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EyeZen : Comprehensive Vision Impairment Testing and Ayurvedic Interventions for All Age Groups

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Abstract: With the advancement of technology and with the rise of pandemics like COVID-19, all businesses, and even household works, have shifted to a technological-based working environment. This digital era has increased screen time, leading to a rise in eye diseases. This study proposes a flexible application, EyeZen, that smoothly connects contemporary technology and ocular health management in response to the urgent demand for thorough and accessible early-stage eye care. EyeZen is a dual-interface application created for both mobile and web platforms, incorporating many features that are specifically suited to meet varied user demographics and unique eye care requirements. One distinguishing feature of the application is the customized questionnaire created by an approved panel of ophthalmologists, which skillfully addresses the eye concerns of users ranging from newborns to adults. The novel incorporation of indigenous treatments, often disregarded in contemporary healthcare solutions, is what sets this application apart. The proposed application opens the door for a comprehensive strategy for managing ocular health by seamlessly fusing conventional wisdom, like Ayurveda, with modern technological features. Users gain access to a curated repository of natural remedies, expertly evaluated to ensure effectiveness and safety. For a variety of users, the app redefines eye health management by blending technology, tradition, and modern methods, with an emphasis on early identification, comprehensive care, and informed decisions. At present, the application has been tested with fifty eye patients, and the results show a high rate of accuracy.

Keywords*: eye diseases, eye care quiz, diagnosis, ayurvedic, infant eye care, web application, mobile application*.

1. Introduction

The foundation of this research is firmly placed in addressing the vital domain of eye care, which is of critical importance in today's fast-paced digital world. The investigation focuses on the creation and execution of a comprehensive application aimed at revolutionizing early-stage ocular health management. This study expands previous works in the areas of eye care, technology, and healthcare innovation and it is supported by pertinent theories and concepts.

The domain of eye care plays a pivotal role in safeguarding individuals' visual health and overall well-being. The timely identification and intervention of vision-related concerns hold the potential to mitigate the impact of ocular disorders. The core research topic of this research is to close the technological gap between the urgent demand for affordable and comprehensive eye care solutions and current technological capabilities and to make an evolutionary step in promoting and raising the awareness of indigenous medical treatments for ocular health. The risk of ocular health problems rises when people are subjected to more screen time and online interactions. The issue is succinctly stated: How can the management of eye health be revolutionized by a novel application that successfully combines cutting-edge diagnostic technologies, traditional treatments, and personalized care.

This study's importance can be seen in its potential to change the way individuals think about ocular health. In a world where eye strain, vision impairments, and other related issues are on the rise, an integrated solution that combines traditional wisdom with cutting-edge technology has enormous practical and theoretical implications. This research has the potential to open the door for a more proactive, informed, and all-encompassing approach to eye care by combining tried-and-true indigenous remedies with cutting edge diagnostics.

Leveraging the ubiquity of mobile technology and the reach of web interfaces, this application consolidates diverse components to cater comprehensively to users across various demographics. The overarching objective is to furnish a suite of tools that not only facilitate the diagnosis of vision impairments but also empower users with the knowledge and resources essential for informed decision-making and effective treatment strategies.

Developing an application that smoothly combines specialized questionnaires for early detection, traditional cures for holistic care, and contemporary diagnostic technologies for precise evaluations are the specific goals of this study. By doing this, the study hopes to equip participants with the information and resources they need to take control of their ocular health. Whether this integrated strategy may result in early detection, informed decision-making, and improved ocular health outcomes is the central research question driving this project.

The subsequent sections of this paper delineate the constituent modules of the application, each serving a distinct purpose within the domain of eye care. The adult eye testing module employs a structured questionnaire-based approach to identify potential vision impairments, furnishing preliminary insights into prevalent ocular diseases. This is complemented by a module dedicated to infant eye testing, enabling parents to guide assessments of their infants' visual behaviors, thereby promoting early intervention and parental engagement in ocular health management.

A novel feature of the application is the integration of indigenous medical treatments and home remedies. Acknowledging the significance of traditional practices, this module provides users with alternative avenues for vision enhancement. Furthermore, the application incorporates a standardized method for the detection of short-sightedness, further enhancing its diagnostic capabilities.

To further solidify the application's commitment to holistic eye care, it integrates location-based recommendations for medical professionals, encompassing both conventional and indigenous practitioners. The idea and design of the application, the development process, validation and testing techniques, and deployment strategies are all covered in the section to follow. Furthermore, subsequent sections contains a clear idea of the proposed system. Each element contributes to the overall understanding of how this cutting-edge application addresses the research issue, advances the administration of eye care, and provide details regarding specific vision impairments covered in the research.

2. Literature Review

In the domain of eye care, the urgency of early detection and comprehensive management of visual impairments is crucial. Addressing these concerns aligns seamlessly with the broader aim of advancing ocular health and overall well-being.

Scholarly inquiries consistently underscore the pivotal importance of early detection of eye disorders. Previous researchers affirm how timely identification of visual impairments in infants and toddlers significantly influences their well-being and quality of life [1]. Additionally, the studies emphasize the direct correlation between early glaucoma detection and the subsequent effectiveness of treatments, advocating ardently for expedient intervention [2].

In recent years, technological progressions have imbued eye care diagnostics with unprecedented potential. The advent of mobile applications has unveiled the remarkable capacity of technology to broaden diagnostic accessibility. This synthesis resonates harmoniously with the innovative direction of this research, which judiciously amalgamates both mobile and web platforms to ensure inclusivity and reach an expansive spectrum of users.

The integration of traditional indigenous medical treatments within the application imparts a distinctive and noteworthy dimension. While modern medical interventions retain their prominence, insights drawn from studies illuminate the efficacy of traditional treatments in managing specific eye conditions [3]. Weaving these age-old practices into the fabric of the innovative EyeZen application equips users with a diverse array of treatment options, encompassing indigenous remedies in a harmonious tapestry.

There are a limited number of mobile applications that are available for personal use. Most of the applications available give inaccurate results and supply very few useful features. Also, these few available applications only detect limited vision problems. The following two reviews attempt to demonstrate and support this hypothesis.

Literature contains several mobile applications related to vision testing. The Vision Problem Tester [4] is a mobile application developed in response to the increasingly busy lives of individuals. This innovative app allows users to accurately detect vision problems from anywhere, at any time, and at no cost with minimal effort. It caters to children under 8 with engaging games designed to identify vision issues. The application also features a Symptom Checker to identify eye disorders based on user symptoms and helps locate nearby doctors and opticians based on the user's location. Endorsed by several ophthalmologists, the app has undergone testing with over thirty eye patients, demonstrating an impressive level of accuracy. Eye Plus [5] is an innovative mobile application that has been proposed for the detection of Cataract and Conjunctivitis. This user-friendly app allows individuals to conveniently test their eyes at any time and place. Notably, Eye Plus boasts the ability to operate without external assistance, offering valuable information on the aforementioned eye diseases. With a success rate of 83.3% based on the analysis of 150 images, Eye Plus stands as a promising tool in the early detection and management of these critical eye conditions. Vision Guard [6] is a groundbreaking solution designed to empower individuals in accurately identifying a range of vision impairments without the need for a doctor's consultation. This innovative mobile application proposes a user-friendly approach, enabling individuals to identify vision-related problems effortlessly, emphasizing early detection for improved outcomes. Beyond detection, Vision Guard offers a wealth of knowledge on vision problems, their causes, cures, and incorporates eye exercises to foster healthy vision maintenance. The application is accessible in English, one of the most widely used global languages.

The propsoed application extends its utility beyond diagnostics and treatment by serving as an intellectual cornerstone in the educational realm. Contemporary healthcare discourses increasingly emphasize the value of health literacy, highlighting the pivotal role of patient education in fortifying treatment adherence and effective disease management [7]. Through a curated collection of informative articles, the newly created application aspires to heighten awareness about diverse eye ailments, equipping users with the knowledge to make discerning decisions about their ocular health.

In summary, insights from extant literature accentuate the indispensability of early detection, technology-driven diagnostic tools, and holistic treatment modalities within the realm of eye care. The subsequent sections of this paper delve into the application's developmental trajectory and multifaceted functionalities, culminating in a profound elevation of accessibility and efficacy in the sphere of eye care management.

3. Methodology

EyeZen, an eye care system was developed using an object-oriented approach. This methodology was chosen for its flexibility, improvement process and ability to adapt to evolving user needs.

When it comes to developing web applications the user interface of EyeZen utilizes the React framework to ensure responsiveness and a user-friendly experience. The backend of the web app is powered by Node.js and Express.js providing an efficient server-side environment. For mobile application development EyeZen leverages React Native to create an app that can seamlessly run on platforms. Like the web app, the backend of the app also relies on Node.js and Express.js. To maintain scalability and reliability, in both the mobile and web apps EyeZen utilizes the MySQL database management system. This secure database effectively manages user profiles, quiz responses, test scores and other important data.

The developed mobile and web application system that aims to improve user experience and accessibility has been achieved in regards of the research. This system includes features such as disease detection, child friendly

options, ayurvedic resources for eye care and a comprehensive directory of eye care specialists. The goal is to provide a rounded and user centered approach to managing eye care.

A. Eye Disease Detection

1) Color Blindness Detection

A genetic disorder called color blindness makes it impossible for a person to recognize a limited range of colors in the color spectrum as shown in Fig. 1. This ailment is genetically inherited among people in society [8]. In the proposed application to detect color blindness it uses Ishihara test plates to assess whether a user has any issues with color vision. Ishihara plates consist of small circles with different sizes and colors and in the middle of that it displays a number. The application will display a specific number of Ishihara plates where the number of plates are approved by ophthalmologists as to ensure the accuracy of the results received through the test, to the user and by analyzing the users ability to correctly identify the numbers displayed on each plate the app will generate a probability value by using the correct choices of the user when performing the test and will determine if they have any color vision deficiencies

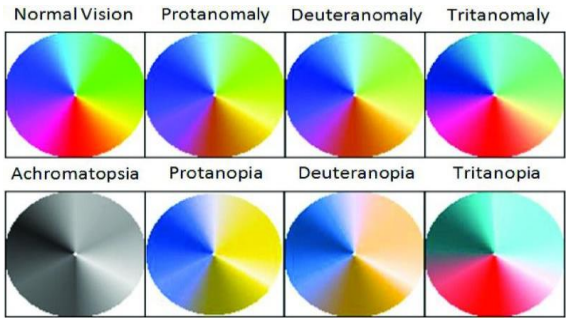

Figure 1: How People with different color deficiencies see certain colors

2) Hyperopia and Myopia Detection

Hyperopia, commonly referred to as farsightedness, is a condition where faraway objects appear clearer than those nearby. It happens when the eyeball is shorter than normal, or the cornea lacks curvature resulting in light focusing behind the retina as shown in Fig. 2 [9].

Nearsightedness, commonly known as myopia is a condition in which objects close are easily visible and distant objects appear blurry. This happens when the shape of the eyeball is elongated or when the cornea is excessively curved causing light to focus in front of the retina as shown in Fig. 2 [10].

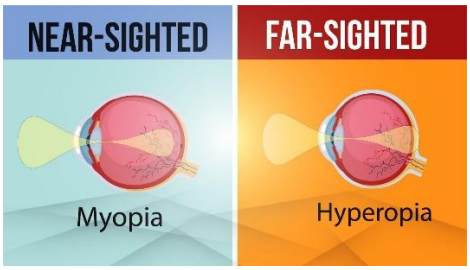

Figure 2: Way of focusing optical waves an eye with myopia and hyperopia.

The proposed application can detect both hyperopia and myopia. To ensure accuracy and reliability the utilization of visual acuity charts such as the Snellen chart, Landolt C symbol chart or logMAR charts which adhere to accepted norms have been used.

To detect myopia users are required to observe the letters and symbols shown via the application and they must respond with whether they can see them or not. And then based on the answers provided by the users the application will generate a probability value and will display the results regarding hyperopia condition is identified

or not. For myopia condition to evaluate, the same process has been used. And the main variation is that the users are required to be within the advised distance and then they must observe the displayed letters or symbols. To increase the usability of the application it has added voice detection so users are just required to confirm whether they can see the displayed letters or images clearly or not. And then in the same way the application will generate the probability of having myopia. The accuracy of these results are ensured by comparing the suggested probability values of having diseases by the ophthalmologists.

3) Poor Depth Perception Detection

The condition of not being able to judge distances and perceive the world in three dimensions is called poor depth perception [11]. Lack of stereopsis is the cause of this issue. Currently it is known that many people struggle with weakened depth perception, which can greatly impact their lives. To assess a person's depth perception the app offers a test. On the test screen several images will be displayed along with instructions. Users can easily follow these instructions on screen and then complete the test regarding the experience they got while performing the task instructed by the application. Afterwards they can review the results to determine if their depth perception is lacking or not based on the test performance.

4) Macular Degeneration Detection

One of the most prevalent eye conditions is macular degeneration mostly impacts persons over the age of sixty and eventually results in visual loss. The central region of the retina known as the macula begins to weaken, which is the cause of this illness as shown in Fig. 3 [12].

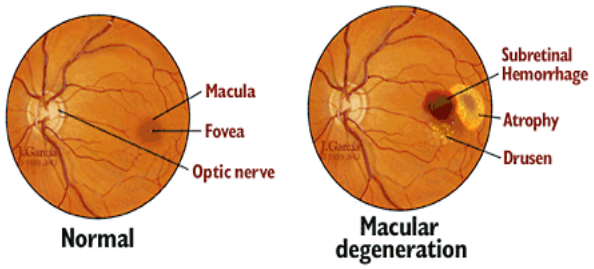

Figure 3: Image of a normal eye and eye with Macular Degeneration

In EyeZen, Amsler grid test is used to provide initial testing on macular degeneration. So that, the application will display the Amsler grid to the user and ask to close an eye at a time and observe the black dot shown in there. And if the lines in the grid seem to be blurred users can answer the test by saying they cannot see the lines clearly. On the other hand, if they can see the grid lines clearly while focusing on the black color dot placed in the middle, they can confirm it by saying they can see it clearly. So, after the provided answer has been submitted, the application will check the given answers with the expected answers and then will display the probability of having macular degeneration.

5) Contrast Sensitivity Detection

The ability of a person's eyes to perceive the difference, in contrast, between objects and their surroundings is referred to as contrast sensitivity. When someone has limited contrast sensitivity they struggle to distinguish between objects and their backgrounds that have levels of contrast [13]. To assess a person's level of contrast sensitivity, the developed application will utilize photographs with levels of contrast. The user is required to review these images and select one from the provided options that appears similar, in terms of contrast. Then based on the provided options and the accurate answer fed to the application which are required to be provided the application will check and display the probability of having contrast sensitivity.

As discussed above through quizzes the EyeZen will evaluate and identify the probability of having eye disease, and the flow of performing a quiz is shown in Fig. 4.

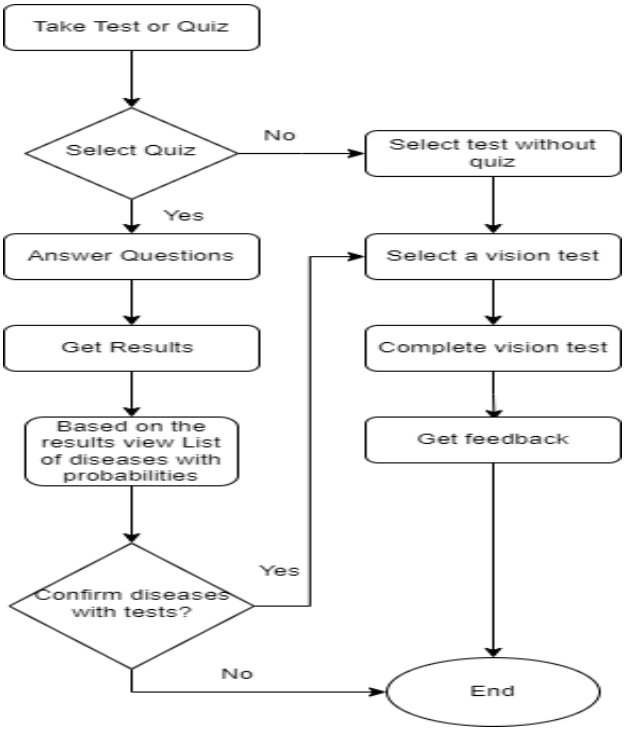

Figure 4: Flow of performing a test regarding an eye disorder.

In case of a user who is not aware of the disease type they can perform the basic quiz which covers most of the eye diseases. Then after the analysis of the responses, a list of potential diseases and corresponding probabilities are presented to the user and after considering the results users will be able to perform a quiz specifically designed for a particular disease.

B. Eye Disease Detection of Children

As expertise are mentioned in that the eye diseases are necessary to be identified in an early stage as some diseases are preventable, the EyeZen offers the capability of checking the vision condition of children below eight years and infants below one year by providing a child friendly interfaces and processes.

In both the web and mobile version of EyeZen it offers a range of kids' games made by using the concept of the possible ways of measuring the vision condition of children. Basically, these games consist of a collection of interactive activities such as selecting the odd image, selecting the image with more contrast, selecting the object displayed in a small size as shown in Fig. 5.

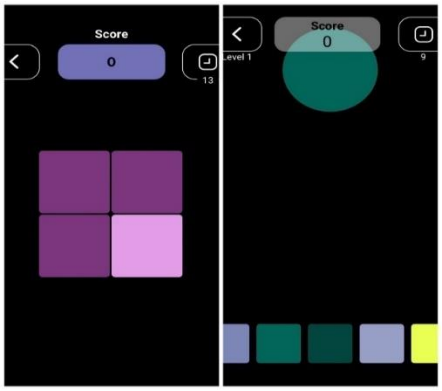

Figure 5: Interface of a kid's eye test based game

Regardless of displaying questions to children it is a very useful and effective way to check the vision of a child through directing them to perform a game. EyeZen will then generate the probability of having eye disorders by evaluating the score obtained by playing the game.

Not only these features but also EyeZen provides effective ways to identify potential vision problems in infants who are below one year. To achieve this EyeZen uses a descriptive way of instructing parents on how to perform tests on their infants. The accuracy of these results is being ensured by obtaining the experts knowledge on providing guide to parents on performing tests. Therefore, parents could clearly identify which they have to perform while interacting with their infant and answer the questions displayed by the application. As for example one of the questions will be asked from parents to move a colorful object side by side in front of their infant and carefully observe the eye movements of the child and then parents can answer with is their infant focuses on those objects or not. And then based on the provided answers the application will analyze and generate the probability of having a vision impairment.

C. Ayurvedic Eye Care

Aligned with the innovative approach to maintaining eyes the EyeZen app includes a special section that focuses on Ayurvedic eye care. Ayurveda, a time-honored system of medicine places importance on overall wellbeing and natural treatments. Within this section users can access a range of resources and information designed to enhance eye health based on principles which are collected through ayurvedic eye health specialists, such as:

- Ayurvedic Treatments for Eyes.
- Ayurvedic Treatments for Eyes.
- Ayurvedic Articles on Eye Health.
- Eye Care Tips.
- Guidance on How to Naturally Improve Eyesight.
- Preventive Measures for Enhanced Eye Care.
- Ayurvedic Eye Care Video Tutorials.

D. Find Eye Care Specialists

1) Doctor Locator

A user-friendly doctor locator is offered through the web app and mobile app. It offers pinpointed locations, utilizes geolocation for nearby results, and clickable pins for quick info. Depending on their unique requirements, users can look for Western and Ayurvedic eye care professionals. The system provides information on the locations and phone numbers of the doctors.

2) Virtual Appointments

Once users have made their reservations through the app, they can conveniently schedule appointments, with doctors online. This helpful feature caters to individuals enabling them to receive expert advice and treatment suggestions without having to visit the doctor’s office.

3) Doctor and Eye Care Centre Phone Book

A comprehensive listing of esteemed eye care practitioners and clinics is provided via the EyeZen application. Users can easily search contact numbers of specialists based on location, expertise, or ratings. Each listing provides detailed profiles, including qualifications and all information and integrated booking simplifies appointment scheduling.

4. Results and Discussion

A. Adult Eye Tests

The goal of conducting eye tests for adults was to identify the probability of having eye disease symptoms and direct them to get treatment to their vision conditions. To prove the usability and accuracy of the application in

the first phase of testing a random sample of thirty people between twenty to sixty-five years were chosen and was asked to perform the eye tests regarding diseases. And parallelly those were evaluated by an ophthalmologist. Then the results were calculated and generated a percentage value to compare the accuracy and as per the results collected through the testing it showed that an average of 81.67% of accuracy rate in the received results as shown in Table 1.

Table 1: Accuracy level of adult eye test

Test No	Test Name	Accuracy	
		Ophthalmologist	***Proposed System***
01	Color Blindness Detection Test	85%	80%
02	Hyperopia Detection Test	90%	85%
03	Myopia Detection Test	90%	85%
04	Poor Depth Perception Detection Test	85%	80%
05	Macular Degeneration Detection Test	80%	78%
06	Contrast Sensitivity Detection Test	80%	82%

B. Kids Vision Testing Games

The objective of implementing these kids' games was to make the eye disease detection of children under eight easier for their parents. To test the accuracy of these games a sample of ten children were selected and asked them to play the game with the guidance of their parents. To judge the judge of efficiency of these games ophthalmologist was thoroughly examined the test and provided the accuracy rates of each test. As per the examination of the ophthalmologist presented that among the tested kids there is an average of only 60% risk of having eye diseases with those children and the proposed system generated a probability of 65% risk of having eye diseases with children. When comparing those results, it shows that the accuracy of kids' games are accurate enough to use with children to test their vision

C. Infants Vision Tester

To test the accuracy of the vision test on infants only five infants below age of one was observed with the help of their parents. Basic tasks were performed by their parents suggested through the application and performed the test. Then the ophthalmologist checked the vision and approved that only one child can have a small possibility of having a vision impairment. And by the proposed system that result was also produced by showing a 100% mark of having a good health condition for four infants and 50% risk for only one infant. So that, it was proved that the proposed system has a higher accuracy level in identifying vision impairments of infants below age of one.

Therefore, through EyeZen the revolutionary mobile app and web platform, has proven to be incredibly effective in correctly identifying a variety of vision issues, color blindness, depth perception, macular degeneration, contrast sensitivity, hyperopia, and myopia disorders and correctly identifying vision impairment regardless of the age. And it allows users to diagnose their vision problems at an early stage so that they can be treated quickly before becoming critical.

In addition, Users can get useful information about traditional medical treatments and Ayurvedic eye care advice from this special ayurvedic section. EyeZen stands out as a complete eye care solution due to the inclusion of Ayurvedic eye treatments, articles on eye health, natural vision enhancement counselling, preventative measures, and video training. Also, with the busy lifestyle user can virtually meet the doctors using the app by channeling them. User can also find the doctor's location and the contact information according to their preferences for ayurvedic and western treatments.

5. Conclusion and Future Work

In summary EyeZen represents a groundbreaking approach to maintaining eye health. It empowers individuals to proactively manage their vision through the integration of advanced technology and user-friendly features. The apps comprehensive approach encompasses a range of offerings, including assessments, interactive quizzes, engaging games suitable for children and even a section dedicated to infant eye care. This ensures accessibility for users of all age groups. What truly distinguishes EyeZen is its blend of principles and Western medical practices making it an unparalleled resource in its field. Users can access a wealth of information spanning from eye care tips to treatments as well as connect with specialized eye care professionals for personalized guidance. Its significant contribution lies in the detection and timely treatment of vision issues such as color blindness and macular degeneration. Even while EyeZen has shown amazing improvements in vision treatment, it's important to recognize some limits. The application currently does not offer a Myopia detection test in the mobile app due to practical constraints related to testing distance. But still user can download the related materials for myopia and check with their own. Looking ahead there is potential for expansion by incorporating vision tests not currently available in both mobile and web applications. Additionally integrating eye exercises along with reminders into the mobile and web platforms could greatly enhance its functionality.

References

[1] T. L. Anthony, “Early identification of infants and toddlers with deafblindness”, American Annals of the Deaf, 2016, 161(4), pp. 412–423.

[2] S. Abdolrahimzadeh, “Rare diseases leading to childhood glaucoma: Epidemiology, pathophysiogenesis, and Management”, BioMed Research International, 2015, pp. 1–11.

[3] A review of Traditional Medicine Research in Sri Lanka: 2015–2019 (2015) World Health Organization. Available at: https://apps.who.int/iris/handle/10665/347359 (Accessed: 19 September 2023).

[4] D. I. De Silva, G.M.T.K.D.S. Suriyawansa, P. B. Ratnayaka, L.N.C. Perera, R.S Somarathne, “The Vision Problem Tester,” In *Proc. International Conference on Computational Techniques in Information and Communication Technologies (ICCTICT)*, New Delhi, India, Mar, 2016, pp. 116-120.

[5] A. Soysa and D. De Silva, “A Mobile Base Application for Cataract and Conjunctivitis Detection,” In *Proc. 5th International Conference on Advances in Computing and Technology*, Kelaniya, Sri Lanka, pp. 76 - 78, Nov. 2020.

[6] L. N. C. Perera, G. M. T. K. D. S Suriyawansa, R. S. Somarathne, P. B. Ratnayaka, D. I. De Silva, “The Vision Guard,” *International Journal of Research in Science and Technology (IJRST)*, vol. 5, no. 4, pp. 179 - 188, Oct. 2015.

[7] R. Khanna, M. Cicinelli and S. Marmamula, “Comprehensive eye care - issues, challenges, and way forward”, Indian Journal of Ophthalmology, 2020, 68(2), p. 316.

[8] A guide vision testing in California public schools. Available at: https://www.schoolhealthcenters.org/wpcontent/uploads/2012/01/Vision-Guide.pdf (Accessed: 19 September 2023).

[9] N. C. Strang, K. L. Schmid, and L. G. Carney, “Hyperopia is predominantly axial in nature”, Current Eye Research, 1998, 17(4), pp. 380–383.

[10] I. G. Morgan, K. Ohno-Matsui and S. M. Saw, “Myopia”, The Lancet, 2012, 379(9827), pp. 1739–1748.

[11] Understanding your depth perception (2015) EyeHealthWeb.com. Available at: https://www.eyehealthweb.com/depth-perception/ (Accessed: 19 September 2023).

[12] P. J. Rosenfeld, “Ranibizumab for neovascular age-related macular degeneration”, New England Journal of Medicine, 2006, 355(14), pp. 1419–1431.

[13] C. Owsley, “Contrast sensitivity”, Ophthalmology Clinics of North America, 2003, 16(2), pp. 171–177.