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RAJAGIRI SCHOOL OF
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Mini Project Report On

ChromaClear

Submitted in partial fulfillment of the requirements for the award of the degree of

Bachelor of Technology

in

Computer Science & Engineering

By

Divya Binu (U2103077)

Diya Baiju (U2103078)

Diya Thankachan (U2103079)

E H Hrithika (U2103080)

Under the guidance of

Ms Dincy Paul

Department of Computer Science & Engineering
Rajagiri School of Engineering & Technology (Autonomous)
(Affiliated to APJ Abdul Kalam Technological University)
Rajagiri Valley, Kakkanad, Kochi, 682039
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CERTIFICATE

This is to certify that the mini project report entitled ***"Chromaclear"*** *is a bonafide record of the work done by* ***Divya Binu(U2103077),Diya Baiju(U2103078),Diya Thnkachan (U2103079),E H Hrithika (U2103080)*** *submitted to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology (B. Tech.) in Computer Science and Engineering during the academic year 2023-2024.*

Project Guide
Ms. Dincy Paul
Assistant Professor
Dept. of CSE
RSET

Project Coordinator
Dr. Saritha S.
Professor
Dept. of CSE
RSET

Head Of Department
Dr. Preetha K. G.
Dept. of CSE
RSET

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Divya Binu

Diya Baiju

Diya Thankachan

E H Hrithika

Abstract

ChromaClear is a website designed to address the challenges encountered by individuals with color blindness in the digital world. By leveraging the daltonization algorithm, ChromaClear ensures that individuals with color vision deficiencies can perceive and distinguish visual content accurately and comfortably.The platform allows users to upload media directly through the website or capture them in real time.Here a color identification feature is also added where the cursor specifies the color at the current point. It also offers a browser extension that seamlessly integrates with browsers, enabling users to experience real-time conversion of any web page while experiencing visual content accurately and comfortably. Additionally, developers and designers can utilize a dedicated browser extension to simulate various types of color blindness directly within their web browsers so that they are mindful in applying colors to their web pages. The main advantages of this model are Enhanced Visual Experience, Easy Media Upload and Real-time Capture,Seamless Integration with Browsers and Empowering Developers for Inclusive Design.

Contents

List of Figures

List of Tables

List of Abbreviations

CVD - Color Vision Deficiency

SVG - Scalable Vector Graphics

Chapter 1

Introduction

1.1 Background

Color blindness affects approximately 300 million individuals globally, posing a significant challenge in accessing digital content. Despite its prevalence, many digital platforms overlook the needs of those with color vision deficiencies, resulting in barriers to comprehension and engagement. With the rapid advancement of technology and the increasing integration of digital interactions into daily life, addressing color blindness in digital content becomes increasingly crucial.

Individuals with color blindness encounter various obstacles when navigating digital interfaces, including difficulty distinguishing between colors, interpreting charts and graphs, and accessing color-coded information. These challenges limit their ability to fully participate in online activities, such as educational pursuits, professional endeavors, and social interactions.

In response to this situation, ChromaClear emerges with a solution. By leveraging advanced algorithms and intuitive interfaces, ChromaClear facilitates the conversion of digital media to accommodate different types of color vision deficiencies. This ensures accurate perception and comfortable interaction with visual content, fostering inclusivity and accessibility in the digital world. Through ongoing research and innovation, ChromaClear aims to empower individuals with color blindness to navigate the digital landscape with clarity and confidence, promoting a more inclusive online environment for all users.

1.2 Problem Definition

The aim of this project is to develop a web application that aids individuals with color vision deficiency (CVD) in distinguishing colors accurately within digital images and

videos. The problem addressed is the lack of accessible tools for individuals with CVD to effectively engage with color-dependent digital content.

1.3 Scope and Motivation

Scope: The scope of this project encompasses the development of a comprehensive web-based platform, ChromaClear, designed to address the challenges faced by individuals with color blindness in the digital world. ChromaClear aims to provide users with the ability to upload images or videos and seamlessly convert them to accommodate various types of color blindness. Additionally, the platform will offer real-time capture functionalities, enabling users to capture media content with adjustments for color blindness. ChromaClear will also feature a browser extension that integrates seamlessly with popular web browsers, allowing users to experience real-time conversion of web pages to enhance accessibility. Moreover, the platform will include tools for developers and designers to simulate color blindness directly within their web browsers, fostering empathy and promoting inclusive design practices.

Motivation: The motivation behind the development of ChromaClear stems from the pressing need to enhance accessibility and inclusivity in the digital realm for individuals with color vision deficiencies. With a significant portion of the population affected by color blindness, there is a growing demand for solutions that cater to their specific needs. ChromaClear seeks to bridge this gap by providing users with tools to experience visual content accurately and comfortably, thereby empowering them to navigate the digital world with confidence. Additionally, by raising awareness about color blindness and promoting empathy among developers and designers, ChromaClear aims to foster a more inclusive digital environment where all individuals can fully participate and engage.

1.4 Objectives

1.Implement advanced algorithms to convert images and videos for different types of color blindness.

2.Improve user experience with easy-to-use features for uploading media and capturing in real time.

3.Raise awareness about color blindness through education and outreach.

4.Make ChromaClear easily accessible by integrating it with popular web browsers.

5.Provide tools for developers and designers to create inclusive digital content.

6.Continuously improve ChromaClear based on user feedback and technological advancements

1.5 Challenges

Making ChromaClear work smoothly in real time is tough because it needs to process things really quickly and use a lot of computing power to apply filters instantly, which is hard to manage.

1.6 Assumptions

Hardware Resources: Assumes availability of sufficient computational power and memory. Image Accuracy: Assumes image quality is high. Compatibility: Assumes compatibility with various devices and platforms.

1.7 Societal / Industrial Relevance

Accessibility in Society: ChromaClear directly addresses the challenges faced by individuals with color blindness, which affects a significant portion of the population worldwide. By providing a tool that enhances visual experiences for individuals with color vision deficiencies, ChromaClear contributes to creating a more inclusive digital environment for everyone.

Media and Design Industries: In industries where visual content plays a crucial role, such as graphic design, advertising, and media production, ChromaClear offers a valuable solution. Designers and content creators can ensure that their creations are accessible to individuals with color vision deficiencies, thus expanding their audience reach and adhering to inclusivity standards.

Education and Awareness: ChromaClear can also be instrumental in educational settings, where educators can use it to create accessible learning materials for students with color vision deficiencies. By incorporating ChromaClear into educational resources, insti-

tutions can promote awareness and understanding of color blindness among students and educators alike.

1.8 Organization of the Report

The organization of the report are as follows:

- Chapter 1-Introduction:The introduction covers the background of the project, the problem definition, the scope and motivation, the objectives,the societal and industrial relevance, the assumptions and the challenges faced by the project.

- Chapter 2-Software Requirements Specification: Our platform offers users a seamless approach to import images or videos, which are subsequently processed with Daltonization algorithms to cater to various types of color vision deficiencies. It defines the overall description of the software, external interface requirements, system features, and other nonfunctional requirements necessary for the development and deployment of the tools.

- Chapter 3-System Architecture and Design: The system architecture and design chapter provides an overview of the project's technical framework. It includes discussions on the system overview, architectural design, identified datasets, proposed algorithms, implementation strategies, module division, and a work schedule presented as a Gantt chart for project planning and management.

- chapter 4-Results and Discussion:ChromaClear's implementation and evaluation have shown significant success in addressing the challenges of color blindness, providing effective tools for improved digital content perception and interaction. Through real-time conversion using advanced algorithms, the platform has notably enhanced accessibility for users with color vision deficiencies. User feedback underscores ChromaClear's potential to contribute to a more inclusive digital environment, while also indicating areas for further refinement and enhancement.

- chapter 5-conclusion: ChromaClear has effectively addressed color blindness challenges through image conversion, facilitating easier discernment of visual content for individuals with color vision deficiencies. The deployment of browser extensions

for real-time webpage conversion and color blindness simulation has significantly improved digital accessibility. Additionally, the cursor feature enables instant color identification, enhancing user browsing experience and empowering them to engage with digital content more comfortably and accurately.

Chapter 2

Software Requirements Specification

2.1 Introduction

2.1.1 Purpose

ChromaClear, a web-based platform, addresses the challenges faced by individuals with color blindness in navigating digital content. It allows image/video import and conversion for various color blindness types. A browser extension offers real-time web page conversion with color identification under the cursor. Developers/designers get a dedicated extension for color blindness simulation while browsing.

2.1.2 Product Scope

ChromaClear is designed to address the challenges faced by individuals with color blindness by providing tools for experiencing visual content accurately and comfortably. The platform includes features such as image and video conversion for different types of color blindness, real-time webpage conversion, color simulation for developers, and color identification.

2.2 Overall Description

2.2.1 Product Perspective

ChromaClear leverages the LMS daltonization algorithm to convert visual content for individuals with color blindness. This software product stands as a standalone solution offering a user-friendly website where individuals can upload and convert images and videos to accommodate various types of color blindness. The idea for ChromaClear originated from recognizing the challenges faced by individuals with color blindness when navigating the digital world. The specific needs it aims to address revolve around providing a

solution that enhances the visual experience for users with color vision deficiencies.

2.2.2 Product Functions

- Media Conversion: Import and seamlessly convert images or videos to accommodate various types of color blindness.
- Browser Integration: Facilitate real-time conversion of any web page and distinguish visual content accurately and comfortably.
- User-Friendly Media Upload and Capture: user-friendly interface for easy media upload and real-time capture, enhancing the overall user experience.
- Color Identification Feature: Implement a feature where the cursor specifies the color at the current point, aiding users in understanding displayed colors.
- Empower developers and designers to be mindful of color choices by providing tools for simulating color blindness.

2.2.3 Operating Environment

- Hardware Platform: ChromaClear is designed to operate on standard personal computing hardware. It is compatible with desktops, laptops, and tablets with a range of processing capabilities. The platform does not have specific hardware requirements beyond those typically associated with web browsing and media processing.
- Operating System and Versions: ChromaClear is compatible with a variety of operating systems to ensure widespread accessibility. Supported operating systems include but are not limited to: Windows (versions 7, 8, and 10), macOS (versions 10.12 and above), Linux distributions, Other major operating systems that support popular web browsers.
- Web Browsers: ChromaClear seamlessly integrates with popular web browsers, enhancing the user experience across different platforms. Supported web browsers include: Google Chrome, Mozilla Firefox etc.
- Software Components: ChromaClear does not require any additional software components or applications for its core functionality.

- Internet Connectivity: ChromaClear operates in an online environment, requiring a stable internet connection for real-time features, such as media upload and browser extension functionality.

2.2.4 Design and Implementation Constraints

- Corporate and Regulatory Policies: Compliance with data protection and privacy regulations is paramount. The platform must adhere to relevant international, national, and industry-specific regulations, imposing constraints on data handling, storage, and user privacy.

- Hardware Limitations: ChromaClear's performance may be constrained by the processing power and memory capabilities of user devices, especially when handling large or high-resolution media files.

- Interfaces to Other Applications: Integration with certain applications or platforms may be limited by external APIs and the availability of cooperation from third-party services. Compatibility with specific software tools or applications may be a constraint.

- Technologies, Tools, and Databases: The development team might face constraints related to the selection of technologies, tools, and databases. These choices could be influenced by factors such as licensing, compatibility, and the need for seamless integration with existing systems.

2.2.5 Assumptions and Dependencies

- Third-Party Components: The availability and continued support of third-party components, such as the daltonization algorithm used for color conversion, are assumed.

- Web Browser Compatibility: ChromaClear assumes compatibility with major web browsers (e.g., Google Chrome, Mozilla Firefox, Microsoft Edge). It relies on standard browser features for seamless integration.

- Internet Connectivity: Users are assumed to have stable internet connectivity for real-time features, including media upload and browser extension functionality.

- User Device Capabilities: Users' devices are assumed to meet standard capabilities for media processing and web browsing.

2.3 External Interface Requirements

The external interface requirements for ChromaClear encompass both software and hardware aspects necessary for seamless user interaction and system operation.

2.3.1 User Interfaces

The HTML code outlines the main interface of the ChromaClear web application, designed to aid colorblind users in distinguishing colors. The interface includes several key sections: a header with a multicolor gradient title and logo, a navigation bar with links and buttons for accessing various features, and a main content area displaying a looping background video. The header's logo is positioned using absolute positioning, ensuring it remains in a fixed spot. The navigation bar offers intuitive access to "Home," "Features," "Help," and "Contact" sections, along with buttons for specific functions like "Enhance Image," "Real Time Capture," and "Extension," each redirecting the user to the respective features. This navigation setup, combined with on-click events, enhances the user experience by dynamically displaying content within the same page, reducing the need for multiple page loads.

The user interface (UI) adheres to a consistent style, with a dark theme (black background, white text) ensuring high contrast for better readability. The UI employs a modern, clean design with elements like multicolor gradient text in the header for a visually appealing effect, and rounded buttons that change color on hover, providing clear visual feedback. Key components such as the features, help, and contact sections are initially hidden and revealed through JavaScript functions, maintaining a clutter-free layout. The code also includes detailed instructions within the help section, guiding users step-by-step through tasks like enhancing an image or capturing real-time video. This design approach not only makes the interface user-friendly but also accessible, catering specifically to the needs of colorblind users. Details of the interface design, including GUI standards and layout constraints, should be documented separately to maintain consistency across the application and facilitate future updates.

2.3.2 Software Requirements

Web Browser: ChromaClear should be compatible with popular web browsers such as Google Chrome, Mozilla Firefox, Microsoft Edge, and Safari. Operating System: The platform should be accessible on major operating systems including Windows, macOS, and Linux. Browser Extension: The browser extension should be available for installation on supported browsers, allowing users to experience real-time conversion of web pages. Development Tools: Developers should have access to necessary tools and libraries to integrate ChromaClear features into their web applications.

2.3.3 Hardware Requirements

Device Compatibility: ChromaClear should be accessible on various devices including desktop computers, laptops, tablets, and smartphones. Screen Resolution: The platform should support different screen resolutions to ensure optimal user experience across devices. Camera (for real-time capture): Devices with built-in cameras should be supported for real-time capture functionality.

2.4 System Features

2.4.1 Real-time Conversion

Description and Priority

Users can upload media in the form of images or videos directly or capture in real time. Here a Live capture feature as well as a media upload feature is included. Real-time conversion is a high-priority feature within ChromaClear due to its immediate impact on accessibility. There are no specific costs included for developing this feature.

Stimulus/Response Sequences

- A user initiates the real-time conversion feature on ChromaClear by either uploading media directly through the website or capturing it in real-time.
- Upon initiating the upload or capture process, the system promptly processes the visual content using the Daltonization algorithm, adjusting colors to accommodate various types of color blindness.

- The user then experiences a seamless conversion of the uploaded media or captured content, providing them with an enhanced visual experience.

Functional Requirements

REQ-1: Upload and Capture

- Users must be able to initiate the real-time conversion feature by uploading images directly through the website.
- Users must be able to initiate the real-time conversion feature by capturing media in real-time using the Live capture feature.

REQ-2: Real-time Processing

- The system must implement a Daltonization algorithm for real-time color adjustment.
- The system must ensure immediate processing of visual content upon the initiation of the upload or capture process.

REQ-3: Color Adjustment

- The system must adjust colors based on various types of color blindness during real-time conversion.
- The system must provide options or settings for users to customize color adjustments according to their preferences.

REQ-4: Seamless Conversion

- The system must minimize processing delays to ensure a seamless and immediate conversion of uploaded or captured media.
- The system must implement smooth transitions between the original and adjusted media to enhance user experience.

REQ-5: User Feedback

- The user must provide necessary feedback to indicate the successful completion of the real-time conversion.
- The users must be able to notify the server of any issues during the upload or capture process.

REQ-6: Accessibility Options

- The system must include accessibility settings allowing users to enable or disable the real-time conversion feature.
- The system must ensure compatibility with different browsers to maximize accessibility.

REQ-7: Error Handling

- The system must detect and appropriately handle errors related to invalid media formats during the upload or capture process.
- The system must provide clear notifications to users in case of any errors, guiding them on how to resolve issues.

2.4.2 Color Identification through Cursor Movement

Description and Priority

The Color Identification on Image Point feature enables users to interact with images on the website by pointing at them with the cursor. When a user points at an image, the system detects the position of the cursor and identifies the color underneath it. Subsequently, the system displays the name of the color, providing users with valuable information about the visual content. This feature is considered of medium priority due to its impact on enhancing user experience and accessibility.

Stimulus/Response Sequences

- User initiates interaction by pointing the cursor at an image displayed on the website.

- System promptly detects the precise position of the cursor relative to the image.
- Upon detection, the system extracts color information from the pixel located under the cursor's position.
- The system applies color identification using Python and the OpenCV and K-means clustering libraries to determine the name or label associated with the identified color.
- Subsequently, the system displays the identified color's name or label in a visually prominent and easily understandable format.
- In response to user movement, the system continuously updates the displayed color name to reflect changes in the cursor's position and the corresponding color beneath it.

Functional Requirements

REQ-1: CURSOR-TRACKING The system must accurately track the cursor movement over the image with high precision to ensure reliable interaction.

REQ-2: COLOR-RETRIEVAL The system must efficiently retrieve the pixel's color information directly under the cursor, utilizing appropriate image processing techniques.

REQ-3: REAL-TIME-DISPLAY The system must dynamically update and display the color information in real-time as the cursor moves across different image areas.

REQ-4: BOUNDARY-HANDLING If the cursor moves outside the boundaries of the image, the system should handle this scenario by suspending color identification functionality until the cursor re-enters the image area.

REQ-5: FEATURE-TOGGLE The system should offer users the flexibility to enable or disable the color identification feature based on their preferences, ensuring a customizable and user-centric experience. Additionally, the option to toggle color identification should be easy to use.

2.4.3 Webpage conversion for enhanced vision

Description and Priority

This feature involves the real-time conversion of webpages on the ChromaClear platform to enhance the visual experience for individuals with color vision deficiencies. Users can access this feature through the ChromaClear browser extension, which seamlessly adjusts colors on any web page in real time. The priority for this feature is deemed "High" due to its significant impact on accessibility and inclusive design principles. There is a moderate level of risk associated with ensuring the accuracy and effectiveness of real-time conversion algorithms across various websites.

Stimulus/Response Sequences

Users initiate the real-time conversion feature by activating the ChromaClear browser extension. The system responds by dynamically adjusting the colors on the current webpage, ensuring compatibility and accurate representation for users with color vision deficiencies.

Functional Requirements:

REQ-1: ChromaClear Extension Activation Users must be able to activate the ChromaClear browser extension. Response to Error: Clear error messages should be displayed if activation fails, guiding users on potential troubleshooting steps.

REQ-2: Real-time Webpage Conversion The system must seamlessly convert colors on any web page in real time. Response to Error: In case of algorithm errors or processing failures, the system should provide informative feedback to the user and potentially suggest alternative actions.These requirements ensure the successful implementation of the webpage conversion feature ,promoting accessibility and inclusivity within ChromaClear.

2.4.4 Color Blindness Simulation for developers

Description and Priority

This feature equips developers and designers with the capability to simulate various types of color blindness directly within their web browsers using ChromaClear. By integrat-

ing a browser extension, this functionality allows professionals to visualize and evaluate the impact of color choices on their web pages, promoting mindful and inclusive design practices. Given its instrumental role in aiding developers, it holds a medium priority.

Priority Components:

- **Benefit:** This feature significantly benefits developers and designers by fostering awareness of color choices, contributing to the creation of more accessible and inclusive digital content. (Rating: 7)
- **Penalty:** While valuable, the absence of this feature would not directly impact the core functionality of ChromaClear for end-users. (Rating: 4)
- **Cost:** Implementing and maintaining the color blindness simulation for developers involves moderate costs associated with extension development and integration. (Rating: 5)
- **Risk:** There is a moderate risk associated with potential challenges in integrating the simulation feature seamlessly across various browsers. (Rating: 6)

2.4.5 Stimulus/Response Sequences

Stimulus: Developer Activates Simulation Extension

1. Developer Action: The developer installs the ChromaClear browser extension.
2. Developer Action: The developer navigates to a web page they are designing.
3. Developer Action: The developer activates the color blindness simulation feature through the extension.
4. System Response: ChromaClear applies the chosen color blindness simulation to the entire web page.
5. System Response: The developer visually inspects the simulated web page to assess color choices.

Stimulus: Switching Between Simulation Modes

1. Developer Action: The developer accesses the extension settings.
2. Developer Action: The developer selects a different color blindness simulation mode (e.g., protanopia, deuteranopia).
3. System Response: ChromaClear updates the simulation mode in real-time on the developer's web page.
4. System Response: The developer evaluates the visual impact of the new simulation mode.

Stimulus: Resetting to Original Colors

1. Developer Action: The developer resets the color simulation to the original colors.
2. System Response: ChromaClear reverts the web page to its original color scheme.
3. System Response: The developer reviews the unaltered appearance for reference.

2.5 Other Nonfunctional Requirements

2.5.1 Performance Requirements

ChromaClear's performance requirements are vital for developers to comprehend the intended functionality and make informed design decisions. Firstly, real-time conversion is critical, necessitating image or video conversion to accommodate color blindness within milliseconds to enable immediate perception for users. Promptness is also essential for media upload and conversion, with processes expected to complete without much time delay. Additionally, scalability is crucial, with the platform required to support at least 100 concurrent users without performance degradation. Seamless integration of the browser extension across popular web browsers, without noticeable performance overhead, is imperative for user satisfaction. Moreover, the color identification feature must provide accurate information within 100 milliseconds of hovering over a point, enhancing usability. Similarly, the dedicated developer browser extension should simulate color blindness types with minimal latency, aiding developers

in inclusive design practices. Adhering to these performance requirements ensures ChromaClear delivers a responsive, efficient, and user-friendly experience for individuals with color vision deficiencies and developers alike.

2.5.2 Safety Requirements

ChromaClear prioritizes security and privacy measures to safeguard user data and ensure compliance with relevant regulations. While the platform does not require user accounts with passwords, security and privacy remain paramount throughout the user experience. Clear and transparent privacy policies are communicated to users, outlining data collection, usage, and sharing practices. Compliance with regulations such as GDPR (The General Data Protection Regulation) and others is maintained to ensure user data is handled in accordance with legal requirements. Secure protocols continue to be employed for media upload and real-time capture to prevent data interception or tampering, with regular audits and updates to address emerging threats. The browser extension undergoes regular updates to maintain security and compatibility with browser updates. Compliance with industry-specific security certifications and standards may also be necessary to ensure the protection of user data and privacy. Overall, by fulfilling these security and privacy requirements, ChromaClear provides users with confidence in the protection of their data and privacy, even in the absence of user login and password features, while also maintaining compliance with regulatory standards.

2.5.3 Security Requirements

Security and privacy requirements for ChromaClear entail several key considerations, even without user login and password features. Firstly, robust measures are in place to safeguard sensitive data and functionalities within the platform. While user identity authentication through passwords and multi-factor authentication is not applicable in

the absence of user accounts, other security measures are implemented to ensure data integrity and protection. ChromaClear must still comply with relevant privacy regulations, such as GDPR. This involves transparently communicating privacy policies, obtaining explicit user consent for data collection and processing.Regular security audits remain essential to identify and address potential vulnerabilities. Updates and patches are promptly applied to mitigate risks and ensure ongoing protection of user data. By ad-

hering to these adjusted security and privacy requirements, ChromaClear can effectively safeguard user data, maintain compliance with regulations, and foster user trust in the platform, even without user login and password features.

2.5.4 Software Quality Attributes

ChromaClear's success relies on a range of essential quality characteristics that cater to both customers and developers. Firstly, the platform's usability is paramount, requiring an intuitive user interface that simplifies media upload and access to conversion features. To ensure effectiveness, usability tests with a sample group can validate user task efficiency. Reliability is another critical factor, demanding consistent performance without unexpected errors or system crashes. By tracking uptime percentages and minimizing errors, ChromaClear aims to instill user confidence in its reliability. Moreover, the platform's maintainability is key, requiring well-documented and organized code for easy updates and maintenance by developers. Additionally, robustness ensures ChromaClear can gracefully handle unexpected inputs and adverse conditions, as verified through stress testing. Interoperability remains crucial, necessitating seamless integration across various web browsers and operating systems to ensure consistent performance. Availability is emphasized, with ChromaClear striving for high uptime and quick response times to minimize service interruptions. Lastly, adaptability is paramount, enabling ChromaClear to evolve with user needs and technological advancements, incorporating new features or updates seamlessly. By adhering to these quality characteristics, ChromaClear aspires to deliver a reliable, user-friendly, and adaptable solution that meets the expectations of both customers and developers.

Chapter 3

System Architecture and Design

3.1 System Overview

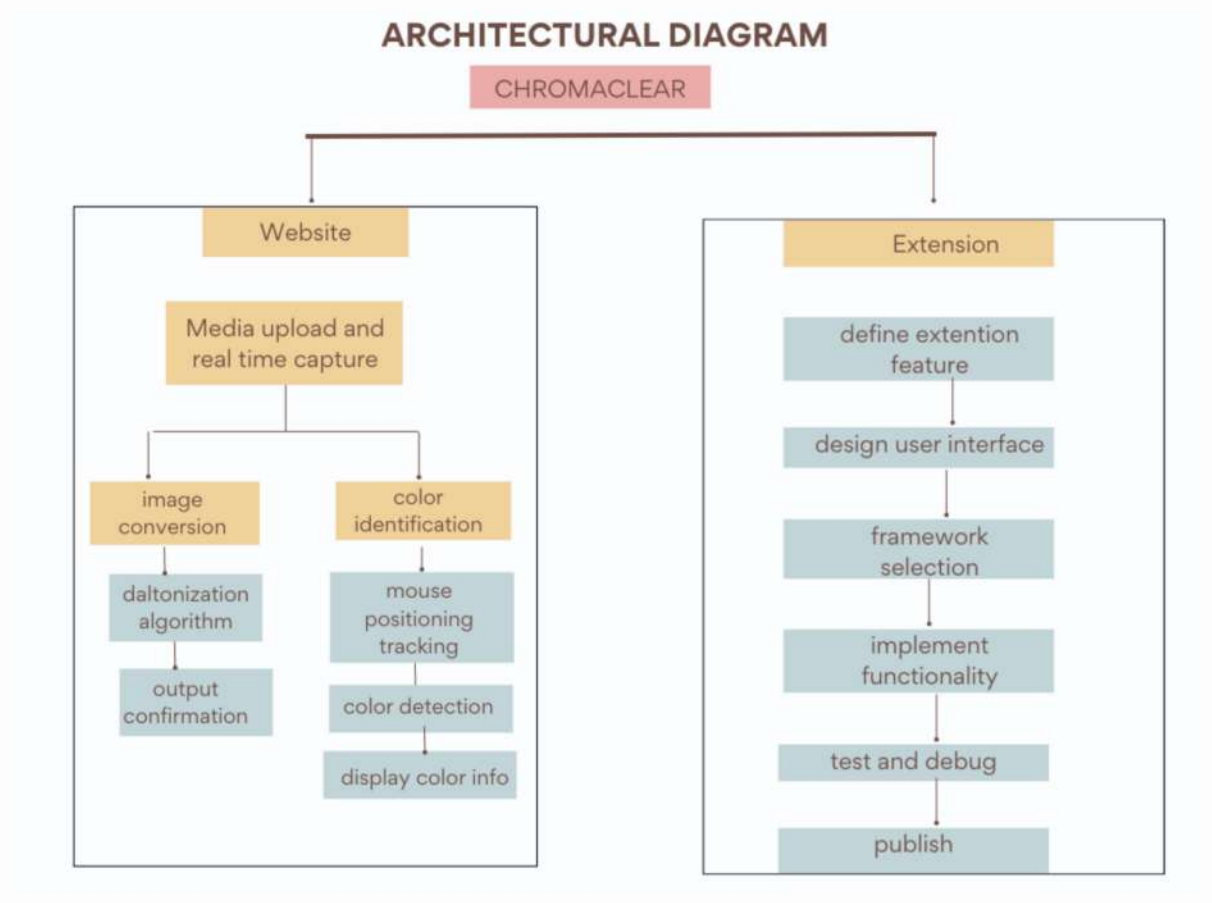

Figure 3.1: Architectural Diagram

The image preprocessing phase initiates with users either uploading an image or capturing one through their webcam. Uploaded images are typically converted into formats suitable for real-time processing, such as RGB or HSV, facilitating efficient manipulation of pixel color data. If the uploaded image employs a color space incompatible with the applica-

tion, such as CMYK used in printing, it may undergo conversion into a more compatible color space like RGB or HSV, commonly employed in computer vision tasks. Following this, color identification algorithms come into play, employing sophisticated techniques to segment the image and identify individual colors within each segment. These algorithms may utilize statistical methods or machine learning techniques to determine the dominant color within each segment, thus facilitating subsequent processing steps.

Moving on to image processing, the core functionality of Chromaclear lies in its Daltonization algorithm, a specialized computer vision algorithm designed to enhance visibility for users with color blindness. This algorithm takes input from the previous step, identifying colors within the image, and applies a color transformation algorithm tailored to address the specific needs of users with different types of color blindness. Meanwhile, the website meticulously tracks user mouse movements across the image, crucial for subsequent steps such as color sampling. Color sampling involves extracting color data from specific regions of the image based on user mouse movements, enabling targeted color adjustments or application of other image editing effects to designated areas of interest.

In terms of user interaction, the website's user interface plays a pivotal role, providing users with features to upload images, navigate image processing functionalities, and confirm or adjust edits. Post-processing, the website likely displays the transformed image to users, allowing them to review edits and make necessary adjustments before saving the final version.

Additionally, considerations such as framework selection, implementation of functionalities, rigorous testing, debugging, and eventual deployment to the public are crucial phases in the development life cycle, ensuring the website functions seamlessly and meets user expectations.

3.2 Architectural Design

- This UML Use Case Diagram for the ChromaClear website depicts the various functionalities available to a user and developer, such as uploading media, captur-

ing media in real-time, using an extension for webpage conversion, and simulating colorblindness. The developer can select the type of conversion for the media or web pages, view and download the converted media, and display converted web pages. Additional functionalities include cursor tracking on converted media. The diagram illustrates the direct interactions and dependencies between these use cases, providing a clear overview of the developer's workflow on the ChromaClear platform.

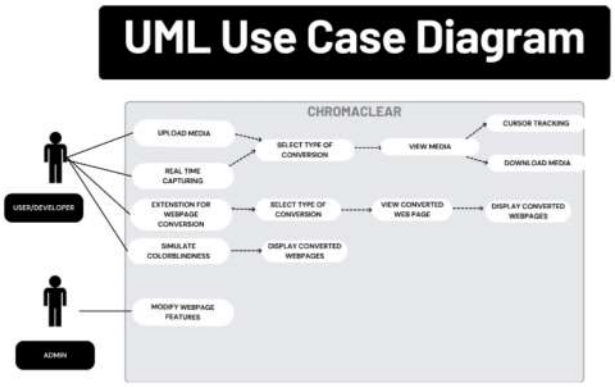

Figure 3.2: Use case diagram

- The sequence diagram below depicts a flowchart that outlines the steps involved in using a software program called ChromaClear to edit the colors of a website. The flowchart starts in the upper left corner with a box labeled "Access ChromaClear Website." From there, the user can either upload media or capture it in real time. Once the media is uploaded, the user can start real-time processing. The user can then adjust the color according to their requirements and move their cursor over the image to retrieve colors. The software will then display the color name in real time. Finally, the user can activate the ChromaClear extension to display the converted webpages.

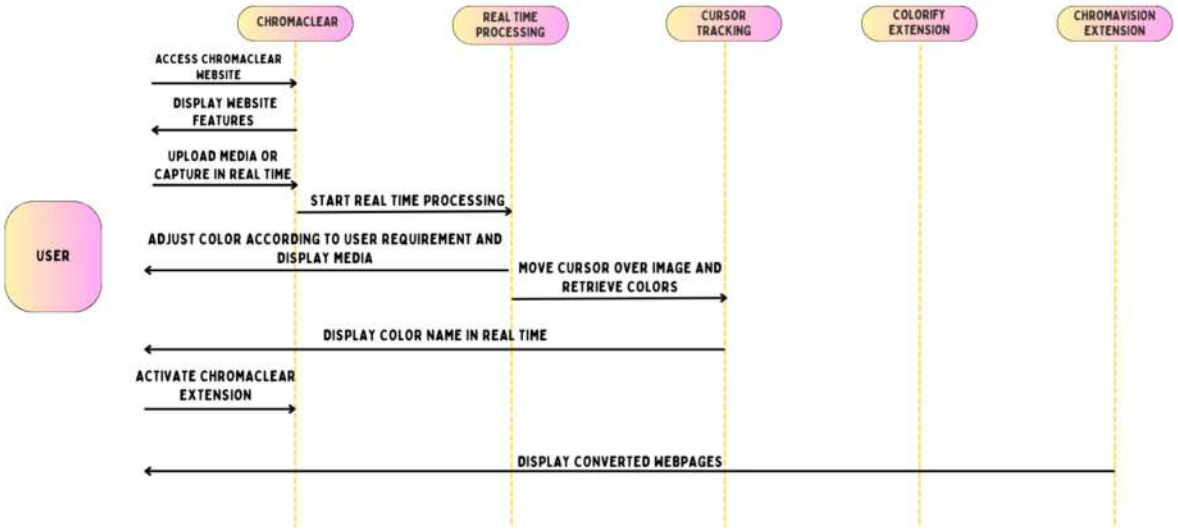

Figure 3.3: Sequence diagram for user

- This flowchart shows how to use ChromaClear to check how your website appears to people with color blindness. It involves activating the ChromaClear extension and then switching between different color blindness simulations to view the website.

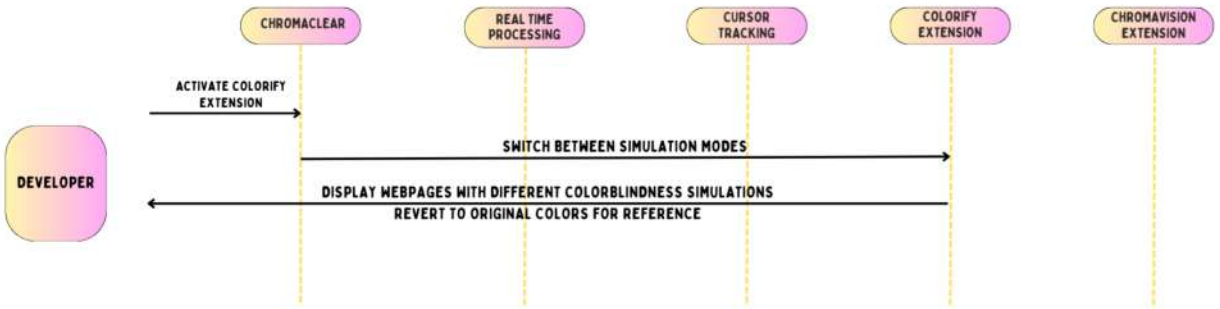

Figure 3.4: Sequence diagram for developer

3.3 Dataset identified

ChromaClear website operates without the need for a dataset.

3.4 Proposed Methodology/Algorithms

The Daltonization algorithm is central to ChromaClear's color correction functionality, addressing various forms of color blindness like Protanopia, Deuteranopia, and Tritanopia. Leveraging the LMS color space and tailored color transformations, it compensates for color deficiencies by predicting and adjusting colors missing in each group of cones, enhancing the visual experience for affected users. While the algorithm inherently includes matrices for Protanopia and Deuteranopia, a novel error modification matrix has been developed specifically for Tritanopia within ChromaClear. This ensures accurate and effective color correction, showcasing the platform's dedication to accessibility and inclusivity.

Algorithm 1: LMS Daltonization

//Input: RGB input image

//Output: RGB color corrected image

1: Convert RGB image to LMS color space using equation (1)

$$\begin{bmatrix} L \\ M \\ S \end{bmatrix} = \begin{bmatrix} 17.8824 & 43.5161 & 4.11935 \\ 3.45565 & 27.1554 & 3.86714 \\ 0.0299566 & 0.184309 & 1.46709 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (1)$$

2: Simulate color-blindness using equation (2) for Protanopia, (3) for Duteranopia and (4) for Tritanopia

$$\begin{bmatrix} L_P \\ M_P \\ S_P \end{bmatrix} = \begin{bmatrix} 0 & 2.02344 & -2.52581 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} L \\ M \\ S \end{bmatrix} \quad (2)$$

$$\begin{bmatrix} L_D \\ M_D \\ S_D \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0.49421 & 0 & 1.24827 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} L \\ M \\ S \end{bmatrix} \quad (3)$$

$$\begin{bmatrix} L_T \\ M_T \\ S_T \end{bmatrix} = \begin{bmatrix} 1.0 & 0.0 & 0.0 \\ 0.0 & 1.0 & 0.0 \\ -0.395913 & 0.801109 & 0.0 \end{bmatrix} \begin{bmatrix} L \\ M \\ S \end{bmatrix} \quad (4)$$

3: Convert $L_iM_iS_i$ back to $R_iG_iB_i$using equation (5), i= {P, D, T}

$$\begin{bmatrix} R_i \\ G_i \\ B_i \end{bmatrix} = \begin{bmatrix} 0.0809444479 & -0.130504409 & 0.116721066 \\ 0.113614708 & -0.0102485335 & 0.0540193266 \\ -0.000365296938 & -0.00412161469 & 0.693511405 \end{bmatrix} \begin{bmatrix} L_i \\ M_i \\ S_i \end{bmatrix} \quad (5)$$

4: Find Difference between original and simulated images by (6), (7) and (8)

$$D_{R(i)} = R - R_i \quad (6)$$

$$D_{G(i)} = G - G_i \quad (7)$$

$$D_{B(i)} = B - B_i \quad (8)$$

5: Shift colors towards visible spectrum by multiplying by error matrices using (9) for Protanopia, (10) for Duteranopia and (11) for Tritanopia

$$\begin{bmatrix} R_{map(P)} \\ G_{map(P)} \\ B_{map(P)} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ 0.7 & 1 & 0 \\ 0.7 & 0 & 1 \end{bmatrix} \begin{bmatrix} D_{R(P)} \\ D_{G(P)} \\ D_{B(P)} \end{bmatrix} \quad (9)$$

$$\begin{bmatrix} R_{map(D)} \\ G_{map(D)} \\ B_{map(D)} \end{bmatrix} = \begin{bmatrix} 1 & 0.7 & 0 \\ 0 & 0 & 0 \\ 0 & 0.7 & 1 \end{bmatrix} \begin{bmatrix} D_{R(D)} \\ D_{G(D)} \\ D_{B(D)} \end{bmatrix} \quad (10)$$

$$\begin{bmatrix} R_{map(T)} \\ G_{map(T)} \\ B_{map(T)} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0.7 \\ 0 & 1 & 0.7 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} D_{R(T)} \\ D_{G(T)} \\ D_{B(T)} \end{bmatrix} \quad (11)$$

6: Add shifted colors to original image using (12), (13) and (14)

$$R_{F(i)} = R + R_{map(i)} \quad (12)$$

$$G_{F(i)} = G + G_{map(i)} \quad (13)$$

$$B_{F(i)} = B + B_{map(i)} \quad (14)$$

Figure 3.5: LMS Daltonization Algorithm

3.5 User Interface Design

- The figure below depicts the homepage of "ChromaClear".

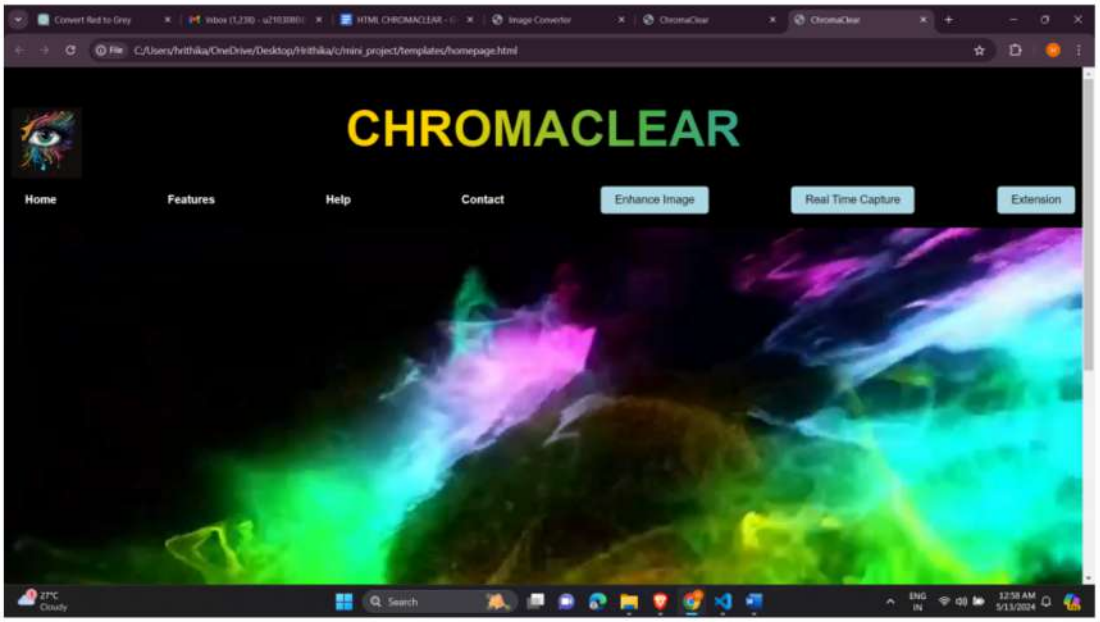

Figure 3.6: webpage1

- The figure below depicts the webpage for Image Conversion/Enhancement.

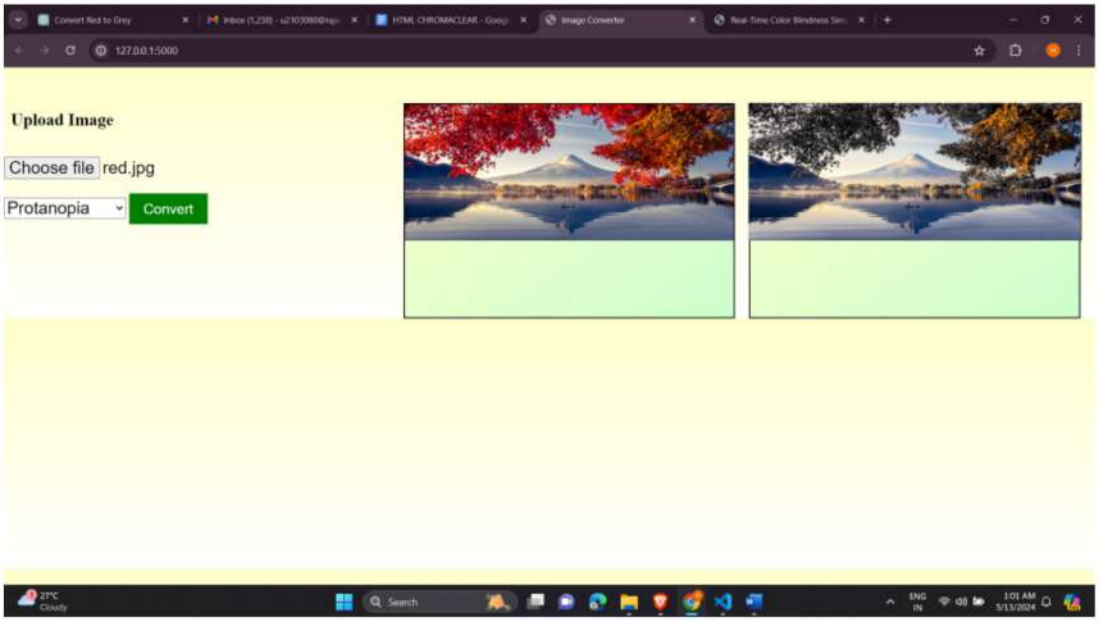

Figure 3.7: Webpage 2

- The figure below depicts the webpage for Extension

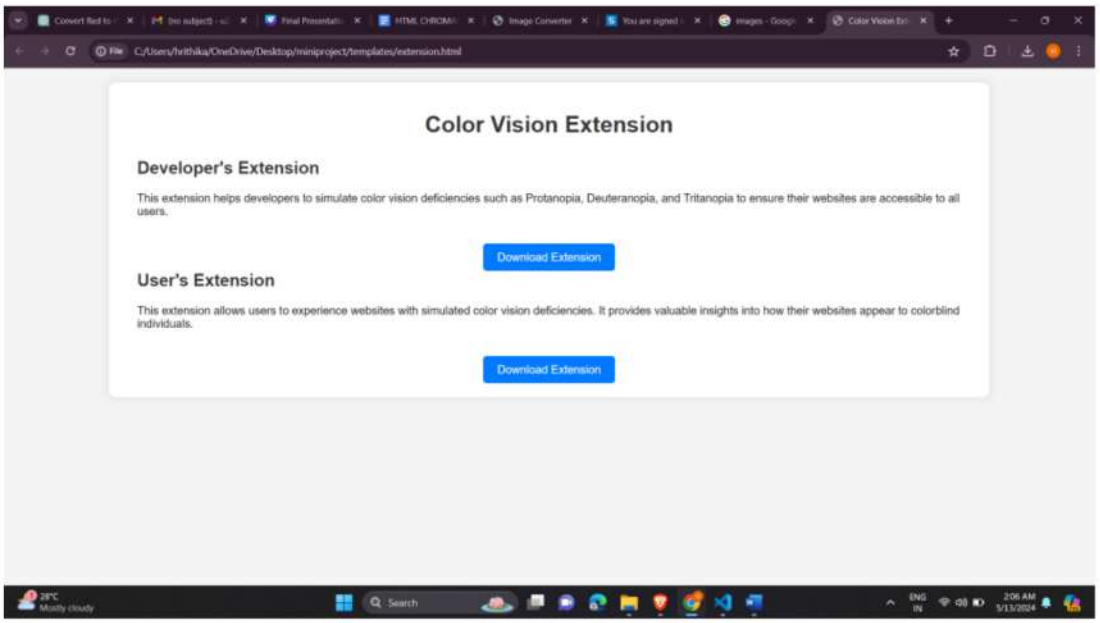

Figure 3.8: webpage 3

- The figure below depicts the webpage for Realtime conversion.

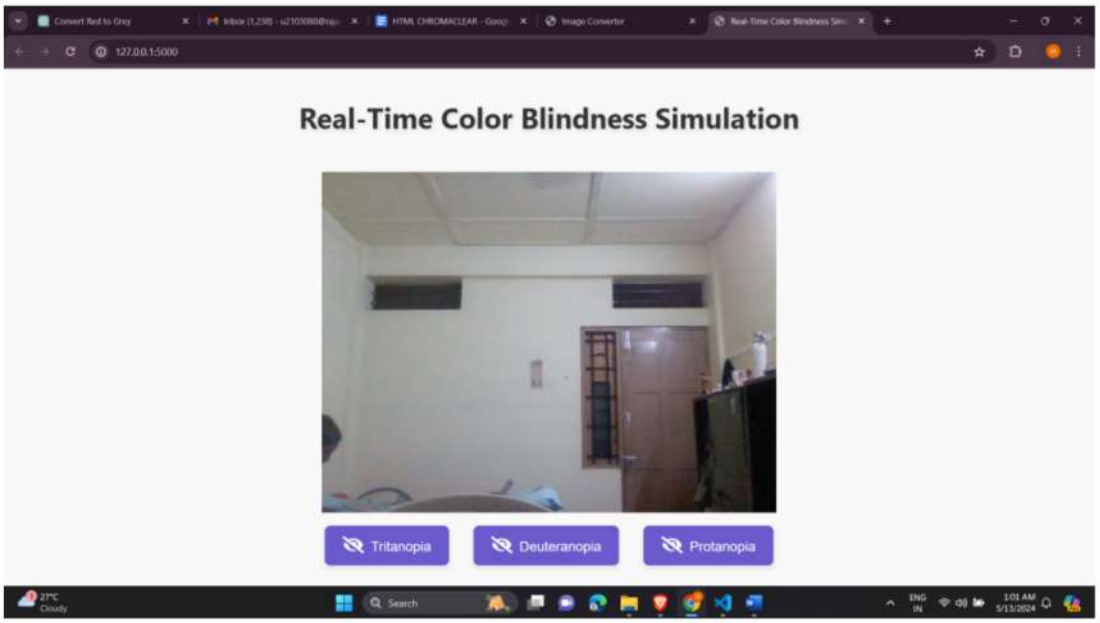

Figure 3.9: Webpage 4

3.6 Database Design

ChromaClear website operates without the need for a database.

3.7 Description of Implementation Strategies

This section details the important implementation strategies used in our project.

Front-end Development: HTML/CSS/JavaScript is used for developing the user interface of the ChromaClear website, facilitating media upload, real-time capture, and other user interactions. The main pages include:

homepage.html: This is the initial page of the website.

enhanceimage.html: Allows uploading and converting images based on the type of color blindness chosen.

realtime.html: Provides real-time video conversion based on the type of color blindness chosen.

extension.html: Enables users to download extensions for color-blind users and developers.

Image Conversion:The image conversion feature uses the daltonization algorithm to adjust colors in images to make them more distinguishable for color-blind users. This process involves the following steps:

Daltonization Algorithm: This algorithm adjusts the colors in an image based on the type of color blindness. Extension for Developers: Simulates colorblindness according to the type of color blindness chosen.

Manifest File: The manifest.json file specifies essential information and configuration settings, including the extension's name, version, permissions, background scripts, icons, and content scripts, enabling the browser to properly install, manage, and execute the extension.

Extension for Users: The manifest.json file specifies essential information and configuration settings, including the extension's name, version, permissions, background scripts, icons, and content scripts, enabling the browser to properly install, manage, and execute the extension.

JavaScript: Used for developing the browser extension that enables real-time conversion of web pages. Relevant files include: popup.js background.js HTML/CSS: Used for UI elements and styling within the browser extension. Relevant files include: popup.html popup.css

Color Identification Feature: JavaScript is utilized for implementing the color identi-

fication functionality using the cursor within the image conversion dropbox.

Real-time Conversion: Python is used to capture real-time video through the camera and convert it based on the type of color blindness chosen. The specific library and methods used include:

OpenCV: For video capture and processing.

Backend Processing and Algorithm Implementation: Python is used extensively for backend processing, implementing the daltonization algorithm, handling media uploads, and executing various tasks related to color conversion. The specific library and methods used include: Daltonization Algorithm: For color conversion.

These strategies ensure that the ChromaClear project effectively addresses the needs of color-blind users through a combination of front-end development, real-time video processing, and backend algorithm implementation.

3.8 Module Division

1.Cursor Movement Module: This module focuses on implementing features for tracking cursor movement over images and videos uploaded to ChromaClear. It involves developing algorithms and functionalities to accurately track the cursor position and provide color information at the cursor point. Assigned to: Divya Binu

2.Real-Time Capture and Conversion Module: This module focuses on implementing features for real-time capture of media content and conversion to accommodate various types of color blindness. It involves developing algorithms and functionalities to ensure accurate and comfortable viewing for users in real-time. Assigned to: Diya Baiju

3.Colorblind Simulation Extension Module: This module involves developing a browser extension specifically for developers and designers, allowing them to simulate various types of color blindness directly within their web browsers. It provides a visual representation of how individuals with color blindness perceive digital content, enabling developers to design more accessible and inclusive websites. Assigned to: Diya Thankachan

4.User Extension Module: This module involves developing a browser extension for users, allowing them to seamlessly access ChromaClear functionalities while browsing the web. The extension provides users with real-time conversion of web pages to accommodate various types of color blindness, enhancing their browsing experience. Assigned to: E H Hrithika

3.9 Work Schedule - Gantt Chart

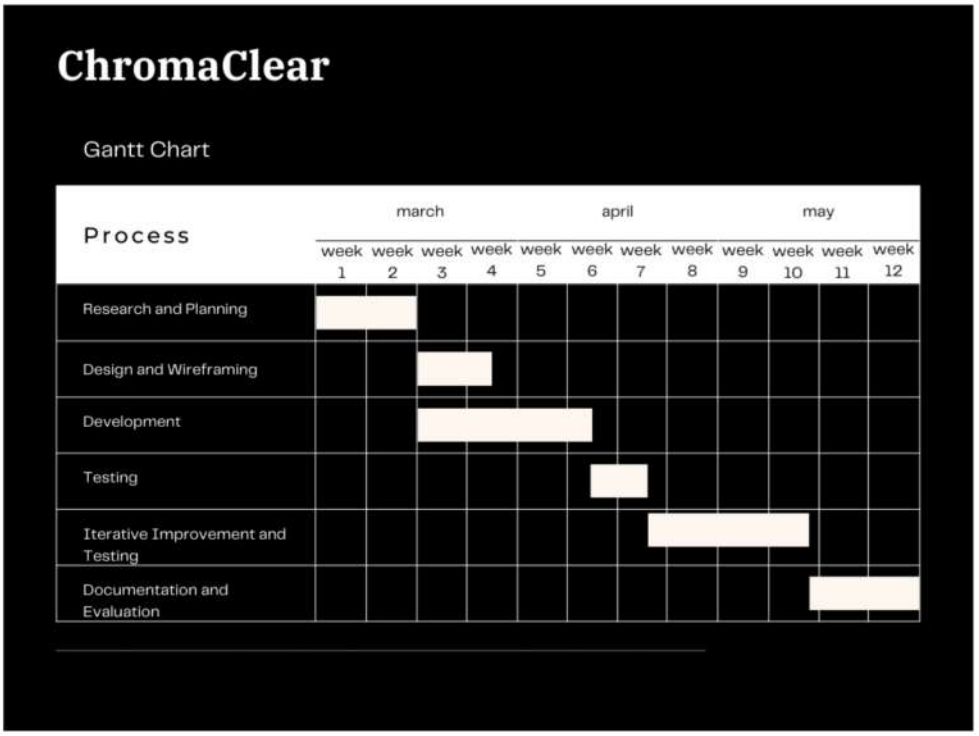

Figure 3.10: Gantt Chart

Chapter 4

Results and Discussions

4.1 Overview

ChromaClear project has successfully addressed the challenges of color blindness by implementing several key features. Through careful image conversion, we've ensured that individuals with color vision deficiencies can discern visual content more easily. The deployment of two distinct browser extensions—one catering to users for real-time webpage conversion and another tailored for developers offering color blindness simulation—has significantly enhanced accessibility across the digital spectrum. Moreover, the cursor feature enables users to identify colors instantly, enhancing their browsing experience. With real-time capture capabilities, ChromaClear is not just a tool but a solution that empowers users to engage with digital content more comfortably and accurately.

4.2 Testing

- The figure below depicts the homepage of the website "ChromaClear" and includes buttons to the next web pages.

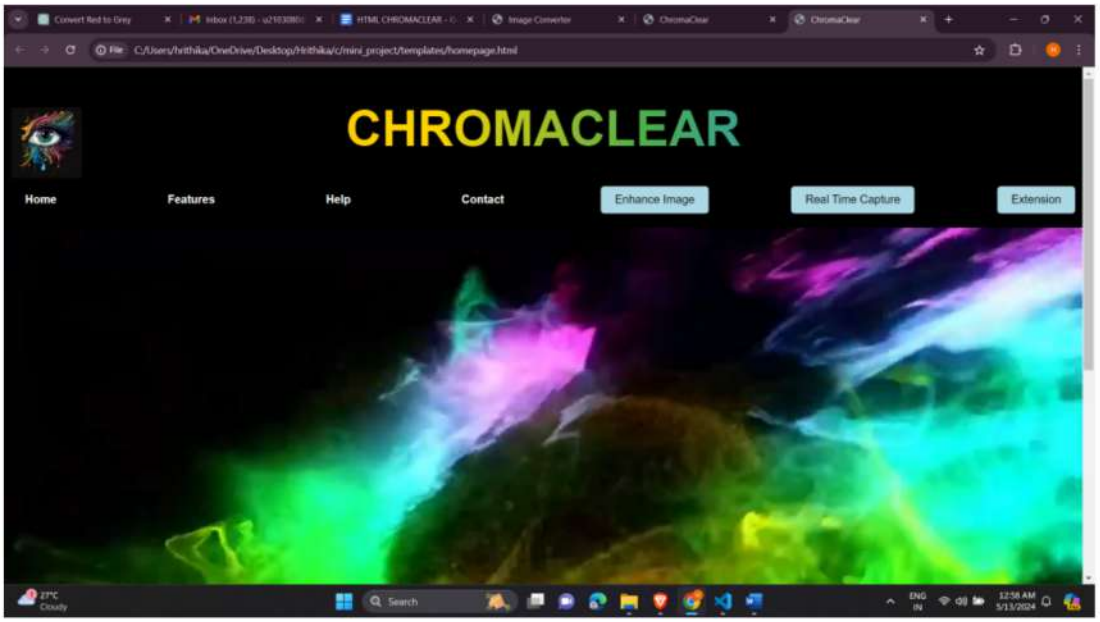

Figure 4.1: Homepage

- The figure below depicts the web page of the "Enhance Image" button on the homepage and includes upload image and drop boxes to choose the type of color blindness to convert the images. Figures 4.2, 4.3, and 4.4 depict the conversion of the images in accordance to protanopia, deutranopia and tritanopia respectively.

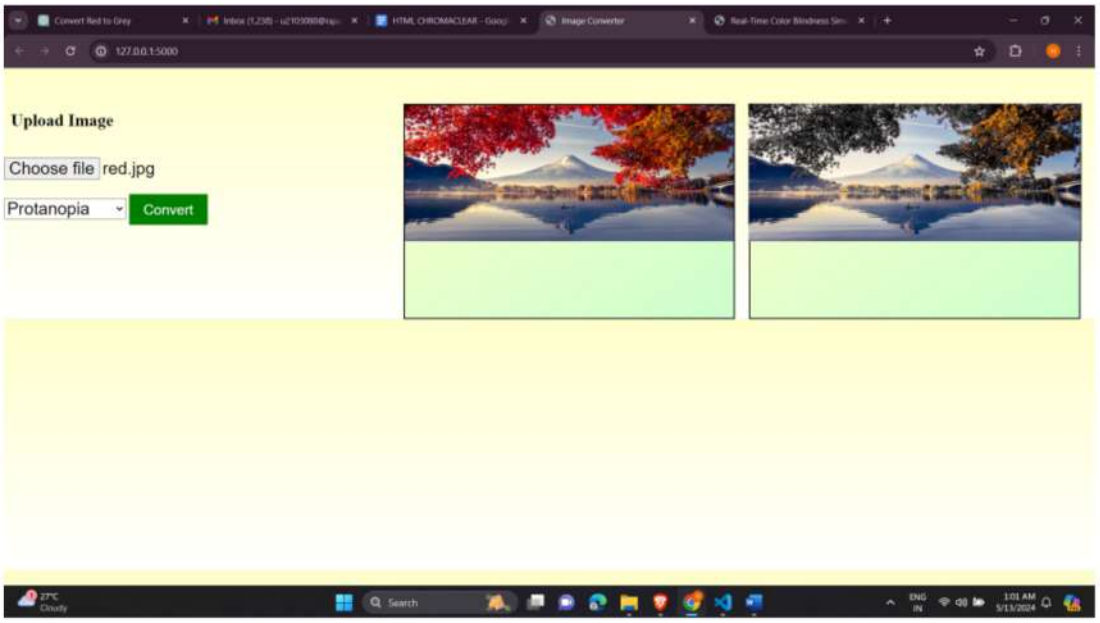

Figure 4.2: Imageconversion-protanopia

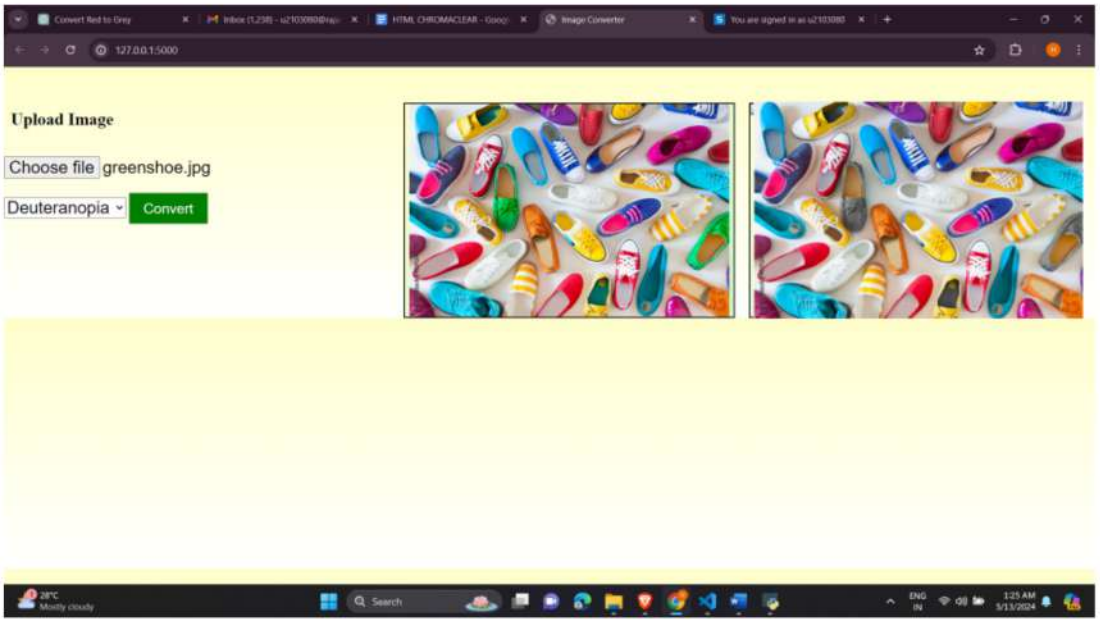

Figure 4.3: Imageconversion-Deuteranopia

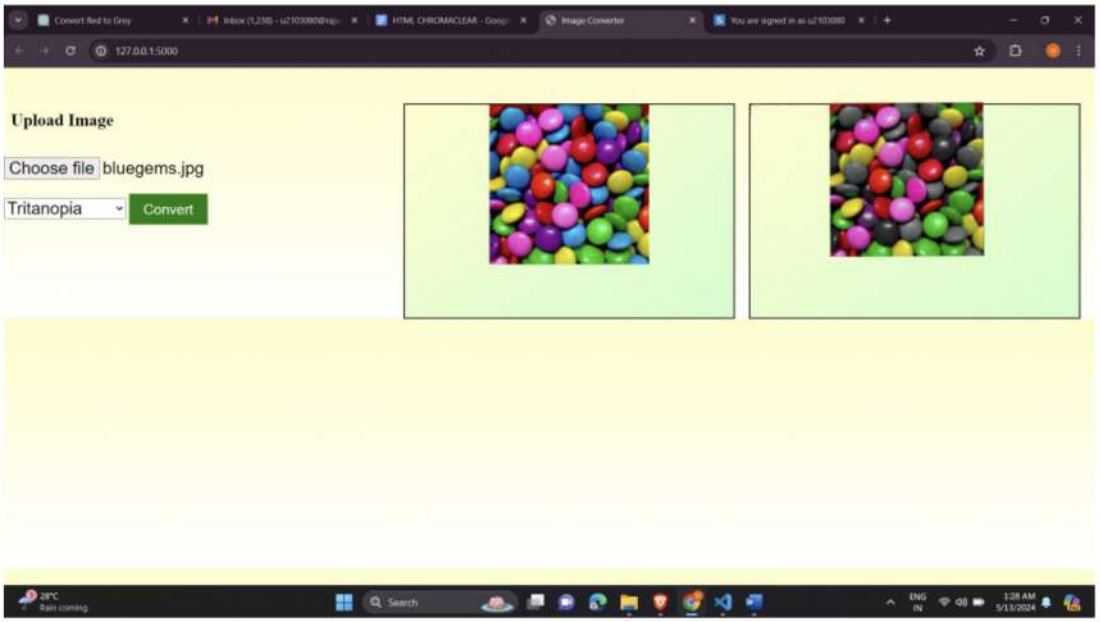

Figure 4.4: Imageconversion-Tritranopia

- The figure below depicts the real time conversion of images before conversion to protanopia occurs.

Figure 4.5: realtimecapture-protanopia-before

- The figure below depicts the real time conversion of images after the conversion to protanopia occurs.

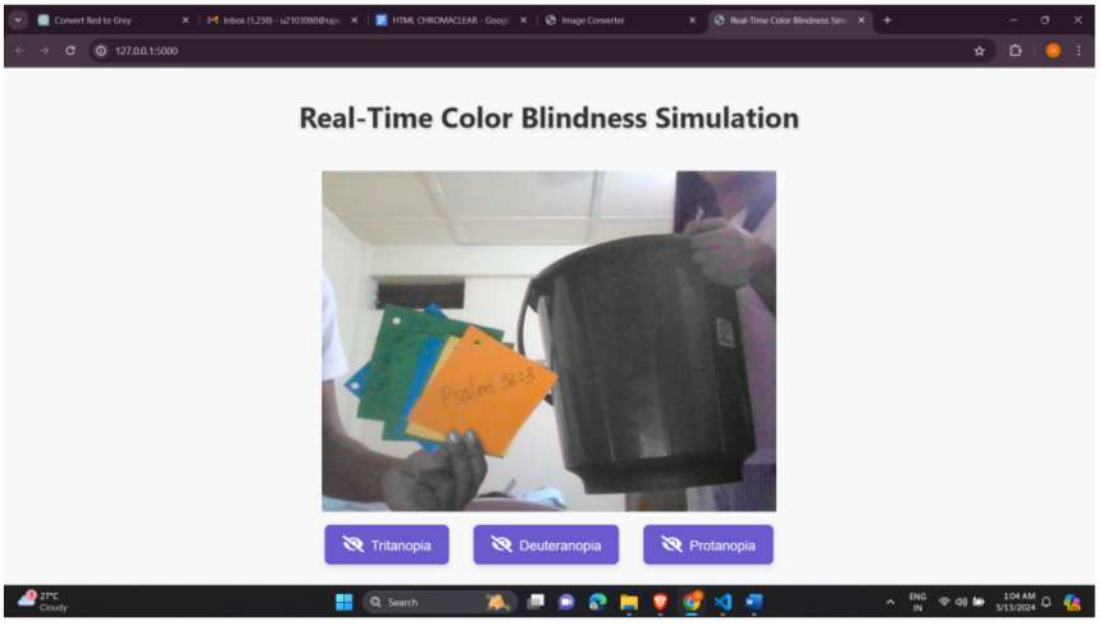

Figure 4.6: realtimecapture-protanopia-after

- The figure below depicts the real time conversion of images before conversion to tritanopia occurs.

Figure 4.7: realtimecapture-before

- The figure below depicts the real time conversion of images after conversion to tritanopia occurs.

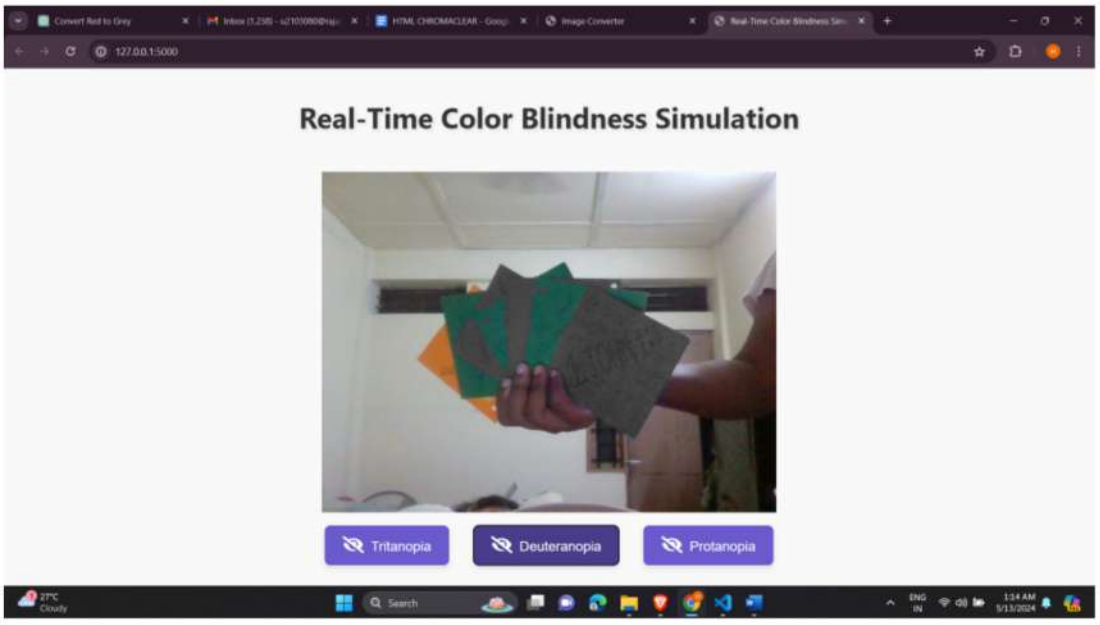

Figure 4.8: realtimecapture-tritanopia

- The figure below depicts the real time conversion of images before conversion to deutranopia occurs.

Figure 4.9: realtimecapture-before

- The figure below depicts the real time conversion of images after conversion to deutranopia occurs.

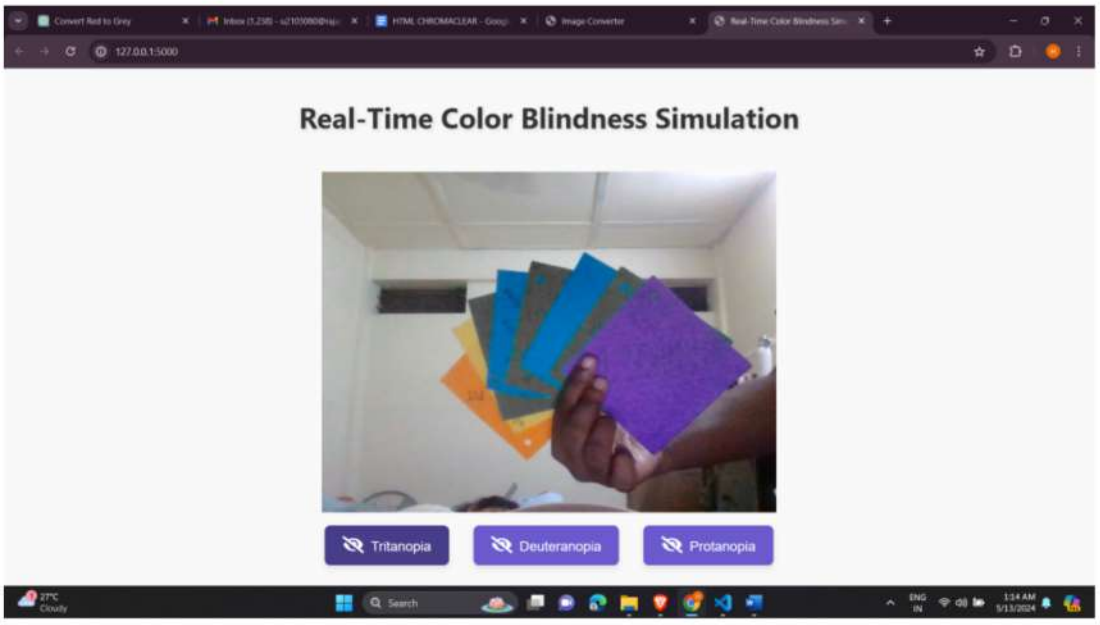

Figure 4.10: realtimecapture-deuteranopia

- The figure below depicts the simulation/conversion of web pages on the basis of Protanopia for developers.

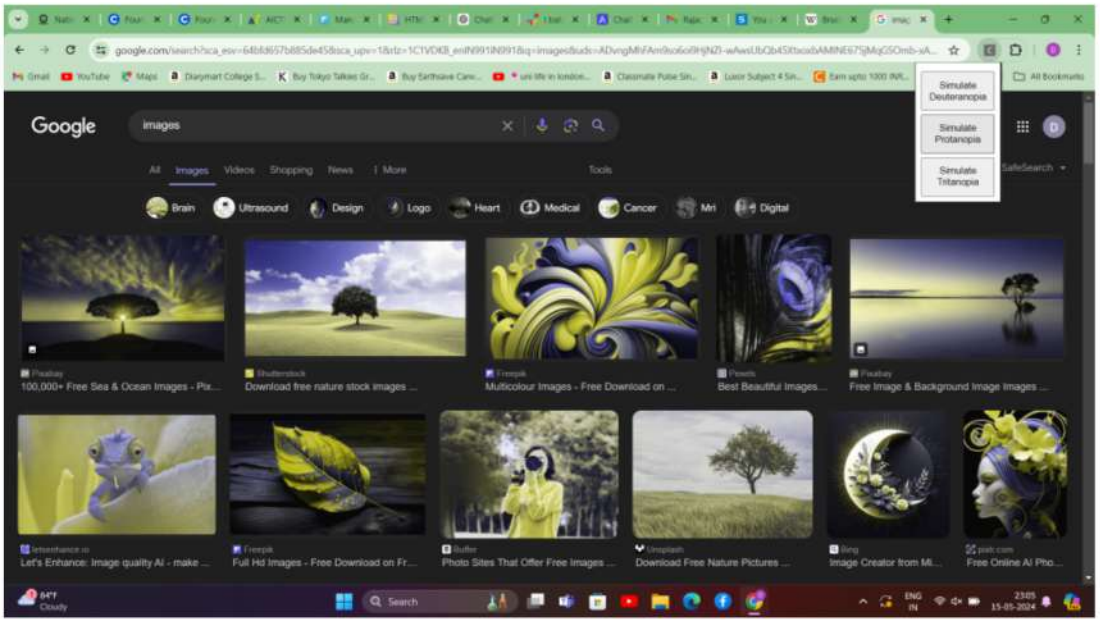

Figure 4.11: Protonopia simulation-developer extension

- The figure below depicts the simulation/conversion of web pages on the basis of Deutranopia for developers.

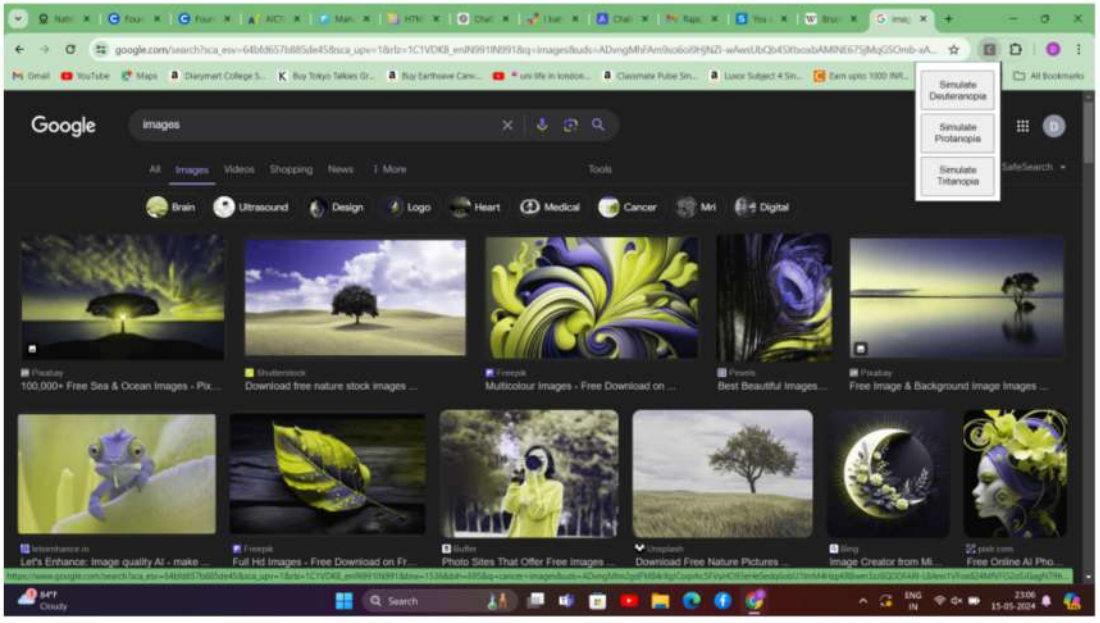

Figure 4.12: Deutranopia-developer extension

- The figure below depicts the simulation/conversion of web pages on the basis of Tritanopia for developers.

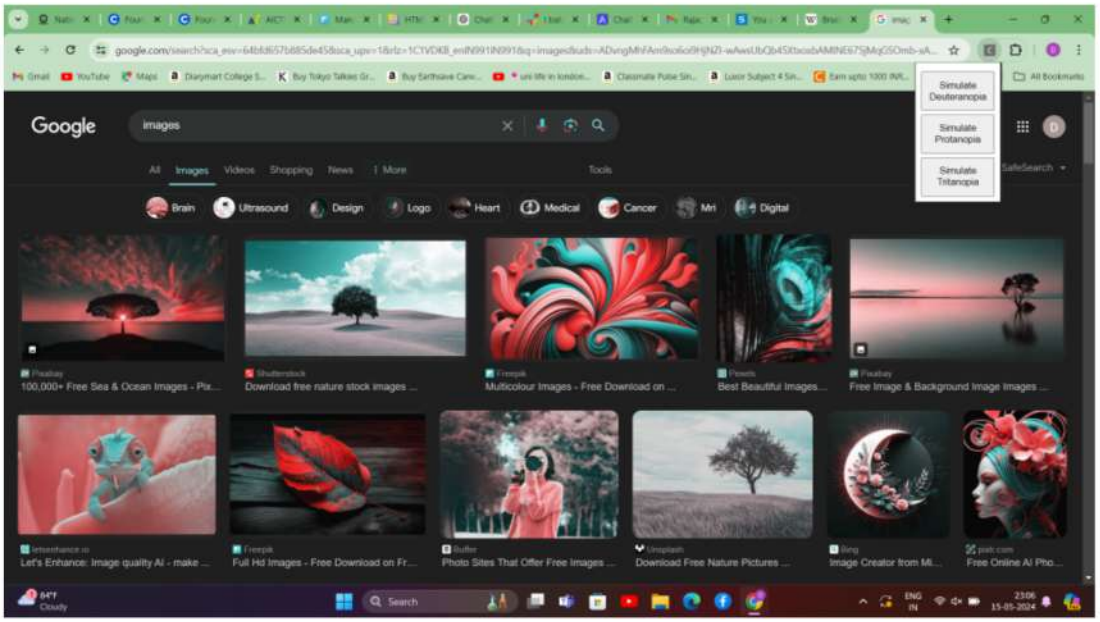

Figure 4.13: Tritanopia-developer extension

- The figure below depicts the simulation/conversion of web pages for colorblind users based on links, text and background color.

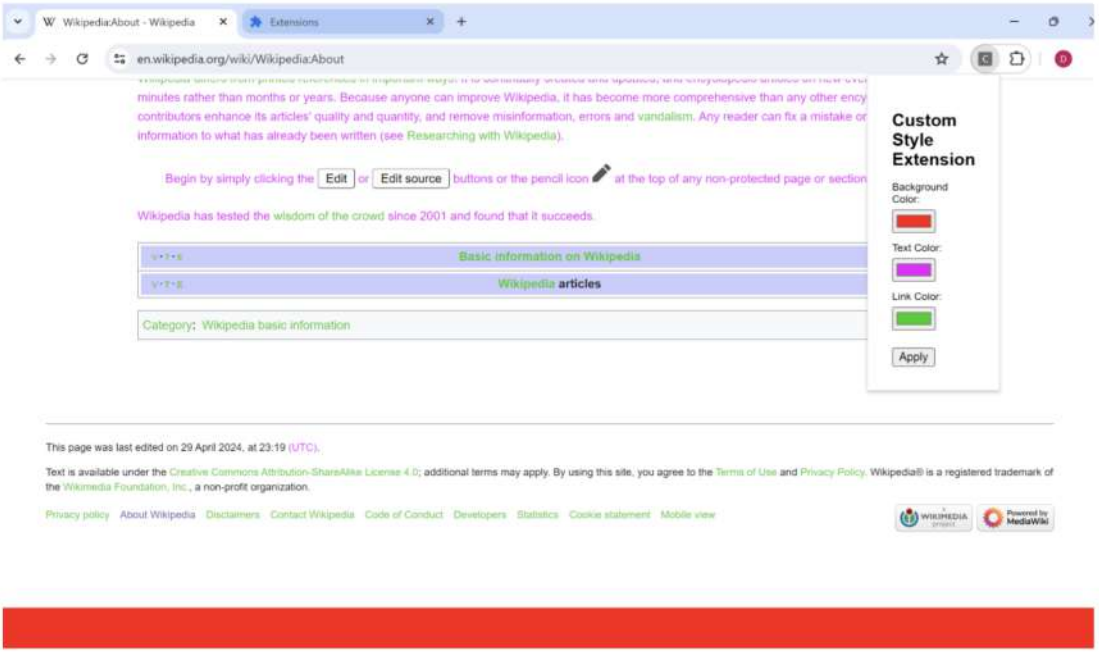

Figure 4.14: user extension

4.3 Quantitative Analysis

Table 4.1: Color Name Recognition Metrics

Function	Accuracy (%)
Color Recognition	85

4.4 Discussion

In this section, we provide a summary of the results obtained from the implementation and evaluation of ChromaClear. The platform demonstrated significant success in addressing the challenges faced by individuals with color blindness, providing them with tools to perceive and interact with digital content more accurately and comfortably. Through real-time conversion of images and videos using advanced daltonization algorithms, ChromaClear effectively enhanced the accessibility of digital content for users with varying degrees of color vision deficiencies.

Furthermore, the inclusion of features such as cursor tracking and color identification contributed to the usability and effectiveness of the platform, allowing users to navigate and interact with visual content with greater ease. The positive feedback received from users during the evaluation phase underscores the importance and impact of ChromaClear in promoting digital accessibility and inclusive design practices.

While ChromaClear has shown promising results, there may be areas for improvement and further refinement in future iterations. This could include enhancements to the daltonization algorithms for even more accurate color conversion, as well as the development of additional features to cater to specific user needs. Overall, the results obtained from ChromaClear underscore its potential to make a meaningful difference in the lives of individuals with color blindness and contribute to a more inclusive digital environment.

Chapter 5

Conclusion

5.1 Conclusion

ChromaClear is an exciting project that aims to make the digital world more accessible for people with color blindness. Our platform offers a user-friendly website and handy browser extensions that cater to different types of color vision deficiencies. With ChromaClear, users can effortlessly upload images and videos, which are then instantly transformed using advanced algorithms to improve visibility and clarity. Also, features like cursor tracking and color identification make it easier for users to interact with digital content in a way that suits their needs.

Beyond just helping users, ChromaClear has broader implications for web design and societal inclusivity. By providing developers and designers with tools to simulate color blindness, we're encouraging them to create websites that are accessible to everyone. This isn't just about technology—it's about empathy and understanding, making sure that no one is left out of the digital conversation. With ChromaClear leading the way, we're working towards a future where everyone, regardless of their color vision, can fully enjoy and engage with the digital world.

5.2 Future Scope

The future scope of ChromaClear is promising and holds potential for further advancements in digital accessibility and inclusive design. One avenue for expansion is the continued refinement and optimization of the daltonization algorithms used to convert images and videos. As technology evolves, there is room for improvement in the accuracy and efficiency of these algorithms, leading to even better results for individuals with color vision deficiencies.

Additionally, ChromaClear can explore the integration of new features and functionalities to enhance the user experience further. This could include the development of additional tools for color identification and customization, as well as the incorporation of machine learning techniques to better understand and adapt to individual user preferences and needs.

Furthermore, ChromaClear has the opportunity to expand its reach and impact by partnering with organizations and institutions dedicated to promoting digital accessibility and inclusivity. By collaborating with educators, advocacy groups, and technology companies, ChromaClear can raise awareness about the importance of accessible design practices and provide valuable resources and support to a broader audience.

Overall, the future of ChromaClear is bright, with possibilities for growth and innovation that can continue to make a meaningful difference in the lives of individuals with color blindness and contribute to a more inclusive digital landscape.

Bibliography

[1] L. A. Elrefaei, "Smartphone-Based Image Color Correction for Color Blindness," International Journal of Interactive Mobile Technologies (iJIM), vol. 12, no. 3, Art. 8160, 2020. [Online]. Available: https://doi.org/10.3991/ijim.v12i3.8160.

[2] M. Simunovic, "Color vision deficiency," Eye (London, England), [Online]. Available: https://www.researchgate.net/publication/38114674.

[3] L. Jefferson and R. Harvey, "An interface to support color-blind computer users," presented at the School of Computing Sciences, University of East Anglia, April 2007.

[4] S. Poret, R. D. Dony, and S. Gregori, "Image Processing for Colour Blindness Correction," School of Engineering, University of Guelph, Guelph, ON, Canada.

[5] T. L. Fuller and A. Sadovnik, "Image level color classification for colorblind assistance," 2017 IEEE International Conference on Image Processing (ICIP), Beijing, China, 2017, pp. 1985-1989, doi: 10.1109/ICIP.2017.8296629.

[6] J. -B. Huang, C. -S. Chen, T. -C. Jen and S. -J. Wang, "Image recolorization for the colorblind," 2009 IEEE International Conference on Acoustics, Speech and Signal Processing, Taipei, Taiwan, 2009, pp. 1161-1164, doi: 10.1109/ICASSP.2009.4959795.

[7] Chin-Lun Lai and Shu-Wen Chang, "An image processing based visual compensation system for vision defects," 2009 IEEE 13th International Symposium on Consumer Electronics, Kyoto, Japan, 2009, pp. 472-476, doi: 10.1109/ISCE.2009.5156821.

[8] J. -Y. Jeong, H. -J. Kim, T. -S. Wang, Y. -J. Yoon and S. -J. Ko, "An efficient re-coloring method with information preserving for the color-blind," in IEEE Transactions on Consumer Electronics, vol. 57, no. 4, pp. 1953-1960, November 2011, doi: 10.1109/TCE.2011.6131176.

[9] X. Hu, X. Liu, X. Mao and T. -T. Wong, "Colorblind-Shareable Videos," 2019 International Conference on Cyberworlds (CW), Kyoto, Japan, 2019, pp. 356-359, doi: 10.1109/CW.2019.00065.

[10] B. S. Ananto, R. F. Sari and R. Harwahyu, "Color transformation for color blind compensation on augmented reality system," 2011 International Conference on User Science and Engineering (i-USEr), Selangor, Malaysia, 2011, pp. 129-134, doi: 10.1109/iUSEr.2011.6150551.

Appendix A: Presentation

Figure 5.1: PPT

Figure 5.2: Table of Contents

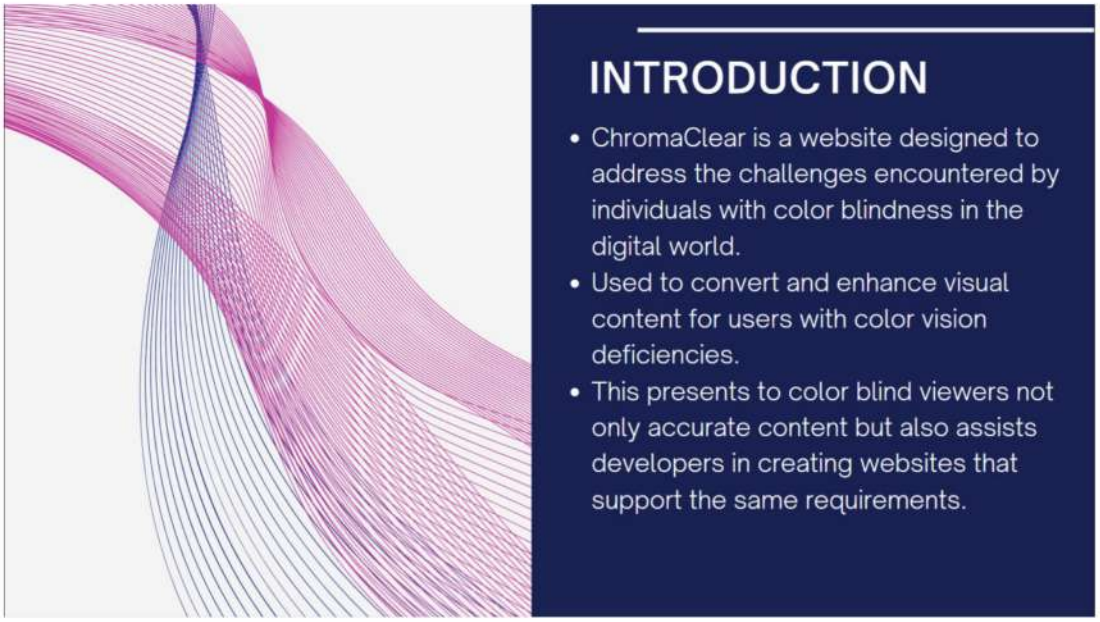

Figure 5.3: Introduction

Figure 5.4: Problem Definition

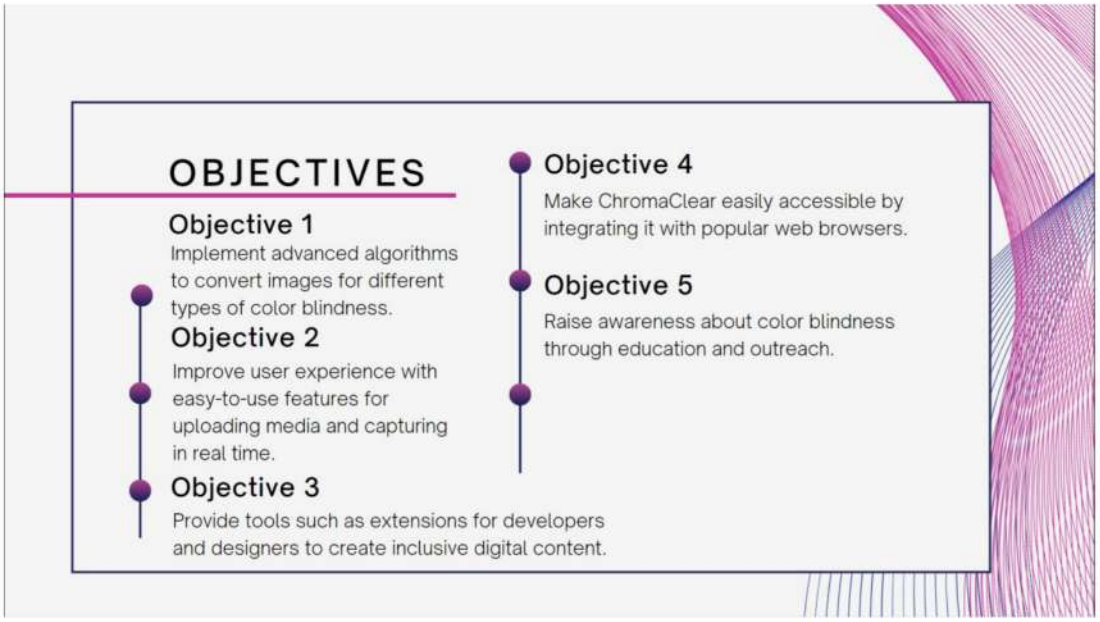

Figure 5.5: Objectives

Figure 5.6: Scope and Relevence

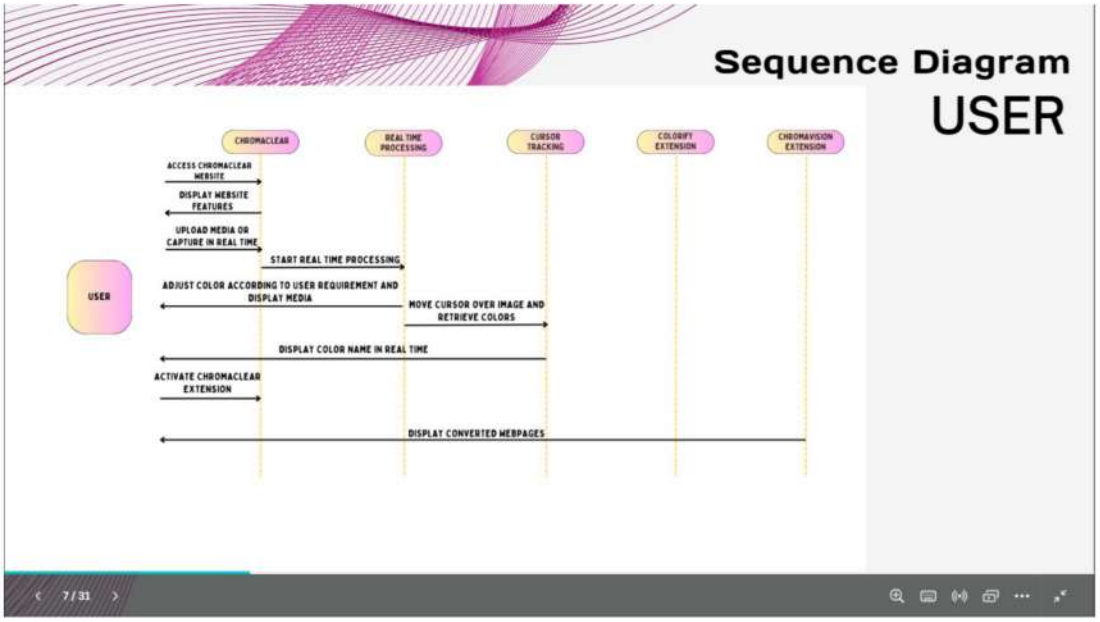

Figure 5.7: Sequence Diagram - users

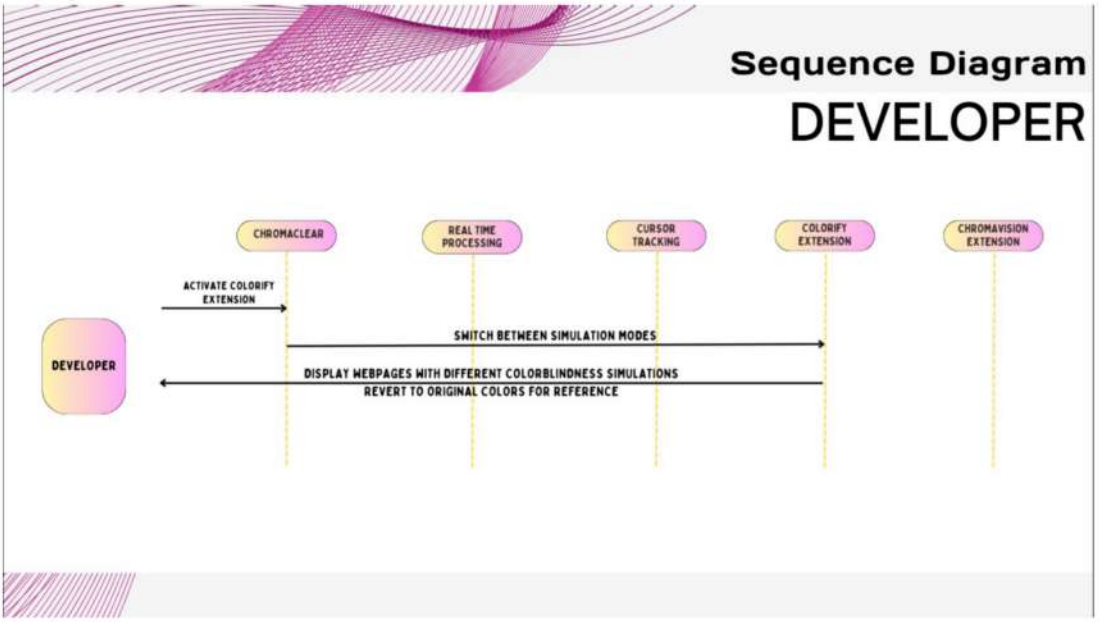

Figure 5.8: Sequence Diagram - developers

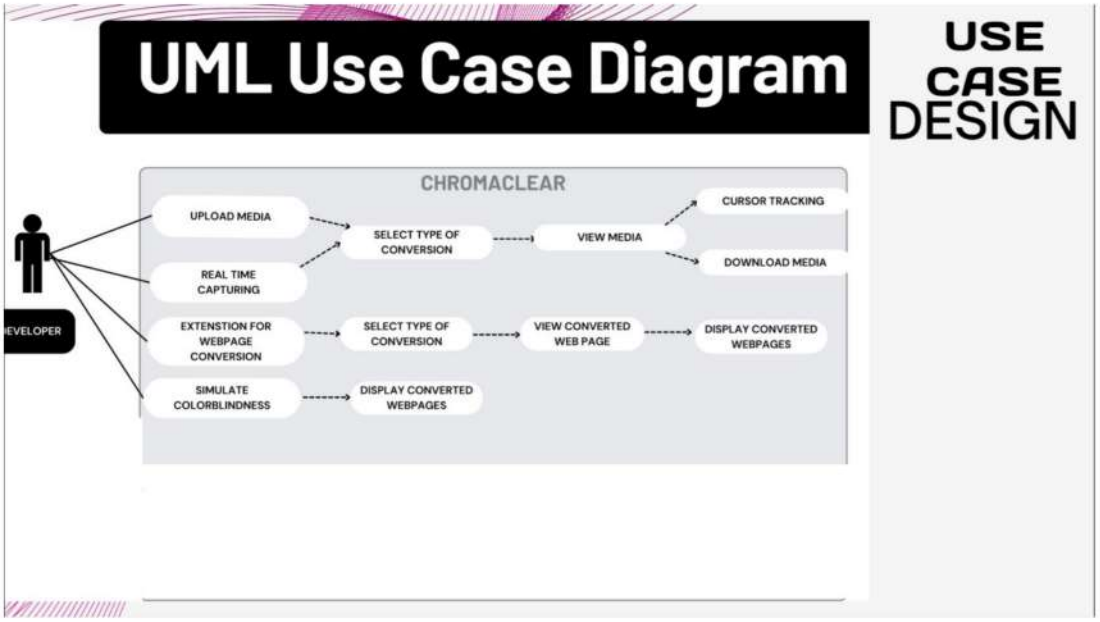

Figure 5.9: UML Diagram

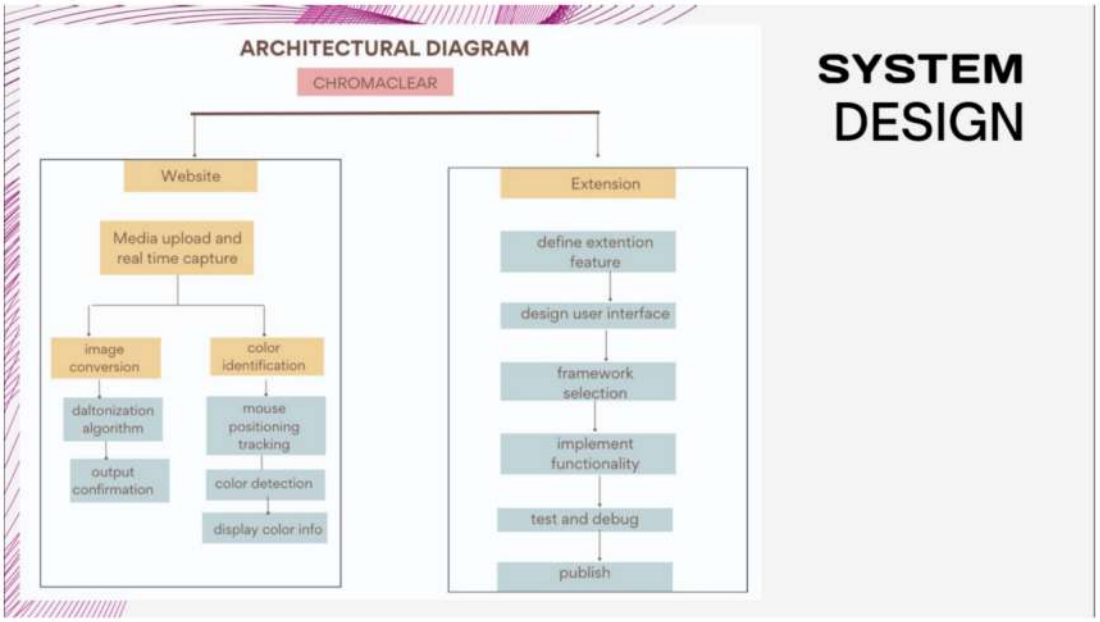

Figure 5.10: System Design

Figure 5.11: System Design 1

Figure 5.12: System Design 2

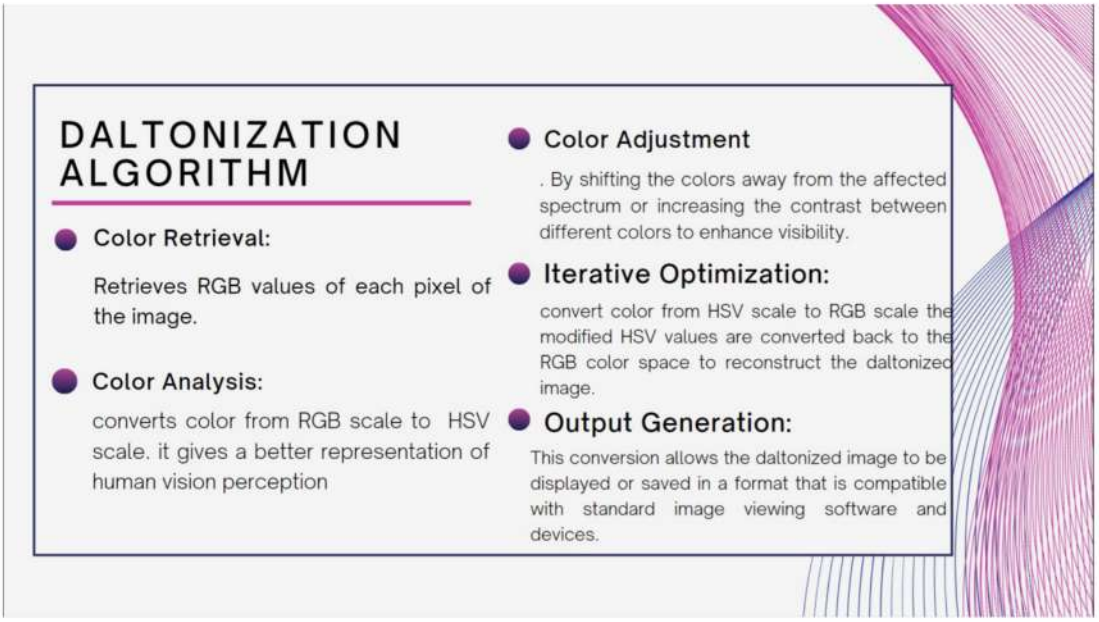

Figure 5.13: Daltonization Algorithm

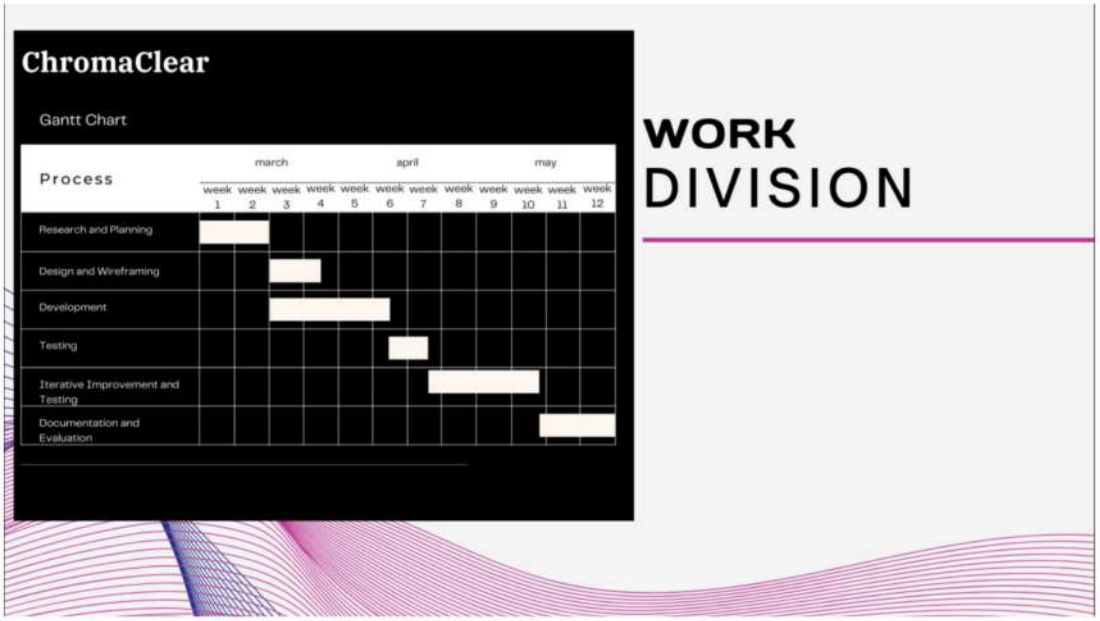

Figure 5.14: Gantt Chart

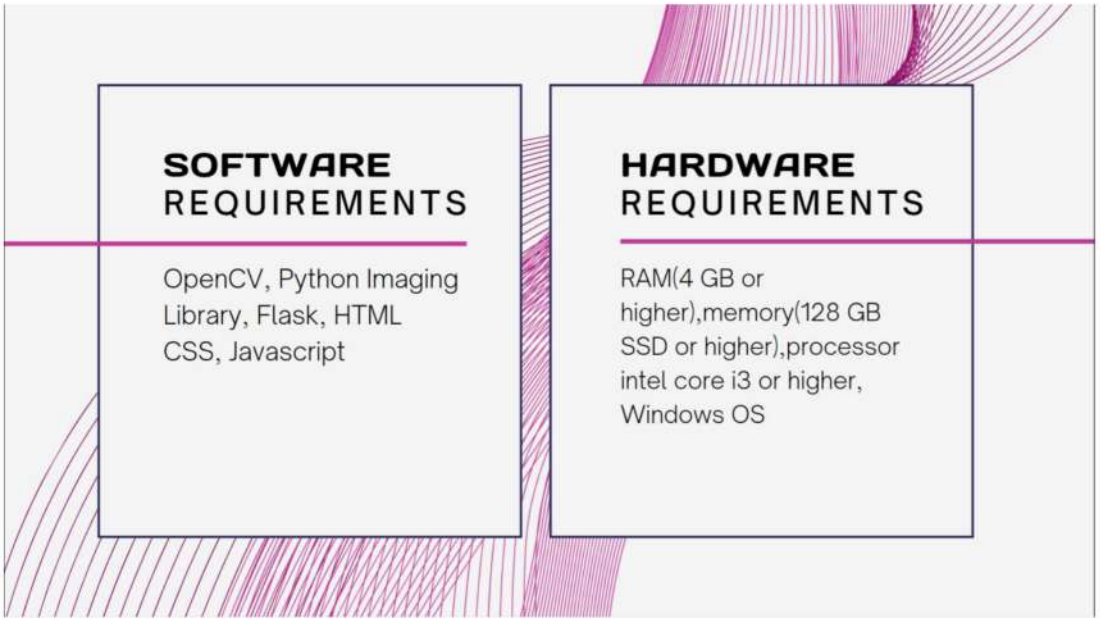

Figure 5.15: Requirements

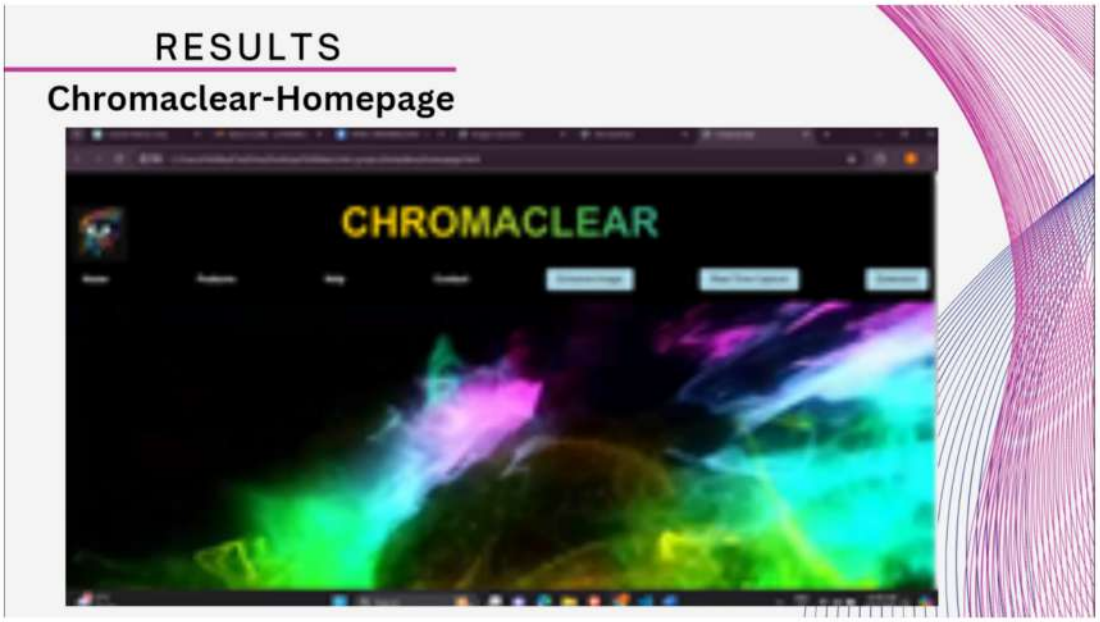

Figure 5.16: Results 1

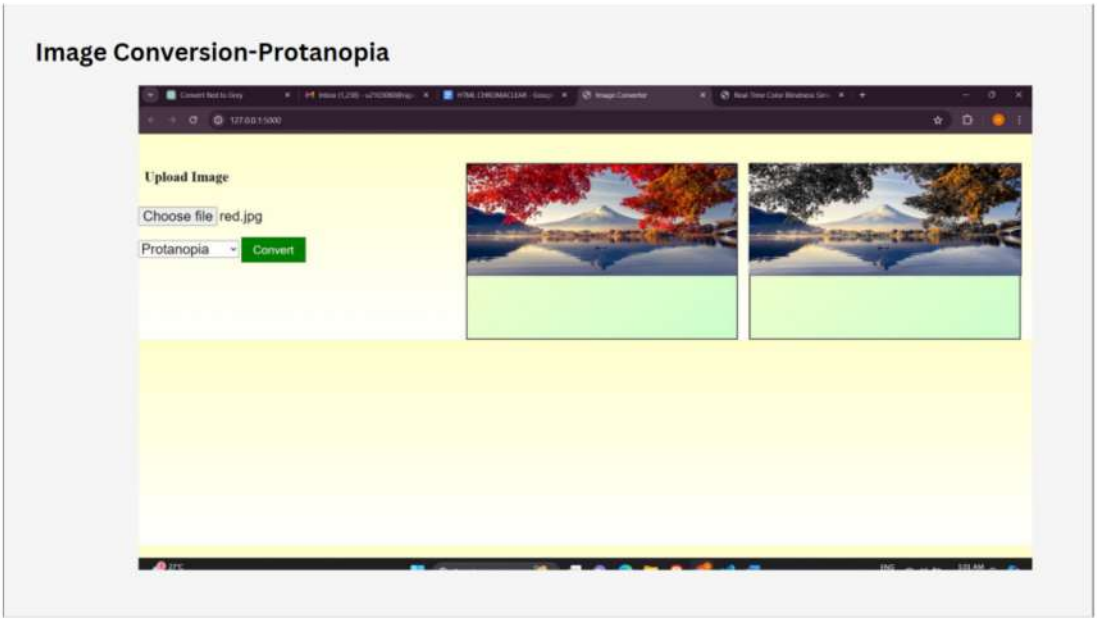

Figure 5.17: Results 2

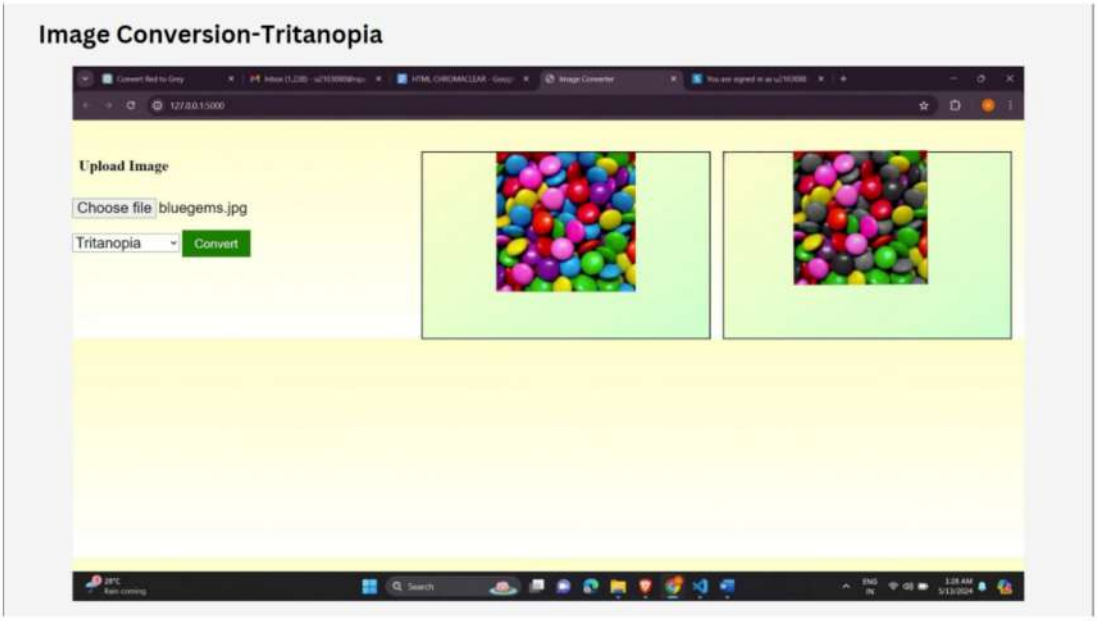

Figure 5.18: Results 3

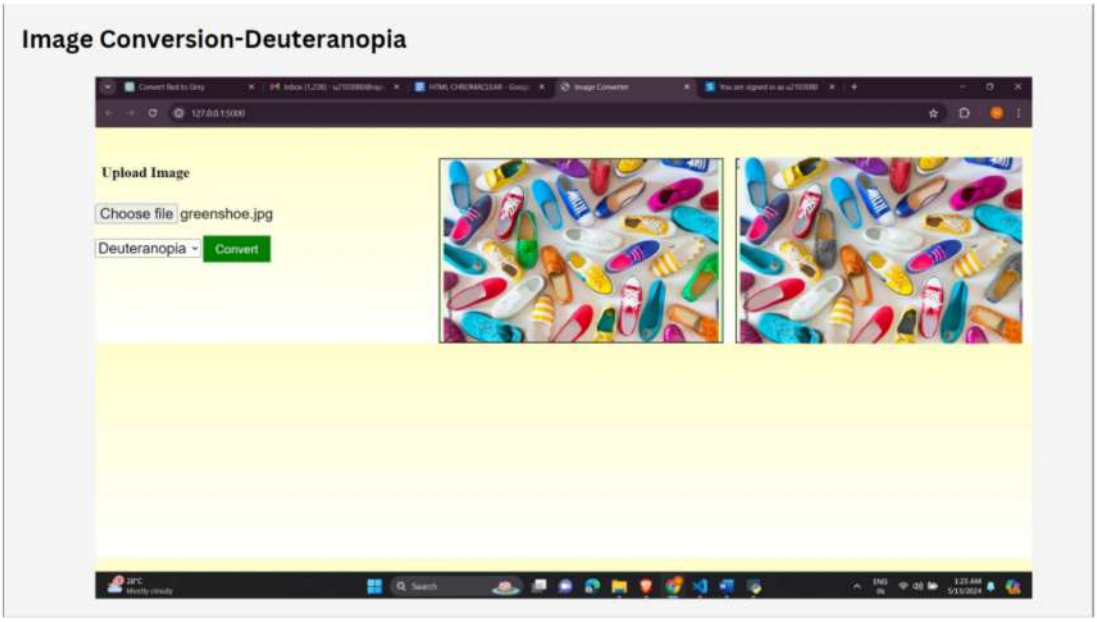

Figure 5.19: Results 4

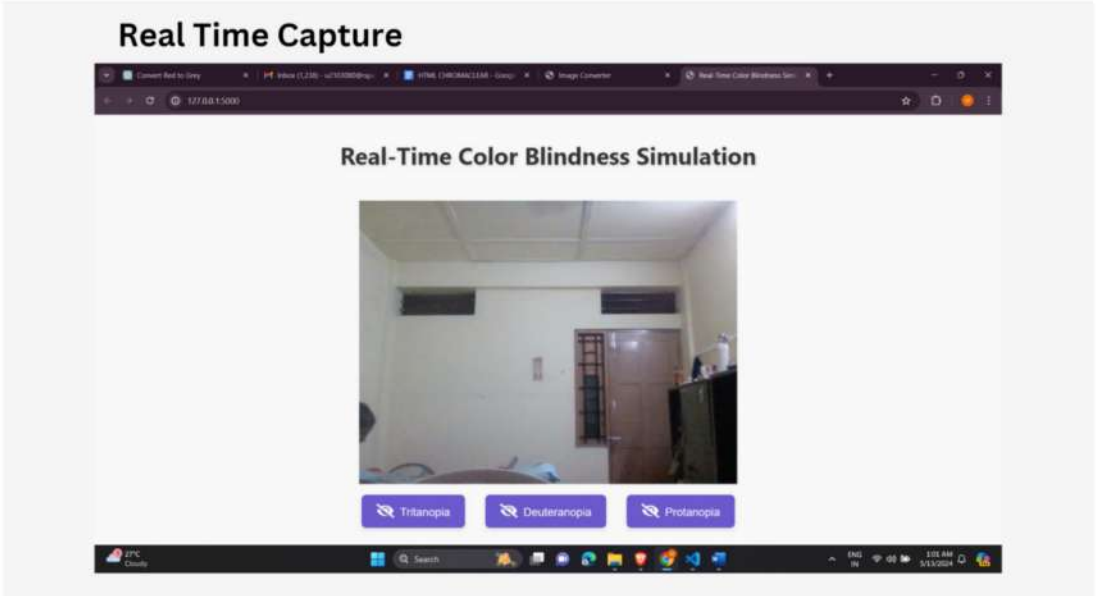

Figure 5.20: real time

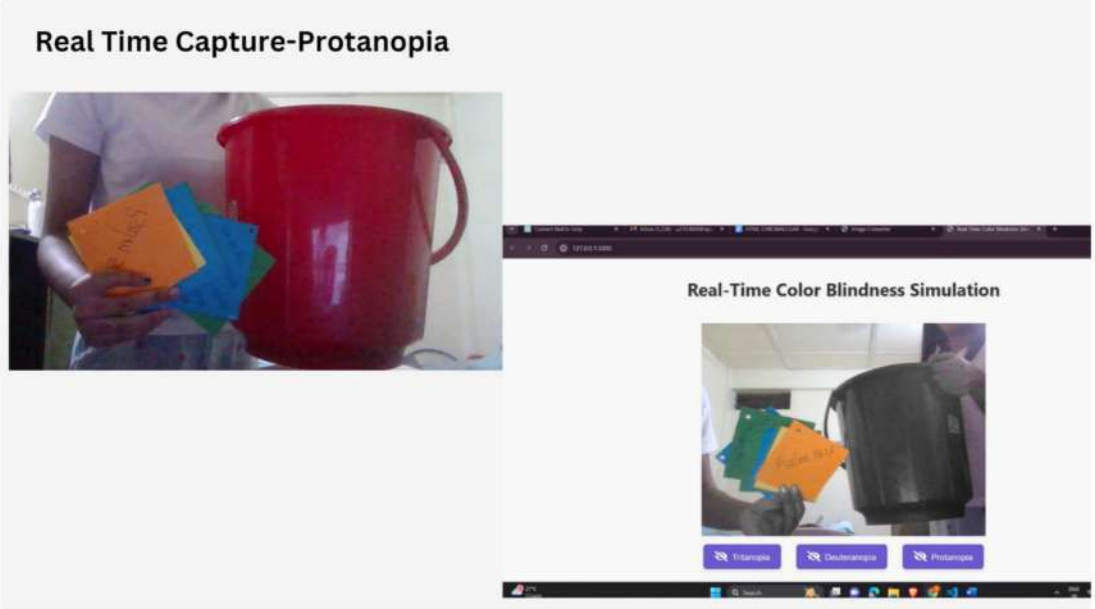

Figure 5.21: real time protanopia

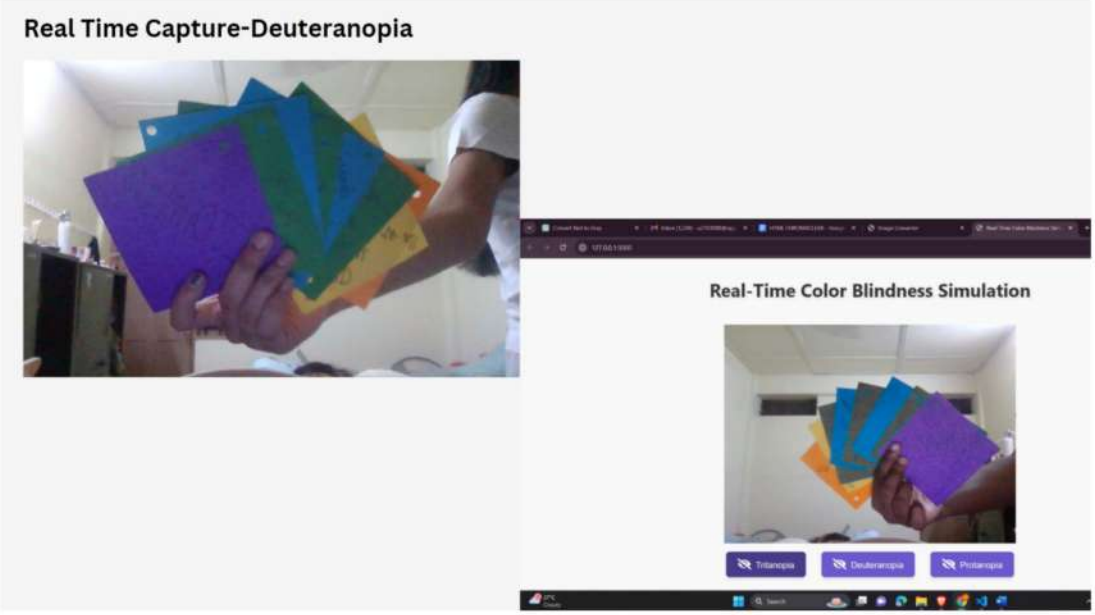

Figure 5.22: real time deutranopia

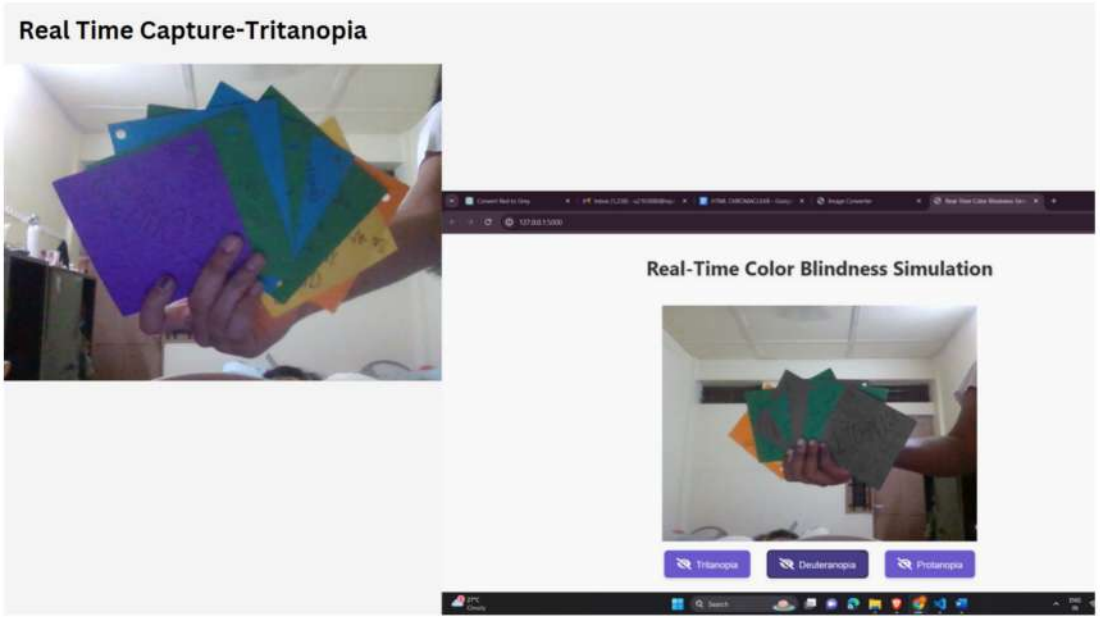

Figure 5.23: real time protanopia

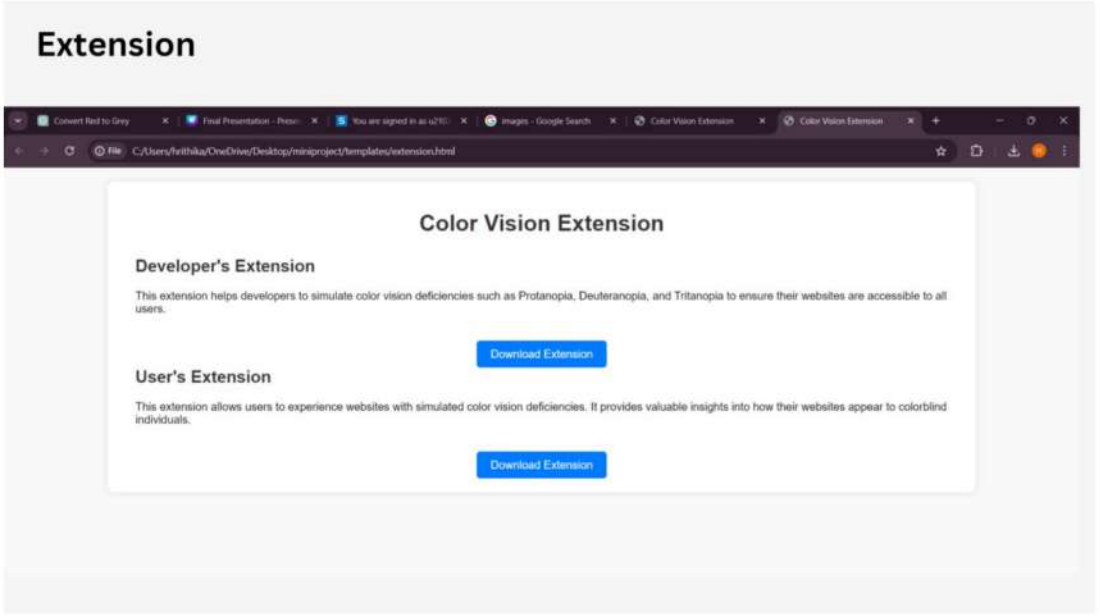

Figure 5.24: extension

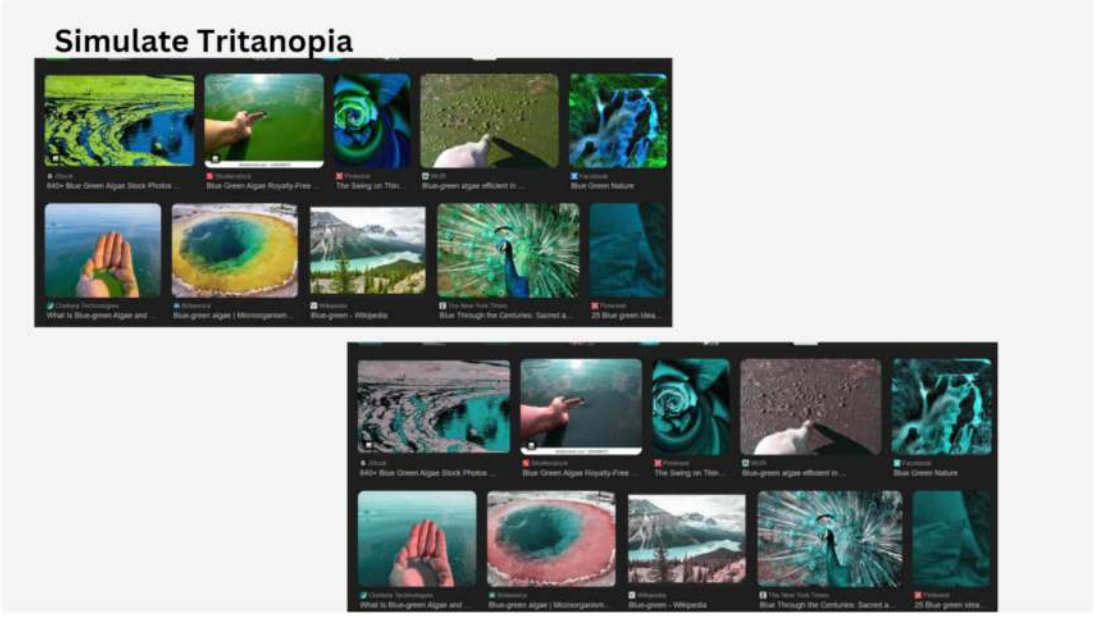

Figure 5.25: tritanopia

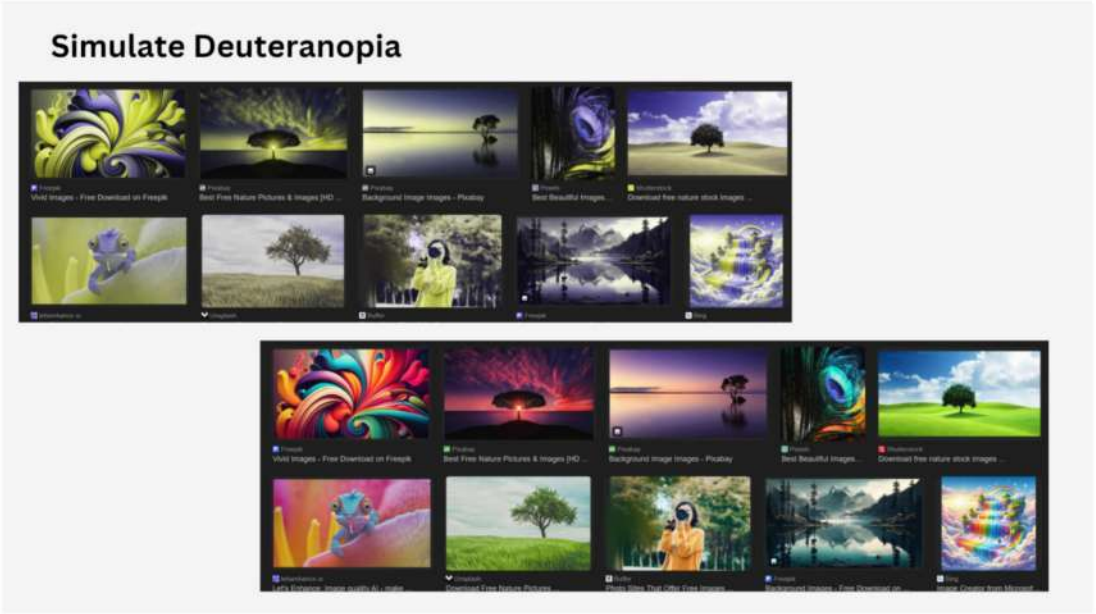

Figure 5.26: deutranopia

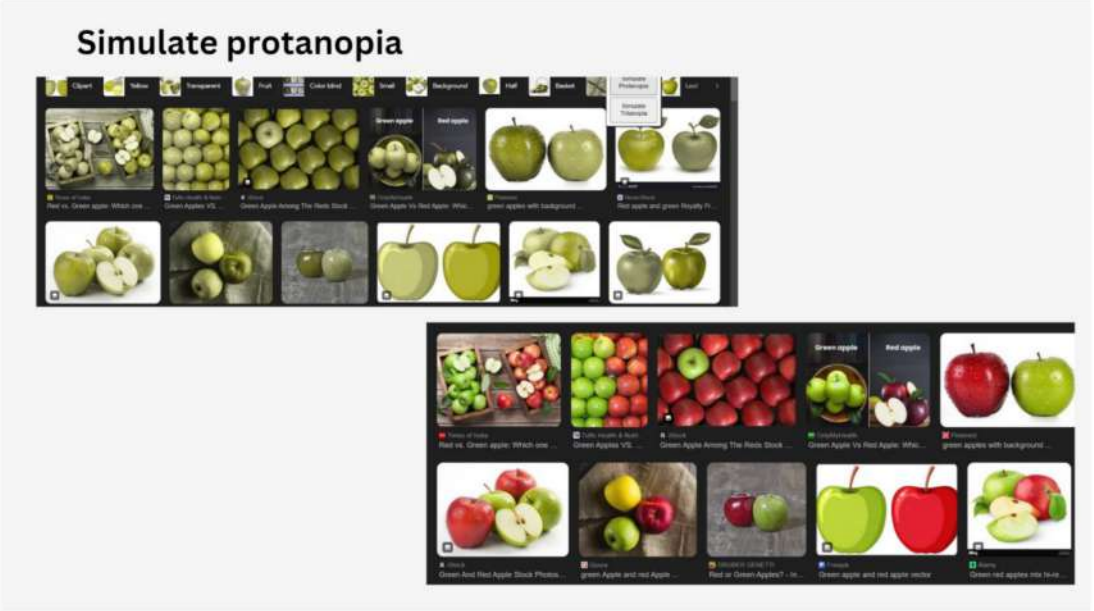

Figure 5.27: protanopia

Figure 5.28: future enhancement

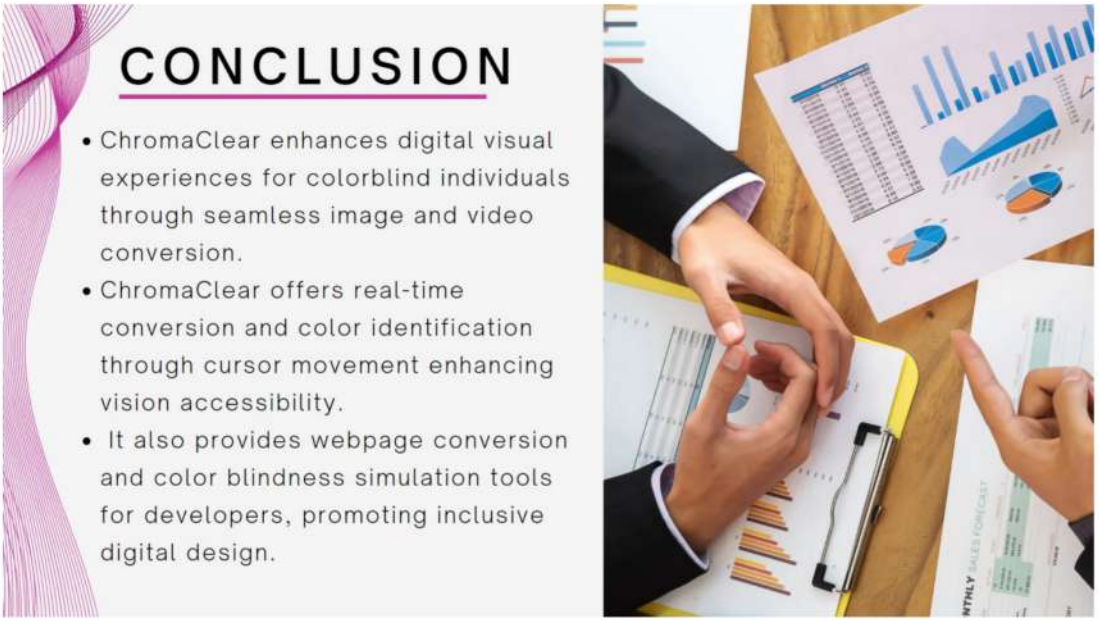

Figure 5.29: conclusion

Figure 5.30: references

Appendix B: Vision, Mission, Programme Outcomes and Course Outcomes

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

RAJAGIRI SCHOOL OF ENGINEERING & TECHNOLOGY (AUTONOMOUS)

RAJAGIRI VALLEY, KAKKANAD, KOCHI, 682039

(Affiliated to APJ Abdul Kalam Technological University)

Vision, Mission, Programme Outcomes and Course Outcomes

Institute Vision

To evolve into a premier technological institution, moulding eminent professionals with creative minds, innovative ideas and sound practical skill, and to shape a future where technology works for the enrichment of mankind.

Institute Mission

To impart state-of-the-art knowledge to individuals in various technological disciplines and to inculcate in them a high degree of social consciousness and human values, thereby enabling them to face the challenges of life with courage and conviction.

Department Vision

To become a centre of excellence in Computer Science and Engineering, moulding professionals catering to the research and professional needs of national and international organizations.

Department Mission

To inspire and nurture students, with up-to-date knowledge in Computer Science and Engineering, ethics, team spirit, leadership abilities, innovation and creativity to come out with solutions meeting societal needs.

Programme Outcomes (PO)

Engineering Graduates will be able to:

1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and Team work: Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.

10. Communication: Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective reports documentation. Make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

Programme Specific Outcomes (PSO)

A graduate of the Computer Science and Engineering Program will demonstrate:

PSO1: Computer Science Specific Skills

The ability to identify, analyze and design solutions for complex engineering problems in multidisciplinary areas by understanding the core principles and concepts of computer science and thereby engage in national grand challenges.

PSO2: Programming and Software Development Skills

The ability to acquire programming efficiency by designing algorithms and applying standard practices in software project development to deliver quality software products meeting the demands of the industry.

PSO3: Professional Skills

The ability to apply the fundamentals of computer science in competitive research and to develop innovative products to meet the societal needs thereby evolving as an eminent researcher and entrepreneur.

Course Outcomes

After the completion of the course the student will be able to:

CO1:

Identify technically and economically feasible problems (Cognitive Knowledge Level: Apply)

CO2:
Identify and survey the relevant literature for getting exposed to related solutions and get familiarized with software development processes (Cognitive Knowledge Level: Apply)

CO3:
Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions of minimal complexity by using modern tools & advanced programming techniques (Cognitive Knowledge Level: Apply)

CO4:
Prepare technical report and deliver presentation (Cognitive Knowledge Level: Apply)

CO5:
Apply engineering and management principles to achieve the goal of the project (Cognitive Knowledge Level: Apply)

Appendix C: CO-PO-PSO Mapping

COURSE OUTCOMES:

After completion of the course the student will be able to

SL. NO	DESCRIPTION	Blooms' Taxonomy Level
CO1	Identify technically and economically feasible problems (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO2	Identify and survey the relevant literature for getting exposed to related solutions and get familiarized with software development processes (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO3	Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions of minimal complexity by using modern tools & advanced programming techniques (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO4	Prepare technical report and deliver presentation (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO5	Apply engineering and management principles to achieve the goal of the project (Cognitive Knowledge Level: Apply)	Level 3: Apply

CO-PO AND CO-PSO MAPPING

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO3
CO1	3	3	3	3		2	2	3	2	2	2	3	2	2	2
CO2	3	3	3	3	3	2		3	2	3	2	3	2	2	2
CO3	3	3	3	3	3	2	2	3	2	2	2	3			2
CO4	2	3	2	2	2			3	3	3	2	3	2	2	2
CO5	3	3	3	2	2	2	2	3	2		2	3	2	2	2

3/2/1: high/medium/low

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/ MEDIUM/ HIGH	JUSTIFICATION
101003/CS622T.1-PO1	**HIGH**	Identify technically and economically feasible problems by applying the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
101003/CS622T.1-PO2	**HIGH**	Identify technically and economically feasible problems by analysing complex engineering problems reaching substantiated conclusions using first principles of mathematics.
101003/CS622T.1-PO3	**HIGH**	Design solutions for complex engineering problems by identifying technically and economically feasible problems.
101003/CS622T.1-PO4	**HIGH**	Identify technically and economically feasible problems by analysis and interpretation of data.
101003/CS622T.1-PO6	**MEDIUM**	Responsibilities relevant to the professional engineering practice by identifying the problem.
101003/CS622T.1-PO7	**MEDIUM**	Identify technically and economically feasible problems by understanding the impact of the professional engineering solutions.
101003/CS622T.1-PO8	**HIGH**	Apply ethical principles and commit to professional ethics to identify technically and economically feasible problems.
101003/CS622T.1-PO9	**MEDIUM**	Identify technically and economically feasible problems by working as a team.
101003/CS622T.1-PO10	**MEDIUM**	Communicate effectively with the engineering community by identifying technically and economically feasible problems.
101003/CS622T.1-P011	**MEDIUM**	Demonstrate knowledge and understanding of engineering and management principles by selecting the technically and economically feasible problems.
101003/CS622T.1-PO12	**HIGH**	Identify technically and economically feasible problems for long term learning.
101003/CS622T.1-PSO1	**MEDIUM**	Ability to identify, analyze and design solutions to identify technically and economically feasible problems.
101003/CS622T.1-PSO2	**MEDIUM**	By designing algorithms and applying standard practices in software project development and Identifying technically and economically feasible problems.
101003/CS622T.1-PSO3	**MEDIUM**	Fundamentals of computer science in competitive research can be applied to Identify technically and economically feasible problems.
101003/CS622T.2-PO1	**HIGH**	Identify and survey the relevant by applying the knowledge of mathematics, science, engineering fundamentals.

101003/CS622T.2-PO2	**HIGH**	Identify, formulate, review research literature, and analyze complex engineering problems get familiarized with software development processes.
101003/CS622T.2-PO3	**HIGH**	Design solutions for complex engineering problems and design based on the relevant literature.
101003/CS622T.2-PO4	**HIGH**	Use research-based knowledge including design of experiments based on relevant literature.
101003/CS622T.2-PO5	**HIGH**	Identify and survey the relevant literature for getting exposed to related solutions and get familiarized with software development processes by using modern tools.
101003/CS622T.2-PO6	**MEDIUM**	Create, select, and apply appropriate techniques, resources, by identifying and surveying the relevant literature.
101003/CS622T.2-PO8	**HIGH**	Apply ethical principles and commit to professional ethics based on the relevant literature.
101003/CS622T.2-PO9	**MEDIUM**	Identify and survey the relevant literature as a team.
101003/CS622T.2-PO10	**HIGH**	Identify and survey the relevant literature for a good communication to the engineering fraternity.
101003/CS622T.2-PO11	**MEDIUM**	Identify and survey the relevant literature to demonstrate knowledge and understanding of engineering and management principles.
101003/CS622T.2-PO12	**HIGH**	Identify and survey the relevant literature for independent and lifelong learning.
101003/CS622T.2-PSO1	**MEDIUM**	Design solutions for complex engineering problems by Identifying and survey the relevant literature.
101003/CS622T.2-PSO2	**MEDIUM**	Identify and survey the relevant literature for acquiring programming efficiency by designing algorithms and applying standard practices.
101003/CS622T.2-PSO3	**MEDIUM**	Identify and survey the relevant literature to apply the fundamentals of computer science in competitive research.
101003/CS622T.3-PO1	**HIGH**	Perform requirement analysis, identify design methodologies by using modern tools & advanced programming techniques and by applying the knowledge of mathematics, science, engineering fundamentals.
101003/CS622T.3-PO2	**HIGH**	Identify, formulate, review research literature for requirement analysis, identify design methodologies and develop adaptable & reusable solutions.

101003/CS622T.3-PO3	**HIGH**	Design solutions for complex engineering problems and perform requirement analysis, identify design methodologies.
101003/CS622T.3-PO4	**HIGH**	Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
101003/CS622T.3-PO5	**HIGH**	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools.
101003/CS622T.3-PO6	**MEDIUM**	Perform requirement analysis, identify design methodologies and assess societal, health, safety, legal, and cultural issues.
101003/CS622T.3-PO7	**MEDIUM**	Understand the impact of the professional engineering solutions in societal and environmental contexts and Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions.
101003/CS622T.3-PO8	**HIGH**	Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions by applying ethical principles and commit to professional ethics.
101003/CS622T.3-PO9	**MEDIUM**	Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.
101003/CS622T.3-PO10	**MEDIUM**	Communicate effectively with the engineering community and with society at large to perform requirement analysis, identify design methodologies.
101003/CS622T.3-PO11	**MEDIUM**	Demonstrate knowledge and understanding of engineering requirement analysis by identifying design methodologies.
101003/CS622T.3-PO12	**HIGH**	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change by analysis, identify design methodologies and develop adaptable & reusable solutions.
101003/CS622T.3-PSO3	**MEDIUM**	The ability to apply the fundamentals of computer science in competitive research and prior to that perform requirement analysis, identify design methodologies.
101003/CS622T.4-PO1	**MEDIUM**	Prepare technical report and deliver presentation by applying the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
101003/CS622T.4-PO2	**HIGH**	Identify, formulate, review research literature, and analyze complex engineering problems by preparing technical report and deliver presentation.

101003/CS622T.4-PO3	**MEDIUM**	Prepare Design solutions for complex engineering problems and create technical report and deliver presentation.
101003/CS622T.4-PO4	**MEDIUM**	Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions and prepare technical report and deliver presentation.
101003/CS622T.4-PO5	**MEDIUM**	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools and Prepare technical report and deliver presentation.
101003/CS622T.4-PO8	**HIGH**	Prepare technical report and deliver presentation by applying ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
101003/CS622T.4-PO9	**HIGH**	Prepare technical report and deliver presentation effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.
101003/CS622T.4-PO10	**HIGH**	Communicate effectively with the engineering community and with society at large by prepare technical report and deliver presentation.
101003/CS622T.4-PO11	**MEDIUM**	Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work by prepare technical report and deliver presentation.
101003/CS622T.4-PO12	**HIGH**	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change by prepare technical report and deliver presentation.
101003/CS622T.4-PSO1	**MEDIUM**	Prepare a technical report and deliver presentation to identify, analyze and design solutions for complex engineering problems in multidisciplinary areas.
101003/CS622T.4-PSO2	**MEDIUM**	To acquire programming efficiency by designing algorithms and applying standard practices in software project development and to prepare technical report and deliver presentation.
101003/CS622T.4-PSO3	**MEDIUM**	To apply the fundamentals of computer science in competitive research and to develop innovative products to meet the societal needs by preparing technical report and deliver presentation.
101003/CS622T.5-PO1	**HIGH**	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
101003/CS622T.5-PO2	**HIGH**	Identify, formulate, review research literature, and analyze complex engineering problems by applying engineering and management principles to achieve the goal of the project.

101003/CS622T.5-PO3	**HIGH**	Apply engineering and management principles to achieve the goal of the project and to design solutions for complex engineering problems and design system components or processes that meet the specified needs.
101003/CS622T.5-PO4	**MEDIUM**	Apply engineering and management principles to achieve the goal of the project and use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
101003/CS622T.5-PO5	**MEDIUM**	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools and to apply engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PO6	**MEDIUM**	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities by applying engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PO7	**MEDIUM**	Understand the impact of the professional engineering solutions in societal and environmental contexts, and apply engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PO8	**HIGH**	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice and to use the engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PO9	**MEDIUM**	Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings and to apply engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PO11	**MEDIUM**	Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments and to apply engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PO12	**HIGH**	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change and to apply engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PSO1	**MEDIUM**	The ability to identify, analyze and design solutions for complex engineering problems in multidisciplinary areas. Apply engineering and management principles to achieve the goal of the project.

101003/CS622T.5-PSO2	**MEDIUM**	The ability to acquire programming efficiency by designing algorithms and applying standard practices in software project development to deliver quality software products meeting the demands of the industry and to apply engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PSO3	**MEDIUM**	The ability to apply the fundamentals of computer science in competitive research and to develop innovative products to meet the societal needs thereby evolving as an eminent researcher and entrepreneur and apply engineering and management principles to achieve the goal of the project.