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Trinetra- A Vision Therapy Application to Aid People with Low Vision

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Abstract: In a more focused analysis, the recent papers stemming from these studies reveal deeper insights into their respective areas. The study cantered on AI in adaptive education uncovers a growing inclination towards neural networks as a potential solution for identifying learning styles. However, despite this interest, there remains a noticeable void in research efforts directed towards comparing and implementing deep learning techniques, highlighting an area ripe for further exploration. In a more focused analysis, the recent papers stemming from these studies reveal deeper insights into their respective areas. The study centred on AI in adaptive education uncovers a growing inclination towards neural networks as a potential solution for identifying learning styles. However, despite this interest, there remains a noticeable void in research efforts directed towards comparing and implementing deep learning techniques, highlighting an area ripe for further exploration. In a more focused analysis, the recent papers stemming from these studies reveal deeper insights into their respective areas.

Keywords: *Vision therapy, low vision, iris tracking, Media Pipe, interactive exercises, progress tracking*

1. Introduction

"Trinetra" aims to provide a comprehensive, accessible, and engaging platform for vision therapy. By leveraging modern web technologies and state-of-the-art eye-tracking algorithms, the system is designed to cater to a wide range of users, ensuring inclusivity and adaptability. One of the most significant advantages of the platform is its ability to bring therapy directly to users' homes, eliminating the need for frequent visits to specialized clinics. This approach not only reduces the financial burden associated with therapy This advanced technology enables precise monitoring of eye movements, a critical aspect of exercises aimed at improving focus, coordination, and muscle strength. Interactive exercises such as thrataka (steady gaze practice) and saccades (quick eye movements between targets) are designed to target specific visual impairments. The project introduces a user- friendly, web-based platform that incorporates advanced tools like Media Pipe's Iris Tracker to monitor and enhance visual performance.

To encourage sustained engagement and motivation, the platform incorporates progress-tracking features, including visually intuitive progress bars, which represent user improvements based on their performance in various tests[1][2][3][4].

1.1 About the Application

The" Trinetra- Vision Therapy Application" aims to assist individuals with low vision by offering an engaging and user-friendly solution for vision improvement. Upon logging in, users gain access to a range of therapeutic exercises tailored to enhance their visual capabilities. These exercises focus on improving eye focus and strength through targeted activities, closely monitored by advanced iris tracking technology from the Media Pipe library. The iris-tracking mechanism captures real-time movements of the user's eyes, ensuring precise tracking and analysis of eye performance during each exercise. The data collected is then processed to evaluate the user's progress in strengthening their vision. Based on this analysis, users are presented with detailed progress reports in the form of intuitive progress bars, providing clear feedback on their improvement over time. This project integrates modern web technologies, seamless user interfaces, and advanced eye tracking algorithms to create an effective vision therapy tool. By combining therapeutic exercises, scientific monitoring, and actionable progress insights, Trinetra" aspires to become a transformative aid for individuals seeking to enhance their visual health and overall quality of life [4][5][6][7].

1.2 Existing System and its limitations

- **In-office Vision Therapy Sessions:** Traditional vision therapy requires patients to visit clinics regularly for in- office exercises guided by optometrists. This approach is inconvenient and time-consuming, making it difficult for users to maintain consistency in their therapy routines.

- **Limited Personalization:** Many existing vision therapy systems lack customization and provide generalized exercise programs. This hinders their effectiveness; as individual users have varied visual needs that are not adequately addressed.

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• **High Costs**: Vision therapy often involves recurring clinic visits, expensive equipment, and professional fees. These factors make it unaffordable for many users, particularly those with low income or insufficient insurance coverage.

• **Restricted Accessibility**: Traditional vision therapy requires users to access specialized clinics with qualified professionals, which are often unavailable in rural or underserved areas. This restricts therapy access for many low-vision users.

• Low Engagement and Motivation: Exercises in traditional systems are often repetitive and lack engaging or interactive features. This leads to reduced motivation and adherence among users, limiting the overall success of the therapy.

2. Literature Survey

Research in vision therapy technologies highlights significant advancements and challenges. Studies have explored innovative prototypes, showcasing real-time benefits and enhanced user interaction, though hindered by cost and specialized hardware requirements. User-centered designs have demonstrated improved patient engagement and therapy outcomes, albeit with challenges in development time and expenses. Feasibility studies revealed potential in enhancing spatial awareness and visual acuity training, though limitations in testing scopes and reliance on advanced technologies persist[8][9]10][11].Font Reading Therapy: Studies highlight font-reading exercises as a way to improve visual tracking and processing speed.

- Eye Tracking for Accuracy Measurement: Incorporating eye-tracking tools like Media Pipe helps in monitoring eye movements and evaluating accuracy.
- Iris Tracking Research: Tracking iris movement helps measure focus and alignment, crucial in therapies like thrataka and saccades.
- Responsive Web Design: Literature suggests that web applications for vision therapy should be mobile-friendly to improve accessibility.
- Use of Bouncing and Blinking Objects: Visual tests with bouncing or blinking elements help train peripheral vision and reaction time.
- Font Size Hierarchy: Studies on typography suggest larger fonts enhance readability, while varying sizes challenge visual adaptability.
- Color Psychology: Using soft and calming colors (e.g., beige and blue) reduces visual strain during therapy exercises.
- Impact of Progress Visualization: Progress bars and performance scores improve motivation by providing clear progress tracking.
- Implementation of Simple UI: A user-friendly Interface ensures the therapy platform is intuitive for users of all ages. Research on therapy systems for older adults and diverse demographics emphasized increased autonomy and adaptability while addressing challenges like technology adoption barriers and steep learning curves. Integration of advanced functionalities, such as thermal sensors, has enhanced therapy immersion but faced issues of complexity and scalability. Practical implementations in real world scenarios have demonstrated the potential of interactive environments and precise monitoring systems, addressing specific therapy needs while highlighting areas for further improvement.

2.1 Relevant Recent Paper's Summary:

Recent research has focused on enhancing user experience, practicality, and adaptability in vision therapy technologies.

Studies on user-centered designs have shown that tailoring therapy systems to individual needs significantly improves patient engagement and therapy adherence. Iterative prototyping has been explored to refine these designs, leading to more effective systems, though challenges remain in managing resource constraints and development timelines. Research into inter active environments has highlighted their potential to create engaging therapy exercises, improving user outcomes through real-world applicability. Additionally, advancements in precise monitoring systems have addressed specific therapy needs, demonstrating their capability to provide accurate feedback and improved therapy outcomes. These studies collectively underline the importance of customization, technological innovation, and practical usability in advancing vision therapy[11][12][13].

2.2 Summary of Literature Survey:

The literature reveals significant advancements in vision therapy technologies, particularly in patient engagement and therapy outcomes. However, challenges like high development costs, hardware dependencies, and barriers for diverse demographics persist[14][15]. Future efforts should focus on:

- Simplifying systems for better accessibility.
- Reducing costs to ensure wider adoption.
- Tailoring therapy designs for diverse user groups, ensuring inclusivity and broader impact.

Vision therapy is a scientifically backed approach to improving eye health, particularly for individuals with low vision or coordination issues. The integration of also encourages consistent engagement, a critical factor in technologies like eye tracking, AR, and gamification significantly enhances therapy outcomes by increasing engagement and precision. Monitoring eye movements with tools like MediaPipe provides valuable insights into user perfor mance and therapy effectiveness. Interactive exercises, such as saccades and thrataka, are effective in strengthening eye muscles and improving focus. Real-time feedback, progress tracking, and gamified scoring encourage user participation and motivation. Adopting responsive design and accessibility standards ensures inclusivity and usability across devices. A simple, intuitive UI with calming colors reduces visual strain and makes therapy sessions more comfortable. Combining proven methodologies and modern web technologies enables the development of an efficient and user-friendly vision therapy platform.

3. Research Problem

Traditional vision therapy systems rely heavily on in-office exercises, making them inaccessible, costly, and inconvenient for many users, especially those in remote areas. These systems lack personalization, failing to cater to individual vision needs, and are often unengaging, which diminishes user motivation. This creates a need for an affordable, accessible, and interactive solution that offers personalized therapy and tracks user progress effectively to assist individuals with low vision in improving their eye health.

3.1. Objectives

This project aims to develop an affordable, accessible and interactive solution.

3.1.1. **Provide Personalized Vision Therapy:** Tailored Exercises: The platform will offer a variety of vision therapy exercises designed to address specific needs based on individual assessments, such as strengthening eye muscles, improving focus, or enhancing eye tracking. For instance, users with poor eye stability might be given exercises that help reduce eye strain, while those struggling with tracking can focus on exercises like saccades.

3.1.2. **User Profile Integration:** The system will create detailed user profiles that include key information such as age, vision condition, and performance on previous exercises. Based on this data, personalized therapy plans will be generated, adjusting the difficulty and types of exercises accordingly to ensure the best therapeutic outcomes.

3.1.3. **Customizable Settings:** Users will be able to adjust settings such as exercise duration, level of difficulty, and type of exercise depending on their needs and progress. These adjustments will ensure that users are continually challenged but not overwhelmed, allowing them to make gradual improvements. Adaptive Recommendations: As users progress, the system will dynamically update their therapy plan, recommending new exercises or adjusting difficulty levels to match their evolving capabilities, ensuring that the therapy remains effective and engaging **.**Track and Monitor Iris Movements: Real-Time Iris Tracking with MediaPipe: The MediaPipe Iris Tracker library will be used to monitor the real-time movements of users' irises during vision exercises. This technology will provide accurate and detailed tracking of eye movements, enabling the system to detect whether the user is properly focusing on targets or deviating from the intended gaze.

3.1.4. **Feedback Based on Gaze:** During exercises like saccades or thrataka, the system will provide real-time feedback based on iris movements, notifying users when they need to adjust their focus or return their gaze to the correct position. This immediate feedback helps to correct errors during the session, enhancing the effectiveness of the exercise.

3.1.5. **Performance Metrics:** The system will continuously analyze users' eye movements, storing detailed metrics such as gaze stability, accuracy of saccades, and duration of focus on a target. These metrics will be used to generate performance reports and track progress over time.

3.1.6. **Accuracy Enhancement:** The system will also track and measure the user's progress in terms of accuracy, such as how closely the user follows moving targets (e.g., the red dot in saccades exercises). This data will guide further adjustments to the therapy plan for optimized results.

3.1.7. **Enhance Accessibility and Convenience:** Online Platform for Easy Access: By developing an online platform, users can perform their vision therapy sessions from the comfort of their own homes. This eliminates the need for physical visits to clinics, making the therapy accessible to users in remote areas or those with mobility issues. The platform will be web-based, accessible from any device with a camera (smartphone, tablet, or computer).

3.1.8. **Flexible Scheduling:** Users will be able to schedule and perform exercises at their convenience, eliminating the need for rigid therapy appointments. This flexibility ensures that therapy can be integrated into users' daily routines, improving adherence and consistency. Real- Time Assistance and Support: Users will have access to real-time help or FAQs through the platform, ensuring they can get assistance if they face issues with exercises or need guidance on using the system.

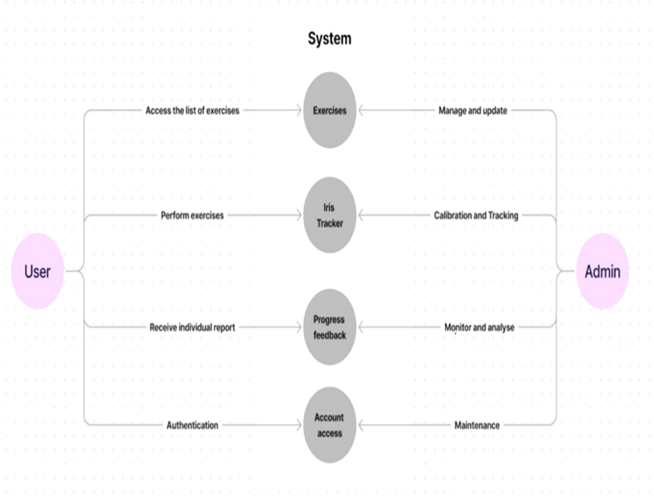
3.1.9. **Offer Progress Analysis:** Progress Bars for Motivation: To keep users motivated and provide clear indications of improvement, the platform will feature progress bars that track key metrics during exercises. These could include visualizing the completion of focus time, successful execution of saccades, or improvements in eye stability. As users complete more exercises, the progress bars will help them visually see their advancements.

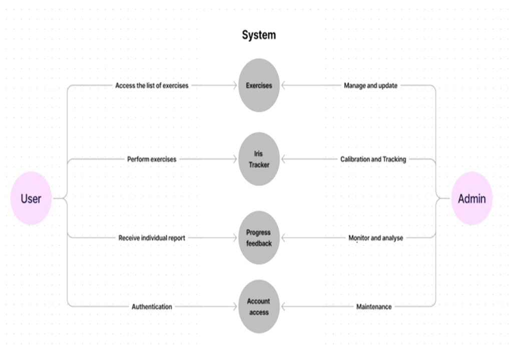
3.1.10. **Detailed Reports**: After each session, users will receive a detailed performance report that breaks down their success in various areas, such as how accurately they tracked moving objects or maintained focus during exercises. These reports will provide insights into their strengths and areas that need improvement, fostering a sense of accomplishment.

3.1.11. **Data-Driven Insights:** The system will analyze data over time, comparing current performance with previous sessions. It will then generate insights and recommendations to help users improve further, such as suggesting specific exercises to focus on based on their progress. Goal Setting and Tracking: Users will be encouraged to set goals based on their vision therapy needs (e.g., improving focus duration or tracking speed). The platform will help users track progress toward these goals, providing feedback and motivation to help them achieve their targets. Visual Performance Analytics: Graphical representations (charts or graphs) of performance data, such as eye stability over time or progress in specific exercises, will help users visualize their progress in a more engaging and comprehensible format.

3.1.12. **Personalized Feedback and Tips:** At the end of each session, the system will offer personalized tips, motivational messages, or additional exercises to continue the improvement journey, based on the user's performance. This keeps users engaged and provides direction for their next steps.

4. System Architecture:





4.1 Functional Requirements

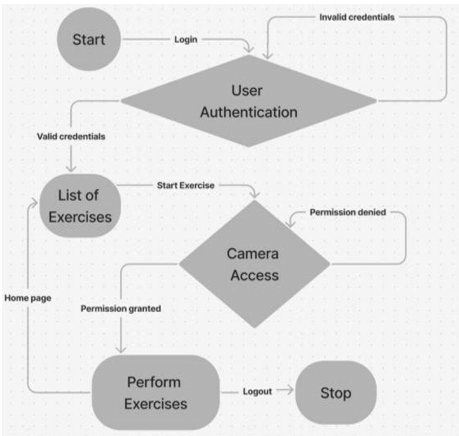
- User Authentication and Management Implement a secure login and sign-up system using Flask-Bcrypt for password encryption, ensuring data security and user privacy. Allow users to create accounts with unique credentials, such as usernames, emails, and strong passwords. Provide login functionality to access personalized therapy sessions and progress data specific to each user. Include account recovery options like password reset through email verification to enhance user accessibility. Ensure the system follows best practices for security, such as limiting login attempts to prevent brute force attacks.
- Exercise Module with Iris Tracking Develop therapy exercises like thrataka (steady gaze practice) and saccades (quick eye movements) to improve focus and coordination. Integrate the Media Pipe Iris Tracker library for accurate iris movement monitoring and real-time feedback during exercises. Record user performance data, such as fixation duration and deviation, for detailed analysis. Include visual cues and instructions to guide users through each exercise effectively. Ensure the system adapts to different screen sizes and environments for a seamless experience on various devices.
- Progress Tracking and Reporting Design real-time progress bars to visually represent improvements in user performance across sessions. Display metrics such as the accuracy of iris movements, session duration, and cumulative progress. Store historical data to generate detailed reports showing trends in therapy outcomes over time. Allow users to download or share their progress reports, enabling collaboration with healthcare professionals if needed. Provide insights into areas requiring improvement to help users focus on specific challenges.
- Customizable Therapy Plans Develop a system to recommend personalized therapy plans based on user performance metrics, such as accuracy and consistency during exercises. Factor in user-specific details like age, visual challenges, and therapy goals to create tailored plans. Allow users to modify the intensity or type of exercises to match their comfort level and requirements. Implement automated reminders or notifications to ensure users follow their recommended therapy schedules consistently. Incorporate feedback loops, enabling users to report their experiences and refine therapy plans for better results.

- Interactive and Engaging User Interface Design a user-friendly web interface with clear navigation to ensure ease of use, even for individuals with minimal technical knowledge. Use visually appealing color schemes, fonts, and layouts to create a calming and motivating environment for therapy. Incorporate interactive elements, such as animated progress bars, gamified scoring, and exercise previews, to keep users engaged. Include a responsive design for compatibility across devices like desktops, tablets, and smartphones. Ensure accessibility standards, such as high-contrast options and text-to-speech features, for inclusivity.

4.2 Non-Functional Requirements:

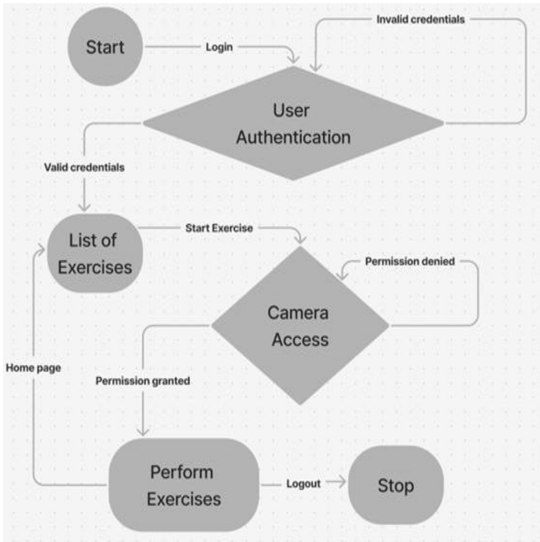
- Performance The system should efficiently handle multiple users accessing the platform simultaneously without any degradation in response time. Implement session management to ensure each user's data remains isolated and secure during concurrent usage. Optimize SQL queries to enable rapid data retrieval and updates, ensuring real-time progress tracking and report generation. Use caching mechanisms for frequently accessed data, such as user profiles and progress charts, to enhance responsiveness. Conduct stress testing to identify performance bottlenecks and ensure scalability as the number of users increases.

- Usability Provide a secure authentication mechanism by hashing passwords with Flask-Bcrypt, protecting user credentials from potential breaches. Implement session tokens to maintain user login states while preventing unauthorized access or session hijacking. Design an intuitive user interface with clear navigation and guidance to ensure ease of use, even for individuals with minimal technical expertise. Offer detailed error messages and user-friendly feedback to guide users when incorrect credentials or other issues occur. Conduct usability testing with a diverse group of users to refine workflows and improve the overall user experience.
- Compatibility Ensure the platform works seamlessly across all modern web browsers, including Google Chrome, Mozilla Firefox, Safari, and Microsoft Edge. Incorporate responsive web design principles to provide a consistent and smooth experience across various devices, such as desktops, laptops, tablets, and smartphones. Utilize cross-browser compatibility testing tools to identify and fix inconsistencies in rendering or functionality. Require a functional camera on the user's Interactive and Engaging User Interface Design a user-friendly web interface with clear navigation to ensure ease of use, even for individuals with minimal technical knowledge. Use visually appealing color schemes, fonts, and layouts to create a calming and motivating environment for therapy. Incorporate interactive elements, such as animated progress bars, gamified scoring, and exercise previews, to keep users engaged. Include a responsive design for compatibility across devices like desktops, tablets, and smartphones. Ensure accessibility standards, such as high-contrast options and text-to-speech features, for inclusivity. The platform can access and process camera input efficiently. Use adaptive algorithms to adjust video quality and processing loads based on device capabilities, ensuring a smooth experience even on low-end hardware.



4.3 User Requirements

- Secure Storage of User Data: User data, including sensitive information like passwords, vision ratings, and progress metrics, must be stored securely in a relational database (e.g., MySQL). Passwords should be encrypted using industry-standard algorithms like bcrypt hashing to prevent unauthorized access, even if the database is compromised. Implement access control mechanisms to ensure that only authorized users can access or modify their data. Utilize secure communication protocols such as HTTPS for transmitting data between the client and server, protecting user privacy from potential eavesdropping or interception. Conduct regular security audits and implement vulnerability management practices to keep data secure over time. Encouraging Messages and Tips After Exercise



- Completion

Provide users with personalized motivational messages after completing therapy exercises to keep them engaged and optimistic about their progress. Integrate dynamic feedback based on exercise performance, such as" Great job! Your focus has improved by 10 percent since last week." Offer practical tips and suggestions for daily eye care and improving vision, ensuring they align with the therapy goals. Use engaging visuals or animations alongside messages to make the user experience more interactive and enjoyable. Allow users to save or revisit motivational messages and tips for future reference or inspiration.

- Ability to Choose Exercises Based on Preferences

Enable users to select from a variety of exercises, such as thrataka, saccades, or balloon games, based on their specific needs or preferences. Provide a brief description and benefits of each exercise, helping users make informed decisions about their therapy sessions. Include a recommendation engine that suggests exercises tailored to the user's performance history, age, and vision improvement goals. Allow users to set priorities or favorite specific exercises to create a customized therapy plan. Incorporate a flexible interface where users can modify or update them exercise preferences at any time, ensuring adaptability to their evolving needs.

- Progress Tracking and Visualization Implement a comprehensive progress tracking system that allows users to monitor their improvement over time. Store detailed metrics such as completion rates, focus improvement percentages, and streak scores for each exercise. Provide visually appealing progress dash boards with graphs or charts to display trends and milestones achieved during therapy sessions. Include comparisons to past performances, weekly or monthly summaries, and badges for achieving specific goals to keep users motivated. Allow users to export their progress reports in formats like PDF or share them with healthcare professionals for further analysis. Ensure that the progress data is updated in real time and accessible from any device through secure authentication. This feature enhances user engagement and enables better evaluation of therapy effectiveness over time.

Start: The User Initiates the Session The user opens the website or app, starting a session.

- User Authentication The user logs in with their credentials. Valid credentials grant access to the dashboard, while invalid ones prompt an error and allow retries.
- List of Exercises The user sees a list of vision exercises (e.g., thrataka, saccades). Exercises include descriptions and benefits for easy selection.
- Camera Access The system requests camera access for iris tracking. If granted, tracking begins; if denied, the exercise cannot proceed.
- Perform Exercises The user completes the selected exercise with on-screen guidance. The system tracks performance and provides a report with results and feedback.
- Stop: The Session Ends The session ends when the user logs out or completes exercises. Progress reports are saved for future reference.

Tools Used

- Flask: A lightweight Python web framework used for building the backend of the project. It provides tools for routing, templates, and easy integration with databases.
- SQLite: A lightweight relational database used to store user data, such as credentials, progress reports, and exercise history, ensuring quick and efficient data retrieval.
- Werkzeug: A utility library used for password hashing and other security features. It ensures safe storage and validation of user credentials during authentication.
- Flask-Login: A Flask extension that manages user sessions and authentication, allowing secure and seamless login and logout functionality.
- HTML, CSS, and JavaScript: – HTML: Defines the structure of web pages. – CSS: Styles the web pages with fonts, colors, and layouts for an appealing interface. JavaScript: Adds interactivity and animations to enhance user engagement on the frontend.
- Open CV: An open-source computer vision library used for video capture and processing, enabling real-time eye movement tracking.
- Media Pipe: A cross-platform framework used for iris tracking and other advanced eye-tracking features, providing accurate insights into user performance during exercises.

Pseudocode

1] START

2] DISPLAY Login/Signup Page IF user chooses "Signup":GET username, email, password, age, gender, vision_rating HASH password SAVE user details in the database REDIRECT to Login Page. IF user chooses "Login": GET username and password VALIDATE credentials with database IF valid: START user session REDIRECT to Home Page ELSE: DISPLAY error message.

3] DISPLAY Home Page with Welcome Message IF user clicks "Start Exercises": DISPLAY list of exercises PROMPT for camera access IF camera access granted: ALIGN user within the frame RUN AR-based exercise SAVE exercise status in the database ELSE: PROMPT to enable camera access 4] AFTER exercise completion:DISPLAY tips and feedback RETURN to Home Page

5] END

Explanation of Pseudocode

- START The application initializes, and the user interaction process begins. DISPLAY Login/Signup Page The user is presented with a choice to either log in to an existing account or sign up to create a new one.
- If the user chooses" Signup": GET username, email, password, age, gender, vision rating: Collect the necessary user details through a form. HASH password: Securely encrypt the password using hashing to protect user data. SAVE user details in the database: Store the user's information in the database for future authentication. REDIRECT to Login Page: Upon successful signup, the user is directed to the login page to proceed.
- If the user chooses" Login": GET username and password: Retrieve login credentials provided by the user. VALIDATE credentials with the database: Check the entered details against stored data in the database.
- IF valid: START user session: Initialize a session for the authenticated user. REDIRECT to Home Page: Direct the user to the home page of the application.

5. Results

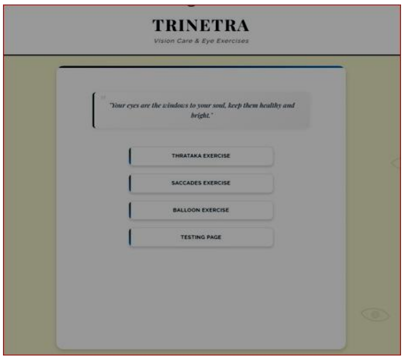


Fig 5.1: List of Exercises

The figure 5.1 shows the HTML page is part of the" Trinetra" vision therapy website, offering users a variety of eye exercises. The page includes a header with the site logo and login/signup options, followed by a main section with links to different eye exercises like Thrataka, Saccades, and Balloon.

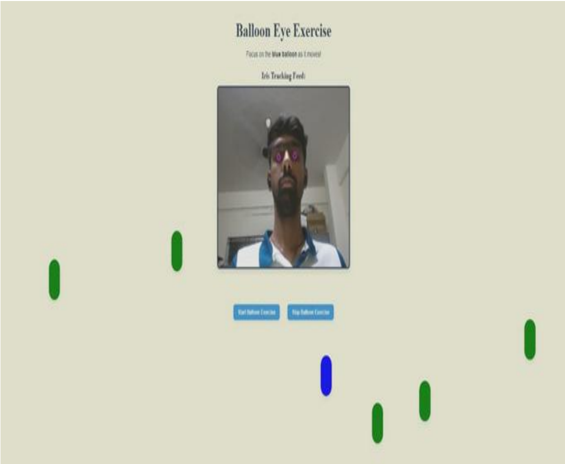


Fig 5.2: Balloon Eye Exercise

The figure 5.2 shows the application is designed for a Balloon Eye Exercise to aid in visual therapy. It displays instructions for the exercise, where users follow a blue balloon with their eyes while ignoring distractor balloons. The exercise starts when the user clicks a button, and the balloons move randomly on the screen. A built-in timer tracks the duration of the exercise, providing users with a clear indication of how long they have been performing the exercise. 'Progress bars or visual indicators show the remaining time for the session. Customizable exercise Settings: Users can adjust the difficulty level by modifying the number, size, and speed of the distractor balloons. Audio cues can be integrated to signal the start and stop of the exercise or to provide motivational feedback during the session. Options to customize the exercise duration can cater to individual therapy requirements. The user can stop the exercise anytime by clicking the" Stop Balloon Exercise" button.

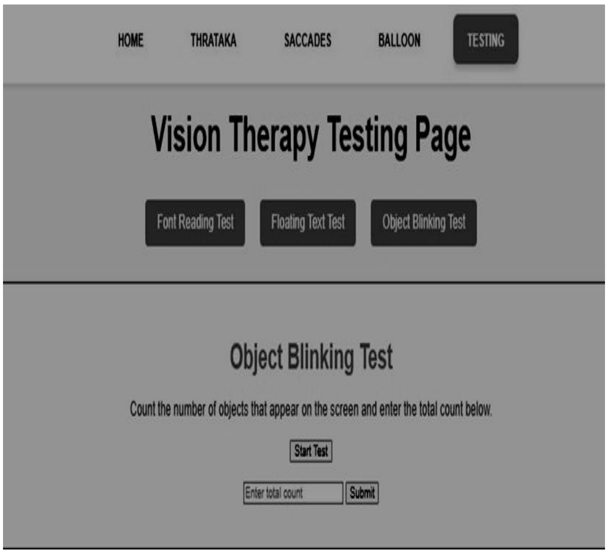


Fig 5.3: The Therapy Testing Page

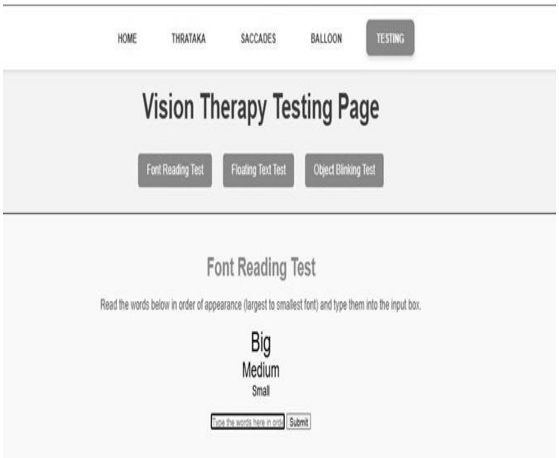


Fig 5.4: Testing Page - Font Reading Test

The test in the above figure 5.3 shows a series of randomly placed objects that blink on the screen for a short period. The user must count how many objects appeared, and their score depends on how accurately they count the objects. The test in the figure 5.4 shows the displays words in varying font sizes, and the user is required to read them in order from largest to smallest, typing them into an input box. The score is based on how accurately and in order the user types the words.

Fig 5.5: Object Blinking Test

The figure 5.5 shows the test involving series of randomly placed objects that blink on the screen for a short period. The user must count how many objects appeared, and their score depends on how accurately they count the objects.

6. Conclusion

Trinetra - Vision Therapy Application represents a transformative approach to vision care, combining advanced technologies with a user-centered design to cater to individuals with low vision. By leveraging Media pipe's iris tracker for real-time eye movement analysis and incorporating customizable vision therapy exercises like Saccades and Thrataka, the platform offers a personalized and effective therapy experience. The integration of intuitive progress tracking, detailed reporting, and a secure user management system ensures accessibility and data security, aligning with industry standards. Built on a robust technology stack featuring modern frontend frameworks like React or Vue.js and SQL-based backend storage, Trinetra underscores its commitment to continuous improvement through user feedback, redefining digital eye care for the modern age. In future, the advancements in therapeutic technology could integrate advanced AR/VR headsets to create immersive therapy sessions, combining them with wearable devices like smart glasses for real-time monitoring of eye movements and other physiological metrics. AI-driven personalization would further enhance the experience by analyzing user progress and dynamically adapting exercises to individual needs.

7. Data Availability Statement

The data that supports the findings of this study, including user interaction logs, visual stimulus sets, and feedback records, are available from the corresponding author upon reasonable request. Due to privacy and ethical concerns involving sensitive information from individuals with visual impairments, some data (e.g., personal health-related details) have been anonymized and restricted. Where applicable, datasets used for interface testing and therapy module validation have been included as supplementary material. Researchers seeking to access these datasets for academic or non-commercial purposes may contact the authors directly.

8. Consent to Publish Identifying Information/Images

All participants involved in the study related to Trinetra – A Vision Therapy Application to Aid People with Low Vision provided informed consent for the collection and use of identifying information and/or images. Where participants were minors or individuals with legal guardians, consent was obtained from the appropriate legal guardian(s). Participants and/or their guardians were informed that the material may be published in an online open-access platform, accessible to the public, and were assured that their participation was voluntary and could be withdrawn at any stage without consequence. All necessary consent forms have been signed and are securely stored by the research team.

9. Ethics Approval and Consent to Participate

The study titled "Trinetra – A Vision Therapy Application to Aid People with Low Vision" was conducted in accordance with ethical standards and approved by the Institutional Ethics Committee of [Full Name of Institution], approval number [Insert Approval Number]. All procedures involving human participants were performed in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments.

Informed consent was obtained from all individual participants involved in the study. For participants under the age of 18 or those legally unable to provide consent, informed consent was obtained from their parent or legal guardian. Participants were fully informed about the nature, purpose, and procedures of the study, and were made aware of their right to withdraw at any point without any negative consequences.

10. Funding Declaration

The authors did not receive support from any organization for the submitted work. No funds, grants or other supports were received.

11. Conflict of Interest

The authors of this article have no conflicts of interest to declare that are relevant to the content of this article.

12. Ethics:

The development of Trinetra: A Vision Therapy Application to Aid People with Low Vision adheres to ethical principles of accessibility, user safety, and inclusivity. We prioritize data privacy, transparency, and collaboration with experts to ensure the app provides reliable and beneficial support. Our commitment is to enhance the quality of life for individuals with low vision while maintaining integrity and ethical responsibility in design and implementation.

13. Consent to Participate:

Participants voluntarily consent to use Trinetra: A Vision Therapy Application to Aid People with Low Vision, with full awareness of its purpose and potential benefits..

14. Consent to publish declarations:

All participants consent to the publication of findings related to Trinetra: A Vision Therapy Application to Aid People with Low Vision, ensuring their data is anonymized and used ethically. They acknowledge that the published content may be shared in academic and research platforms.

Author contributions:

Pushpa G & Manjunath G S: Conceptualization, Methodology, Writing-Original draft preparation, Software, Validation, Visualization, Investigation
Dr. Kavitha C & Nalini B M: Visualization, Investigation

Abhiram R P & Sumukh M K: Software, Field study, Data curation Writing-Reviewing and Editing, Visualization, Investigation.

Conflicts of interest

The authors declare no conflicts of interest.

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