medical care, and vision test activities.

In addition to the introduction, this conference paper consists of several sections. Subsequent sections of the paper include a literature review, methodology, discussion, and results. The literature survey aims to examine the present literature on vision-related ailments and provides a synopsis of prior research outcomes. The methodological part of the conference contribution presents the research approach pursued in the study and various elements such as requirements gathering and system development process.

2. Literature Review

There are quite a few mobile vision programs available for personal use, and the ones that are available still have some serious flaws. These programs frequently struggle with challenges relating to the program's usability, accuracy, and the variety of visual impairments one can successfully handle. In this extensive literature review, the team draw conclusions from three primary sources “A Mobile Base Application for Cataract and Conjunctivitis Detection” by A. Soysa and D. De Silva [1], “The Vision Problem Tester” by D. I. De Silva et al. [2] and “The Vision Guard” by L. N. C. Perera et al. [3] in-depth on these difficulties while supporting the claim that the current mobile vision applications fall short in providing comprehensive solutions for the wide range of vision-related problems.

The research A Mobile Base Application for Cataract and Conjunctivitis Detection shows the rapid development of technology in modern society has resulted in an appreciable rise in the occurrence of eye conditions, variables including extended screen time have contributed to this rise. It has been extensively reported that eye health is becoming a growing problem in the digital era. The introduction also highlights the need for creative home-based solutions by highlighting how reluctant people are to use established healthcare systems, mostly because

of their busy schedules. Home-based healthcare apps have been the subject of prior study, which repeatedly emphasized their usability and practicality [1].

The study under A Mobile Base Application for Cataract and Conjunctivitis Detection consideration focuses only on the diagnosis of conjunctivitis and cataracts, two common eye diseases. Even if there is a large amount of literature on these conditions, earlier research may provide important information on other diagnostic techniques and technology therapies. Additionally, because the proposed mobile application relies on Image Processing and Deep Learning techniques to identify eye diseases, a thorough analysis of comparable technological advancements in the field of medical diagnosis is required, outlining each application's advantages and disadvantages. The introduction highlights the existence of local internet and mobile technologies in Sri Lanka for the identification of eye diseases in the context of locally adapted solutions. It is crucial to conduct a critical evaluation of these programs that takes into account their advantages, disadvantages, and user experiences. The need for the envisioned application is strengthened by this data-driven investigation, in addition to a comparison between the suggested mobile application and the existing localized solutions. This side-by-side comparison takes into account crucial factors including the range of illnesses identified, diagnostic precision, and user-friendliness. In addition, it's critical to address issues with mobile eye testing, especially when it comes to issues like nearsightedness and shortsightedness. It is essential to do a thorough examination of the literature on the complexities of mobile-based eye testing, including the validity of the findings. In addition, exploring the drawbacks of using smartphones for eye testing and looking at how users engage with these applications offers insightful information on their general usefulness, including the accuracy of results [1].

Similarly, the analysis in “The Vision Problem Tester” by D. I. De Silva et al. examines five well-known mobile vision applications and provides a thorough description of each one's shortcomings. One such program, “Vision Test,” is praised for its extensive feature set, which includes eye exams, quizzes, a locator for opticians, and eye guidance. Despite this comprehensive approach, the program has one significant flaw: it can only diagnose four types of visual disorders. Additionally, consumers have complained that the optician locator tool is inaccurate, which reduces its usefulness. The application's limited target market, which mostly caters to adults, is a notable drawback as it significantly reduces the number of prospective users [2].

Hartman, E. Eugenie’s ‘Preschool Vision Screening: Summary of a Task Force Report ‘shows that an array of four essential features, including eye exams, quizzes, an optician finder, and ocular assistance, are provided by the Vision Test [4] app. This application's extensive variety of capabilities, which go beyond simple eye exams, is one of its key strengths. However, it restricts itself to addressing just four visual problems when it comes to the breadth of eye exams. Unfortunately, inaccurate results from the optician locator feature detract from its usefulness. The application's shortcomings are particularly apparent in its lack of functionality and its sole focus on adult users. As a result, the app's pool of prospective users is still small.

Similar to this “The Vision Problem Tester” by D. I. De Silva et al. the review promotes “Healthy Vision,” which stands out by providing effective eye workouts for both adults and kids. However, a serious flaw is revealed while analyzing its diagnostic skills. For a variety of visual issues, the program depends on the ineffective technique of presenting pictures of degraded vision. These visuals frequently make it difficult for users to identify their particular vision problems, which leads to a less successful diagnostic process [2].

By offering a variety of vision exams, “I CARE Vision Test,” as stated in “The Vision Problem Tester” by D. I. De Silva et al. enters the picture; nonetheless, it struggles with poor usability. Its absence of crucial components like eye exercises is a serious flaw that reduces the efficiency of the program overall. Similar to previous programs, “I CARE Vision Test” limits its inclusivity by aligning its target demographic mostly with adults.

Turning to discuss The Vision Guard, the review presents “B2 Eye Test,” which provides vision tests, a survey, and a quiz. Despite its wide range of options, usability becomes a serious problem. The intricacy of the vision tests is criticized, and a glaring lack of additional characteristics limits its comprehensiveness [3].

Finally, The Vision Guard analyses “Vision Test,” a rival product on the market. Although this program, as previously said, has a wide range of features, its diagnostic capabilities are restricted because it only provides tests for four particular visual issues. Notably, the optician locator function is rife with errors. Vision Test is largely intended for an adult audience, which limits its potential reach, like its rivals [3].

In conclusion, the literature study highlights a recurring theme across existing mobile vision applications: many struggles with constraints such a lack of thorough diagnostic features, inefficiencies in eye examinations, and a restricted emphasis on certain vision disorders. These common issues function as a potent catalyst for change, stressing the pressing need for more efficient and widely available solutions in the area of mobile vision applications. The conclusions drawn from A Mobile Base Application for Cataract and Conjunctivitis Detection, The Vision Guard.

App Name	Eye Tech Solution	Healthy Vision	Central Vision	Icare	Vision Tester	Vision Checkup	B2 Eye Test	Vision Guard
Features of App								
Games for Contrast Sensitivity	✓							
Nearest doctor and optician finder	✓				✓			
Quiz related to the health of the eye and recommendations.	✓							✓
Customized glasses for selection.	✓							
Vision Progress Detector	✓							
Online Medical Support	✓							
Symptom Assessment	✓						✓	✓

Table I. Comparison Between The Existing Vision System And Eye Tech Solutions.

3. Methodology

The choice of the development framework for the application is a critical decision that can impact the system's functionality and efficiency. Eye Tech Solution is developed using MERN as the framework of choice.

MongoDB is a NoSQL database that stores data in a flexible format. It is known for its scalability, flexibility, and ease of use. It is an ideal choice for the application since MongoDB is well-suited for applications that require scalability in their data storage when handling large amounts of data [5]. Express.js is a lightweight web application framework that provides a set of features for creating scalable web applications. Express.js efficiently handles HTTP requests and responses of the system by the process of creating APIs [5]. When considering the functionalities of the application, it requires real-time updates and interaction with the server. React.js is a JavaScript library for building user interfaces that allow developers to create reusable UI components. React.js allows users to interact seamlessly with the application. Node.js is a powerful runtime environment that allows developers to run JavaScript on the server-side. Because of the Node.js runtime environment for synchronous requests [5], it offers a highly scalable and flexible application that is easy to manage in the future.Fig.2 Below shows a high-level architecture diagram of the web application.

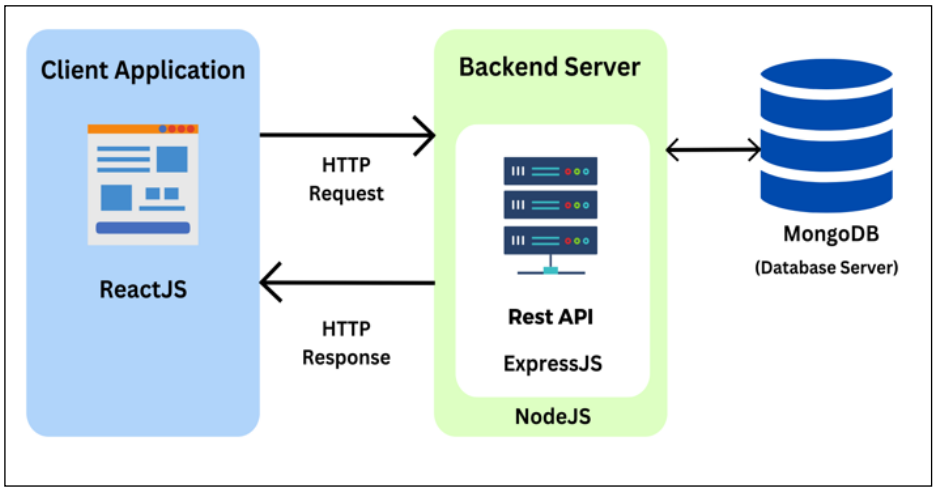


Fig. 1 . High-level architecture diagram of the web application.

The Eye Tech Solution encourages users to take an active role in their quest to improve their vision by providing a variety of vision tests such as contact sensitivity and visual acuity test. Also, the system is able to evaluate an individual's eye symptoms and provide guidance based on their responses using the symptom assessment quiz. The vision tracker aims to provide users with tools to analyze, track, and improve users' visual abilities. In addition to detecting eye problems, users can get doctor appointments based on quiz results. The following is a brief description of the methodologies of all the features of the proposed application.

A. Symptom Assessment Quiz and Recommendations

The symptom assessment quiz provided by Eye Tech Solution served as a crucial tool for evaluating the eye symptoms of the participants and providing guidance or recommendations based on their responses.

These quizzes are designed to ask targeted questions related to a specific eye disease. The responses are scored, and users receive results or recommendations based on their scores. The development of such a quiz involves careful consideration of the target audience, collaboration with medical experts, and clear and concise questionnaire design, usability, and functionality [9].

Upon completion of the quiz, users receive not only their scores but also detailed explanations of what those scores mean. The recommendations provided are personalized and actionable, offering users a clear understanding of their eye health status. This empowers them to make informed decisions about their eye care journey, whether it involves seeking immediate medical attention, scheduling regular eye check-ups, or adopting specific preventive measures tailored to their individual needs.

These quizzes aim to provide users with valuable insights into their or specific situations, helping them to make informed decisions about seeking medical advice or taking appropriate actions.

Furthermore, Eye Tech Solution's commitment to user education is a core component of these quizzes. In addition to the assessment and recommendations, users may also find informative resources, tips, and guidance related to their specific eye condition. This holistic approach ensures that users not only receive valuable insights into their eye health but are also equipped with the knowledge and tools necessary to proactively manage and maintain their vision.

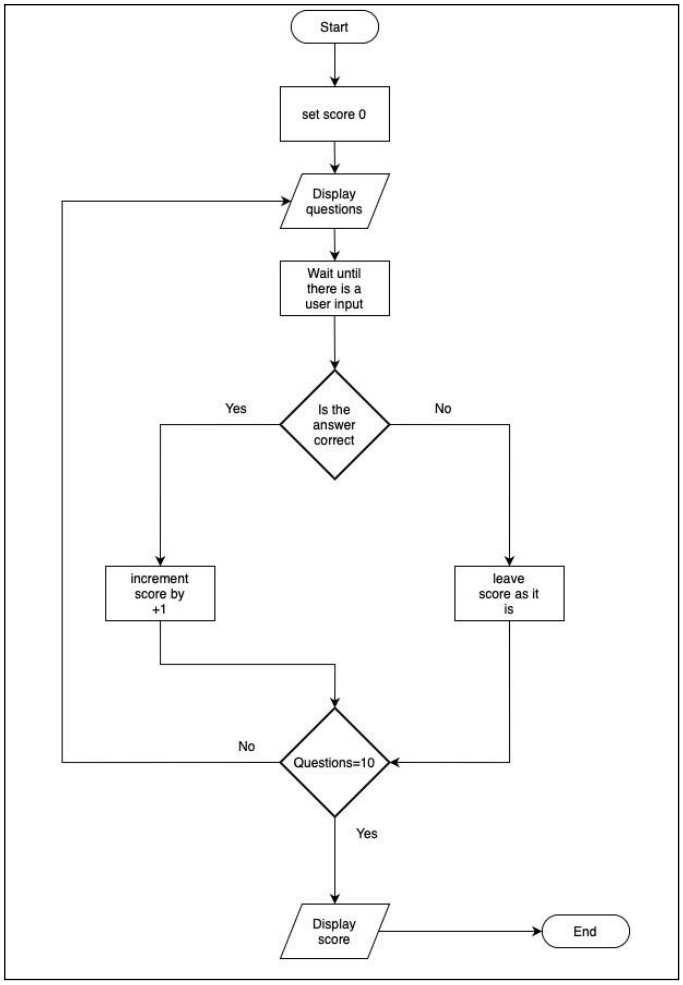


Fig. 2. Flow chart for symptom assessment quiz

B. Vision Tests and Games

Vision Tests and Games are developed to help users identify and improve their eye conditions in a more fun and interactive way.

1) Color Blindness Test- Color blindness, also known as color vision deficiency, is a condition that affects a significant portion of the population. It can impact an individual's ability to perceive and differentiate between specific colors [6]. To address this issue, a digital Ishihara Test is envisioned to help individuals self-assess their color vision. This test uses classic Ishihara plates, which are the standard for colour blindness diaognosis. The application will store all users' test results enabling them to track their progress over time.

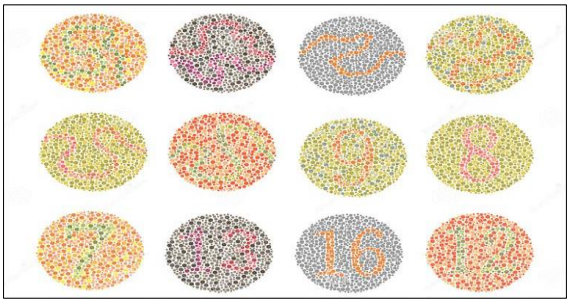


Fig. 3. Ishihara Tests

2) Visual Acuity Tests - Visual acuity (VA) is a measure of the ability of the eye to distinguish shapes and the details of objects at a given distance [7],[8]. This test is designed to evaluate the sharpness and clarity of the user's vision, particularly their ability to discern details at various distances. This test uses images of small letters at various distances to evaluate the user in which the application will provide a fractional value based on the results determining whether the user suffers from Visual Acuity. The application will store all users' test results enabling them to track their progress over time.

Fig.4. Visual Acuity test

C. Vision Progress Detector

The Vision Progress Detector (vision tracker) is a unique feature integrated into the Eye Tech Solution platform. It is designed to empower users by providing them with a tool to actively monitor and track the progression or regression of their eye conditions over time. Here is the functionality of VPD.

1) Disease Selection- Users can select the specific eye disease or condition they wish to monitor. This allows the vision tracker to provide results specific to that condition, enhancing its accuracy and relevance..

2) Data Input Methods

- Quiz: Users can take a quiz that assesses their current symptoms and provides immediate feedback on their condition's status.
- Image Upload: Users can upload images of their eyes, which are then processed using advanced algorithms to predict the current state of the eye condition.

3) Graphical Display - The VPD graphically represents the progress of the eye condition over time. This visual representation is based on quiz results and image analysis, offering users a clear and easy-to-understand overview of their eye health condition.

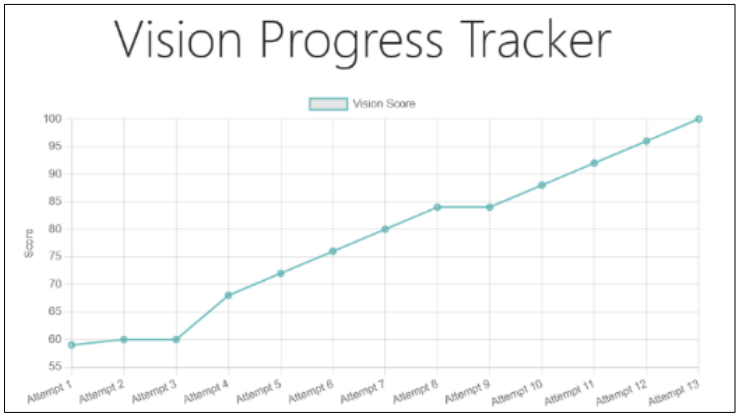


Fig.5. Graphical representation of Vision Progress Detector

4) Condition Categorization - Based on the results, users are categorized into one of three groups, indicating the level of recovery or progression of the disease:

- Green Zone (Mild): Indicates early stages of the condition or significant recovery. Immediate medical intervention might not be necessary, but regular monitoring is advised.
- Yellow Zone (Moderate): Represents a mid-stage condition. Medical consultation is recommended to prevent further progression.
- Red Zone (Severe): Indicates advanced stages of the condition. Immediate medical intervention is crucial.

5) Image processing mechanism - The Vision Progress Detector's image upload feature is powered by Convolutional Neural Networks (CNNs). CNNs are advanced neural networks optimized for image analysis. When an eye image is uploaded, the CNN dissects it to identify intricate patterns and characteristics. Trained on vast datasets, CNNs can recognize specific visual cues related to eye conditions. Their design, inspired by the human brain's structure, allows them to excel in tasks like image recognition and categorization. In essence, the Vision Progress Detector leverages CNNs to provide detailed insights into eye health based on the patterns detected in the uploaded images [1].

The Vision Progress Detector (VPD) relies heavily on Convolutional Neural Networks (CNNs). With their layered architecture, these networks are able to automatically and adaptively identify spatial hierarchies of features from input images. This is achieved by combining many layers. Convolutional layers, pooling layers, and completely connected layers are the main parts of these layers. The convolutional and pooling layers handle feature extraction in the early phases. They identify important details in ocular images, like patterns, textures, and edges, which are helpful in identifying ocular disorders. Specifically, the convolutional layers use filters to iteratively process the input image and produce feature maps that capture local patterns. The fully linked layers act similarly to a traditional neural network as one gets to the later layers. To carry out classification tasks, they utilize the high-level features that were extracted by the previous layers. Based on the identified features in the picture, this classification method within the VPD framework can determine the severity of an eye problem. CNN is trained with a tagged dataset of eye pictures to guarantee its effectiveness. Every image in this dataset has a tag that describes the condition or state of health that goes along with it. In order to reduce the classification error, the network modifies its weights throughout the training phase in response to the input images and their corresponding labels. After training is finished, CNN is prepared to examine a user-submitted image of a fresh eye. It analyzes this picture through all of its many levels to provide a prognosis regarding the state of the eye. When combined with the quiz results, this prediction provides a comprehensive assessment of the user's eye health. Moreover, the condition classification method of VPD may easily incorporate CNN's output. The image is categorized into green, yellow, or red zones, each of which denotes the severity of the problem that was detected based on the confidence scores and attributes that the CNN identified [1].

CNN integration into VPD has a number of advantages. First off, their unmatched accuracy in disease identification is guaranteed by their capacity to identify complex patterns in photos that conventional algorithms can miss. Second, because they are skilled at independently identifying the most relevant features from the training dataset, they add a layer of automation by eliminating the requirement for manual feature extraction. Finally, their scalability is praiseworthy. As more data comes in, CNNs can be retrained to improve their accuracy, which will eventually make the VPD system even more dependable and strong. To put it simply, CNN's incorporation into the Vision Progress Detector ensures that customers receive the most accurate and up-to-date assessment of their eye ailments, enabling them to make educated decisions about their eye health.

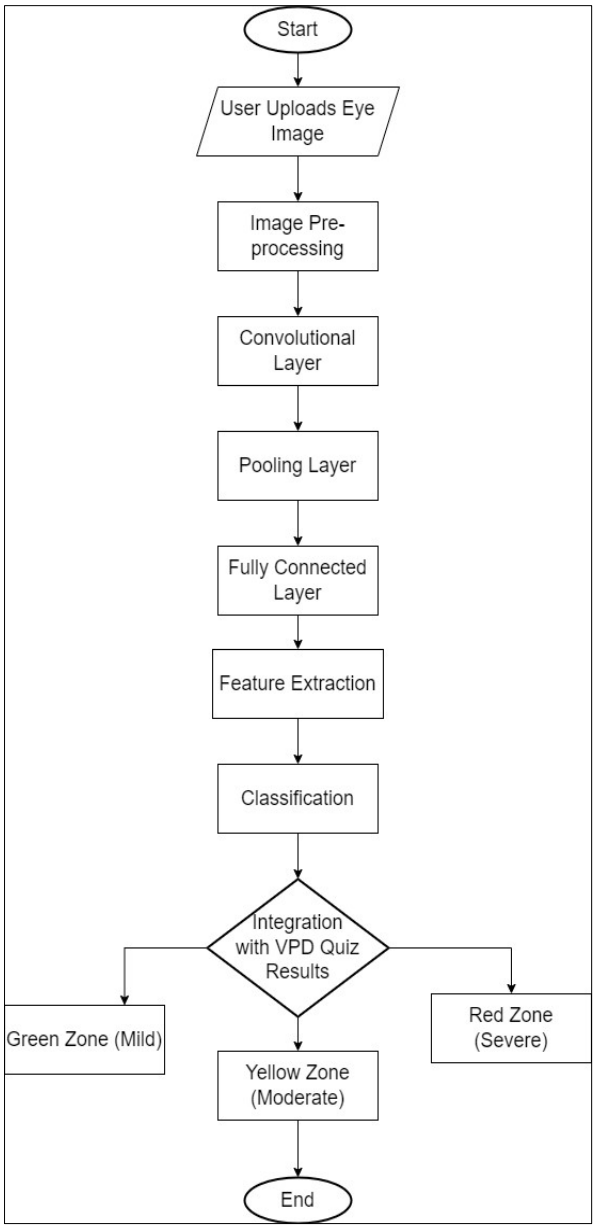
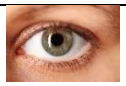


Fig.6. Flow Chart of image processing

Benefits of Vision Progress Detector

- Early Detection: By regularly using the vision progress detector, users can detect any negative changes in their eye health at an early stage, allowing for timely medical intervention.
- Empowerment: Users have the ability to gain knowledge and access tools to manage their eye health, reducing the need for visits to the clinic.
- Personalized Feedback: The vision tracker provides customized feedback that's specific to the users chosen condition guaranteeing that the information given is pertinent and can be put into action.
- Ease of Use: With its intuitive design and clear graphical representations, the vision progress detector is user-friendly, encouraging more individuals to actively monitor their eye health.

Table I. Unit Testing Results For Data Extraction And Classification For Pink Eye

Image	Actual situation	Level of recovery	Correct output
	Normal Eye	Green	Yes
	Pink eye	Red	Yes
	Recovering pink eye	Yellow	Yes

D. Doctor Appointments and Customized Glasses

1) Adding Doctors and Scheduling -This part includes a thorough investigation of the specializations and consultative availability of medical practitioners. Understanding the methods by which doctors may efficiently manage their calendars and assign appointment spaces within the suggested system was the main goal. The process of obtaining requirements included locating crucial information, such as the names of the doctors, their specialties, and the available time slots. Additionally, a clear user interface design was designed to make it easier for doctors to submit their availability and indicate their areas of expertise. Additionally, backend functions that concentrated on the management and storage of thorough doctor data and appointment schedules were established.

2) Displaying Relevant Doctors and Time Slots - In this phase, the inquiry focused on developing a coordinated plan to match doctors with relevant illnesses and to smoothly display their open time slots to users. In order to link physicians' specialist fields with particular ailments and ensure the applicability of their recommendations, tough criteria have to be identified throughout the needs-gathering phase. The fundamental reasoning behind showing users available time slots was also carefully laid out. Clear standards were outlined for the creation of front-end components responsible for presenting users with thorough doctor information and available time slots in order to support a smooth user experience.

3) Removing Doctors and Canceling Appointments - This phase focused on understanding the specifics connected with these procedures, delving into the mechanics of removing providers from the system, and supporting user-initiated appointment cancellations. The main focus was on creating an easy-to-use administrative interface that would enable administrators to effectively manage medical information and then remove doctors from the system. At the same time, the mechanism for users to cancel appointments was defined, detailing relevant practices and perhaps relevant concerns for cancellation rules.

4) Updating Doctor Details and Times - This section mainly explored efficient methods for doctors to update their contact information and availability for appointments over time. The range of data that may be updated was decided through a methodical approach, taking into account things like contact information, specialist domains, and accessible consultation hours. The process of gathering requirements further illustrated the complexities involved in creating an interface specifically for doctors that would make it easy to change their information and availability. Additionally, in order to protect the integrity of updated information, considerations were expanded to include data validation tools and a secure backend architecture.

5) Generating the Most Prevalent Affliction Report - This phase required a thorough grasp of the criteria and algorithms guiding this process since it was focused on uncovering the processes underlying the identification of the most common eye condition within a particular month and the subsequent development of a full report. The identification of crucial data points, such as identified illnesses and their corresponding frequencies, that go into the computation of prevalence was one of the core needs. The construction of an algorithm capable of precisely calculating and detecting the most common disease was specified in great detail. Additionally, the resulting report's structure and distribution method were carefully determined, providing a seamless integration into the entire system architecture.

6) Customized Glasses Ordering - This phase focused on the complex process of enabling users to create their eyeglasses and place orders within the system, delving into the world of personalized glasses. Determining the whole range of customization choices, including frame kinds and color variants, was crucial to the requirements collecting process. A user-friendly frontend mechanism was also rigorously described for the user interface design, allowing users to choose their chosen modification settings with ease. In order to ensure a flawless user experience, the backend processing system accountable for the safe storing and processing of personalized glasses orders was identified.

4. Results

The Eye Tech Solution app offers a range of tools to detect and manage vision issues while also bridging the gap between patients and eye care professionals. By incorporating technologies and frameworks the app ensures accuracy, scalability, and user-friendliness.

The Vision Progress Detectors integration of Convolutional Neural Networks (CNNs) demonstrates how machine learning can enhance the precision of vision assessments. Combined with features in the app users can approach eye care comprehensively. Take proactive steps to maintain their eye health.

Moreover, the app emphasizes user empowerment through features like the symptom assessment quiz and vision progress tracker. This ensures that individuals don't just passively receive care but actively participate in their journey towards eye health. In today's world, where people often neglect their well-being due to time constraints and other commitments, this approach is crucial.

One significant challenge in healthcare accessibility is addressed by connecting users with eye care specialists through Eye Tech Solution. By offering a platform that allows users to not only evaluate the health of their eyes but also receive expert guidance and treatment the application guarantees that early intervention can take place minimizing the chances of encountering serious vision issues down the line.

Although the application has demonstrated outcomes it is crucial to enhance and update it to meet the ever-changing requirements of users and to integrate technological advancements. Further research could concentrate on broadening the scope of vision tests available by incorporating machine learning algorithms and establishing collaborations with eye care institutions to further improve the applications' capabilities.

5. Discussion

This study focuses on allowing users to diagnose their vision problems at an early stage so that they can be treated quickly before becoming critical and provides quick access to eye contact specialists through the application. It also provides a vision progress tracker to track progress in a user's vision over time.

Vision tests and games and the symptom assessment quiz effectively identify common vision-related issues, that allow users to gain insights into their specific symptoms. In addition, after completing the quiz, Eye Tech Solutions provides the facility to make an appointment with the most suitable eye specialist nearby. This feature provides users with the specialist's information and time slots, allowing for seamless appointment booking tailored to their needs. Furthermore, the Vision Progress Detector analyzes the accuracy and effectiveness of monitoring users' vision over time.

The EyeTech Solution has been tested for usability testing to ensure that interfaces are consistent. In addition, unit testing, integration testing, system testing, and other general testing methodologies are used to enhance the system's overall optimization and performance.

6. Conclusion

This research has explored the effectiveness and impact of four main components of the EyeTech Solution application such as the Symptom Assessment Quiz and Recommendations, Vision Tests and Games, Vision Progress Tracker, and Doctor Appointment and Customized Glasses. The MERN stack has been chosen as the framework for this application due to its efficiency, scalability, and ability to handle large volumes of data.

While there are several vision applications, most of them fail to provide an application that represents a significant step forward in the early detection and management of vision problems like EyeTech Solutions.

Moreover, this web-based application creates a comprehensive vision health ecosystem that addresses a range of user needs, from symptom identification to professional care.

In conclusion, this research marks a notable improvement in the domain of early vision problem detection and management. By embracing a holistic approach to vision care, findings underline the potential for significant improvement in user well-being.

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