Bilkent University
Department of Computer Engineering

Senior Design Project

T2313: The Aura Palette

Analysis and Requirement Report

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1. Introduction

Colors are everywhere we see and they subconsciously have an enormous place in people's lives. They change our moods by affecting our emotions. Thus, we can associate colors with feelings. The color theory explains that humans associate colors with emotions, such as sadness, anger, or joy. Therefore, color psychology and color harmony are crucial concepts in the design and marketing industry, and choosing the color palette for a design is a critical step in the design process.

The Aura Palette is an application to help people choose the colors for the medium they will be using. This context will be determined by the word or sentence the user writes to the system. Then, the application will recognize the mood and context in the sentence and give a color palette consisting of the most appropriate colors. The system will do this with the help of machine learning and many sample datasets. The more datasets are used, the system will give more accurate results.

The project we will be working on will focus on the issue of choosing a color palette by using the technology of machine learning. With this project, we aim to assist designers and any creative person in determining a palette for their creations by providing them with a tool. With this tool, the goal is to return a color palette recommendation to the requester depending on the keyword provided by them.

This project aims to help creative people determine which colors they use for a design by providing them with a tool powered by machine learning technology and color theory algorithms. By using machine learning, the tool will be able to generate intelligent and corresponding results to the input of the user and color theory algorithms will ensure the harmony between colors in the palette.

This report will go through the software and requirement analysis topics. It has the system requirements, models, and other analysis elements such as risks, alternatives, the project plan, responsibilities, and strategies. The report also includes diagrams as figures to represent the system better.

2. Proposed System

2.1 Overview

The Aura Palette is a tool assisting creators in choosing a color palette for their designs. There will be various features that will benefit regular users and designers. Users will be able to provide an emotion, a “mood” as input to generate a palette. Also, users will be able to type keywords and determine the context of the medium of the palette. These inputs will be processed by our machine learning algorithms and datasets that follow color theory and color theory algorithms which will be derived from our research.

After a palette is generated, users will have the ability and flexibility of adjusting the palette by changing the specific color values to create the palette for their specific needs. Users’ modifications on the palette include choosing RGB or CMYK for a digital or print medium, adjusting hue-saturation-brightness values, giving predefined colors, or excluding a color. The palette can be changed as emotions or contexts correspond to more than one palette.

The front-end side of the project will have a simple design but will be able to provide all functionalities of the tool for use. Descriptions of these features will take place and guide the users to create a user-friendly experience for every visit. Palette-adjusting features will be provided via a simple interface to increase the usability of these features.

The back-end side of the project will include more complex technologies and algorithms and our decisions about its design will affect its structure. First of all, we will provide a mechanism with machine learning and a large, detailed and accurate dataset to process the inputs of the users. This mechanism will work with color theory and color theory algorithms to ensure that generated colors are in harmony and aesthetically compatible with each other. These algorithms will also work for further adjustments of the user and protect this harmony.

This project will introduce a new way to alter the process of color palette generation to be different from the ones already in the market. We will use the studies on color theory and machine learning to make it much faster, more accurate, and more valuable with flexible ways to adjust the palette, which no other competitor currently has.

This chapter goes through the requirements for the system. Functional requirements will determine the functions discussed in this overview, and nonfunctional and pseudo requirements will have the parts needed to make the application work as it should.

2.2 Functional Requirements

This part consists of the system and user functionalities: The system functionalities determine what the system should do, and the user functionalities are what the user should do with the system.

2.2.1 System Functionalities

- The system must provide users with different predetermined emotions to create a related color pattern.
- The system should enable users to enter a word or sentence for palette generation.
- The system will analyze the sentence, and the algorithm will generate five colors according to the context of the words.
- The system should introduce color palettes and their values, such as HEX or RGB codes, according to a given sentence or emotion.
- The system should provide a “properties screen” for each palette to manually change the specific color properties, like hue, saturation, and lightness, to the user, giving developers and designers more flexibility.

2.2.2 User Functionalities

- Users will access the system through a website available to the public.
- Users can create a color palette based on a given keyword.
- Users can select the medium (prints, webpages, posters etc.) and the harmony rule (analogous, complementary, triad etc.) that the system will use to generate a palette. They can change these parameters later on.
- Users can include a color to the palette or exclude one from it.
- Users can pin the color palettes they like so that they will not disappear once they generate another one.
- Users can modify the hue, brightness and saturation of the generated colors.
- Users can lock colors individually so that they will remain the same even when the other colors are changed.
- Users can save the color palettes of their choice, then delete them later.
- Users can export their palettes as png files to use them in their projects.
- Users can view the history of their keyword searches.

2.3 Nonfunctional Requirements

These nonfunctional requirements are shaped under the essential topics for our project: usability, reliability, efficiency, and extensibility.

2.3.1 Usability

- The system must provide a simple and understandable design that prevents users from being confused and losing time while navigating.
- The system must guide the users via an efficient tutorial mechanism to what they should and can do with it since its aim is to make the users find their way in it intuitively.

2.3.2 Reliability

- The algorithms behind the color palette generation should work consistently. Generated palettes must be correlated to what users ask.
- The palettes generated by the system must fit the color theory studies we will use in our research and implementations.

2.3.3 Efficiency

- The system must process the user inputs through our mechanism to understand the input and color theory algorithms in no more than 10 seconds since one of the primary purposes of our project is to decrease the time spent on creating color palettes.
- Optimization of the application is critical. Currently, with most AI-generated image creation applications, the creation process takes longer than our planned time.

2.3.4 Extensibility

- The system should be extended to give more palettes with more words and sentences. The project should work with emotional words and sentences with more keywords from general topics after some while.
- In addition to creating palettes from scratch, the system should also be extended to give more colors according to the user's colors.
- In the future, users may be able to create a palette for their type or medium of work, such as magazines, posters, or websites. This way, we can best adjust color settings for their kind of work.
- In the future, login and sign-up mechanisms can be implemented for users to store their previously generated color palettes.

2.4 Pseudo Requirements

This part includes pseudo requirements set by the conditions to operate the system.

- The result of this project will be a web-based application available for the modern and most used browsers.
- The project codes will be versioned and tracked by Git through GitHub.
- To train the models, a GPU (min GTX1080) will be required.
- PyTorch will be used for deployment of the trained model.
- PAT (palette-and-text) dataset [1], created by Hyojin Bahng and team, will be inspected, tested and utilized to obtain the required color palette results.
- Algorithms mentioned in the research paper [1] will be tested to obtain accurate results.
- Development of the system must be completed before CS Fair 2023.

2.5 System Models

2.5.1 Scenarios

Scenario 1: Sign Up

Actor: User

Entry Conditions: The user opens the website.

Exit Conditions: The user clicks the “Back” button or “Sign Up” button.

The flow of events:

1. The user clicks the “Sign Up” button on the right side of the top bar.
2. The user enters their valid email address, name and password.
3. The user clicks on the “Sign Up” button.
4. User gets created in our database, along with a repository for that user.

Scenario 2: Log In

Actor: User

Entry Conditions: The user opens the website.

Exit Conditions: The user successfully logs in or closes the website.

The flow of events:

1. The user clicks the “LogIn” button on the right side of the top bar.
2. The user enters their email address and password.
3. The user clicks on the “LogIn” button to complete the log-in.

Scenario 3: Create Palette

Actor: User

Entry Conditions: The user enters a keyword (no log-in required).

Exit Conditions: The user closes the website or generates a new palette.

The flow of events:

1. The user enters a keyword in the search bar.
2. The user chooses the medium and the harmony, which are optional.
3. The user either presses the enter key or clicks on the search icon.
4. A color palette with five colors appears on the screen with input parameters.

Scenario 4: Modify Palette

Actor: User

Entry Conditions: The user creates a color palette (no log-in required).

Exit Conditions: The user closes the website.

The flow of events:

1. The user changes the specified keyword, medium, and/or harmony.
2. The user modifies one to five colors in the palette by changing their HEX, RGB, hue, saturation, or brightness values.
3. A new palette is generated with each modification.

Scenario 5: Export Palette

Actor: User

Entry Conditions: The user creates a color palette (no log-in required).

Exit Conditions: The user exports the palette.

The flow of events:

1. The user clicks on the “Export” button.
2. A PNG file that has the palette is downloaded.

Scenario 6: Save Palette

Actor: Logged-in user

Entry Conditions: The user creates a color palette (log-in required).

Exit Conditions: The user saves the palette.

The flow of events:

1. The user clicks on the “Save” button.
2. The palette is saved in the system for that user.

Scenario 7: Delete Palette

Actor: Logged-in user

Entry Conditions: The user creates a color palette (log-in required).

Exit Conditions: The user deletes the palette.

The flow of events:

1. The user clicks on the “Profile” icon in the top bar.
2. The user’s profile page opens and shows the user’s saved palettes.
3. The user clicks on the “Delete” button next to the palette they want to delete.

Scenario 8: View History

Actor: Logged-in user

Entry Conditions: The user opens the website (log-in required).

Exit Conditions: The user closes the website or switches to the main menu.

The flow of events:

1. The user clicks on the “Profile” icon in the top bar.
2. The user’s profile page opens and shows the user’s history of palettes including the keyword and the time it was generated.

2.5.2 Use Case Model

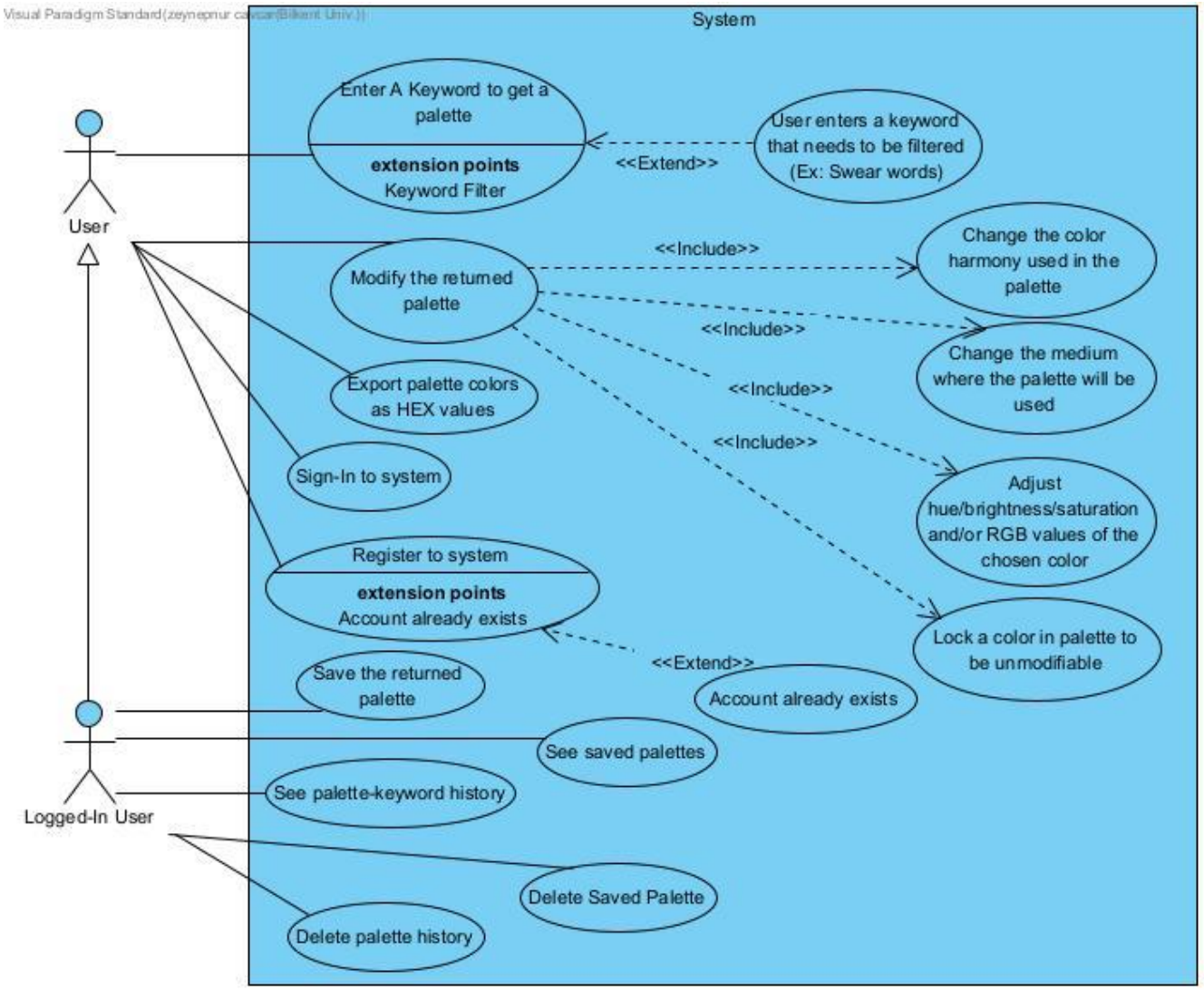


Figure 1. Use-Case Model

2.5.3 Object and Class Model

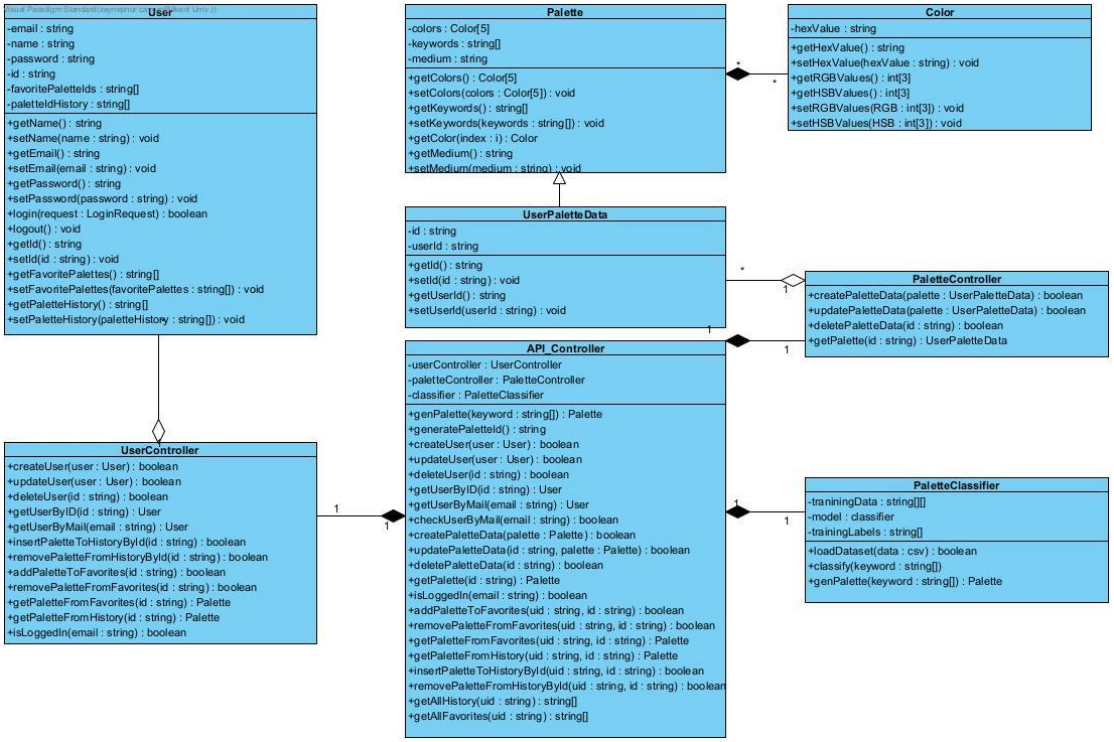


Figure 2. Class Diagram

- **User** class will keep the information of registered users and functions to provide the features specific to the registered users such as saving palettes on a private repository and choosing favorite ones among these palettes. This class will also help us to implement additional features for the users with or without an account in our platform.

- **UserController** class will be our controller class to perform operations on user data stored in the database. While adding additional features, we will modify and benefit from this class too.

- **API_Controller** class will be used to access controllers/views of the backend along with the classification class.

- **Palette** class will keep all the required information about the color palettes that are output by the trained model. It will contain 5 colors stored in the hex format. It furthermore will save the keywords used to obtain this color palette. Since we want to

create a design tool that will be used for different mediums, the model will also store that.

- **Color** class will be used to store information regarding properties of the Palette and specifically properties of the colors used in the Palette.

- **UserPaletteData** class will be used only in certain cases where the user is logged in. When the user is logged in all the palettes generated by their requests need to be saved to their history and they can also have favorite palettes that are saved in their account. These special palettes need to be saved to the database and they will be saved under the format of UserPaletteData.

- **PaletteClassifier** class will be responsible for keeping information about the training data and neural network model. It will also save the training labels used while training the neural network. This is the main part where we obtain the desired results.

- **PaletteController** class will be used to provide access between the database and palettes generated by users with accounts. This class will provide the ability to update and delete the palette data.

2.5.4 Dynamic Models

2.5.4.1 Sequence Models

2.5.4.1.1 Login Model

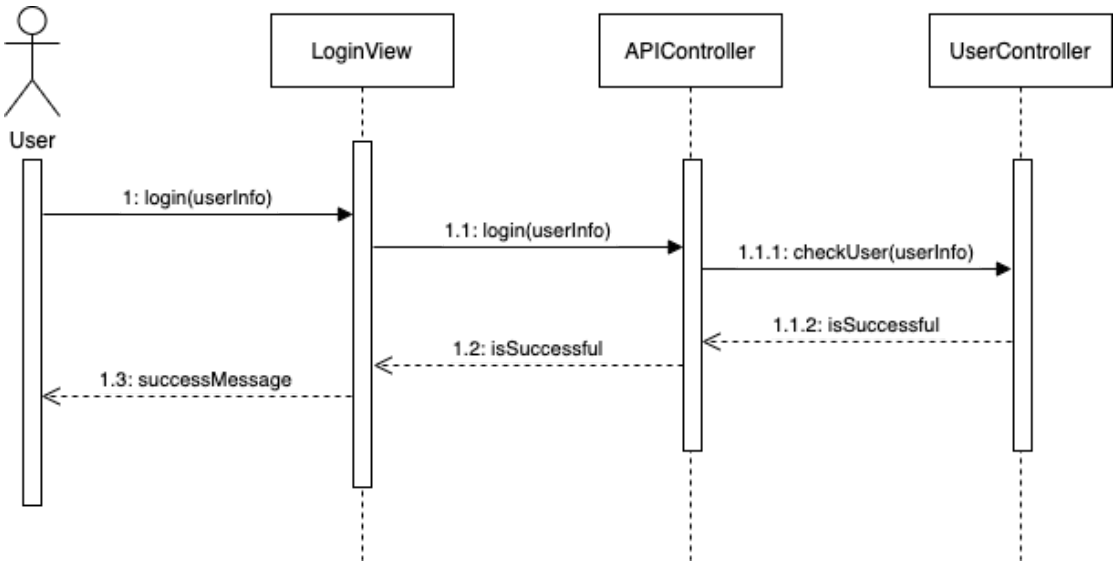


Figure 3. Login Diagram

This sequence model explains the way the user logins to the system. After submitting the login information to the web application, the Login View page makes an api call to the Api Controller that then redirects the information to User Controller. There, the information is checked with the database to determine if the user exists/information is valid. If yes, a success message is returned to the user.

2.5.4.1.2 Color Palette Generation by User and Saving to Profile

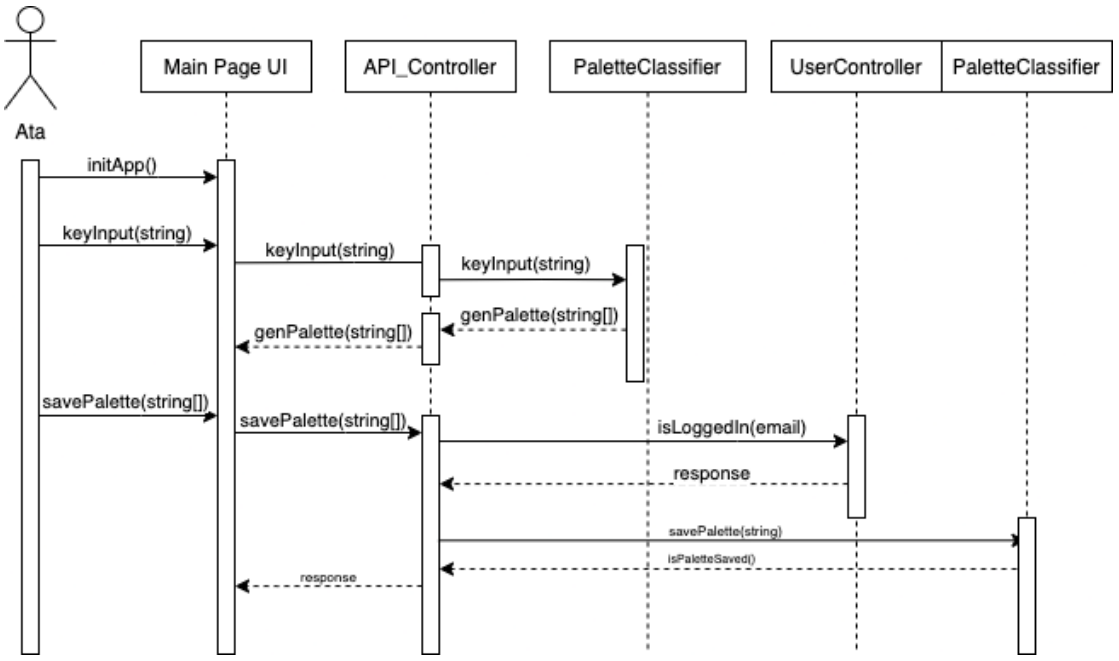


Figure 4. Palette Request and Favorite Function Diagram

This model explains how a logged in user enters the web application and generates a color palette. After getting the result, the user wants to save the color palette for future use. The web application first checks if the user is signed, and if signed, allows saving the color palette. In case the user is not logged in, the user is redirected to the login page mentioned in 2.5.4.1.1.

2.5.4.1.3 Color Palette Generation by User and Listing User History

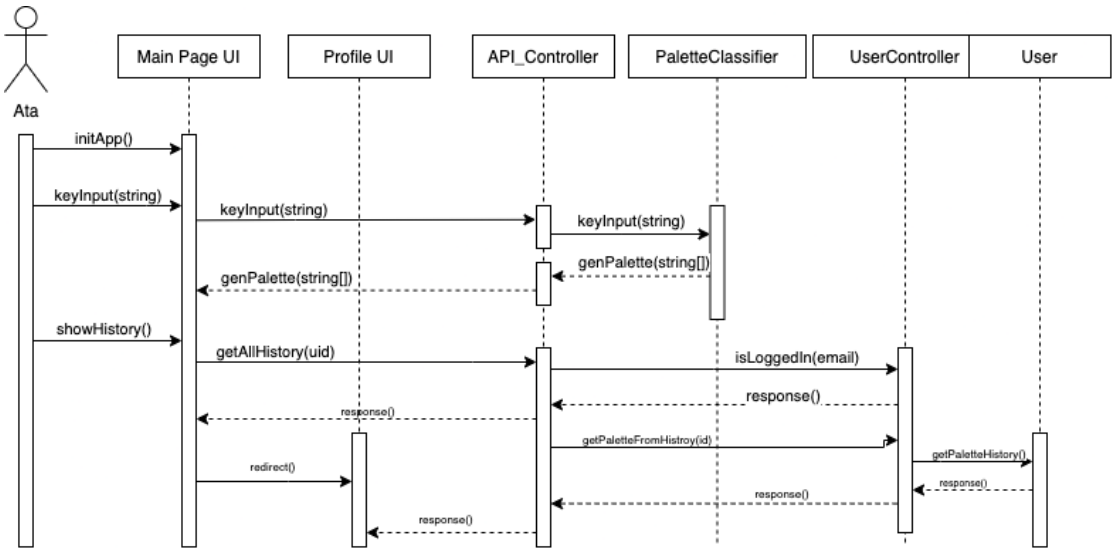


Figure 5. History Diagram

2.5.4.2 Activity Diagram

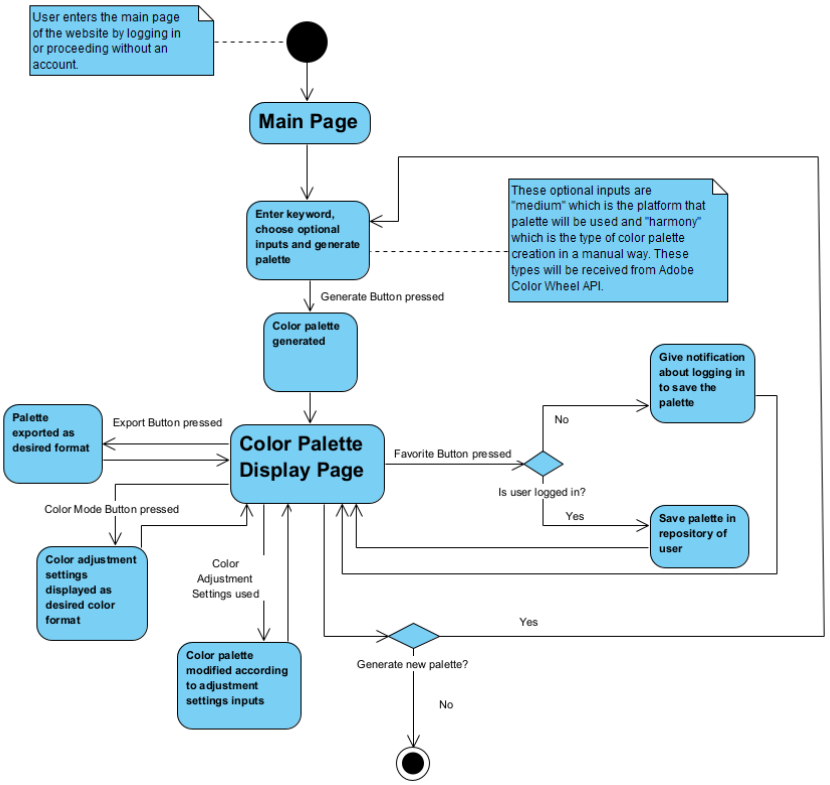
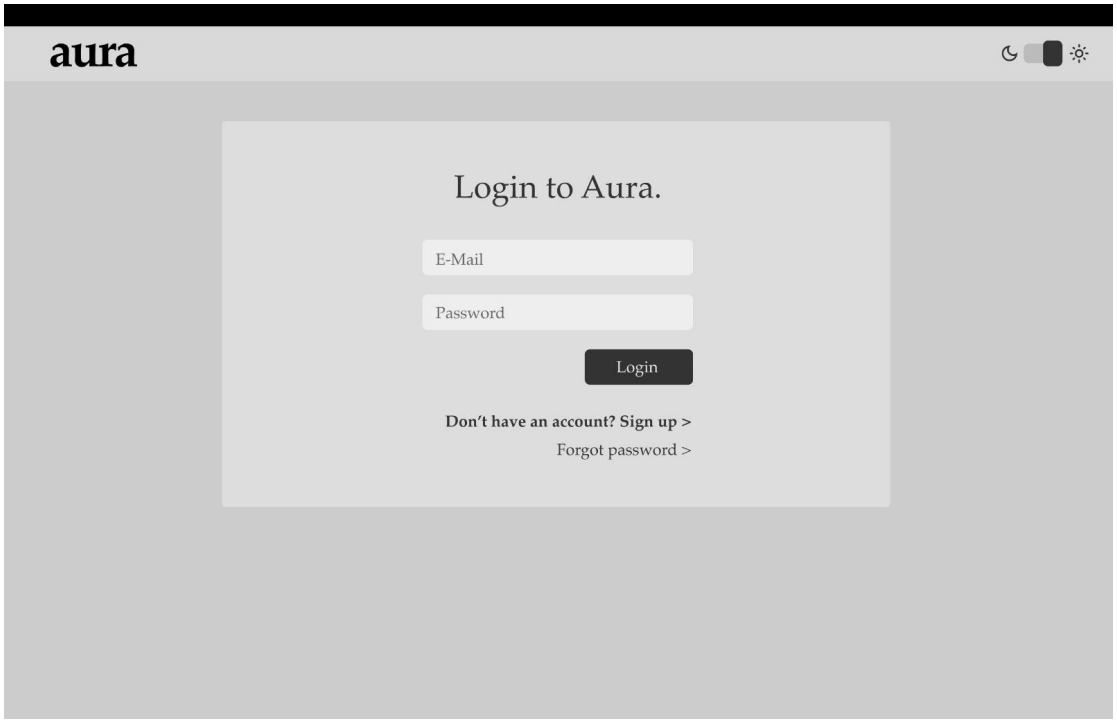


Figure 6. Activity Diagram

This activity diagram shows how our platform can be used. First of all, a user will access our website and open the application with or without an account. A user can proceed on the website without signing up too. Our main page will welcome the user with a text area for the keywords that will be used as input for color generation. Users also will be able to choose “harmony” and “medium” settings of the palette on this page too. When the Generate button is pressed and generation is complete, color palette will be displayed on the Color Palette Display Page. Other than the generated color palette, there will be various features displayed on this page. On this page, users can save the generated palette to their repository which will be available only for registered users. Unregistered users will be notified about signing up and making this feature available. Users can export the palette as their desired file format and download to their devices. By using Color Mode button, users can display color values as desired color format such as RGB or CMYK. To make specific adjustments to the colors, Color Adjustment Settings will be displayed on this page and palette will be modified according to these changes. Finally, a user can choose to create a new palette or exit the platform.

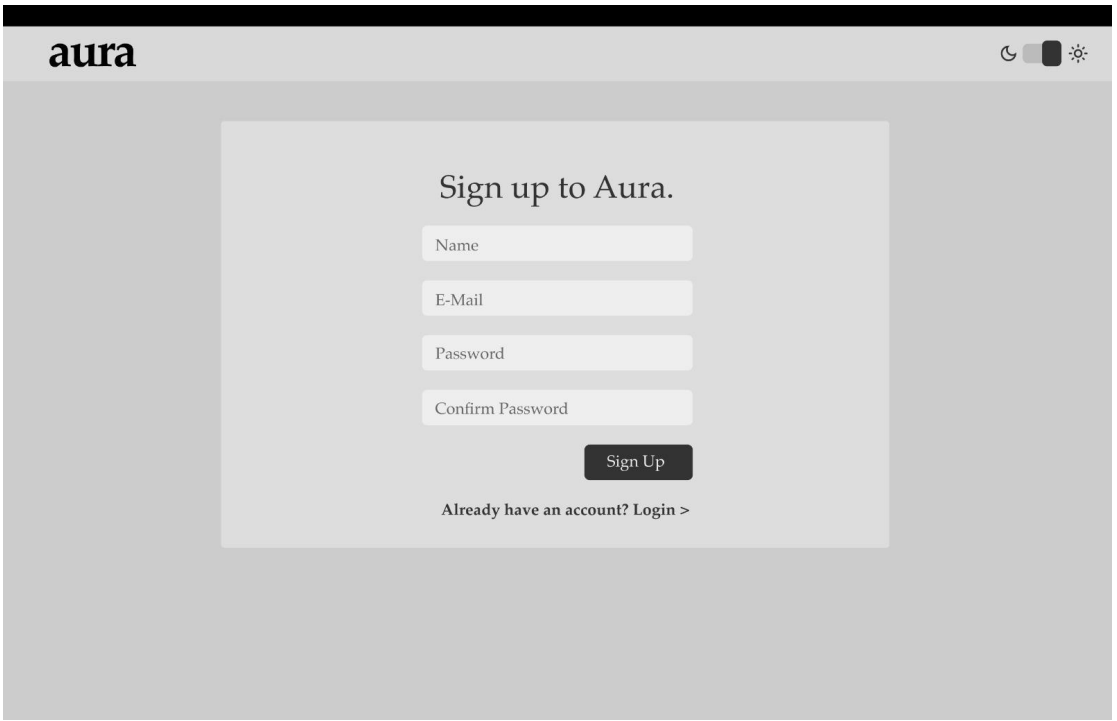
2.5.5 User Interface - Navigational Paths and Screen Mock-ups

2.5.5.1 Login Page



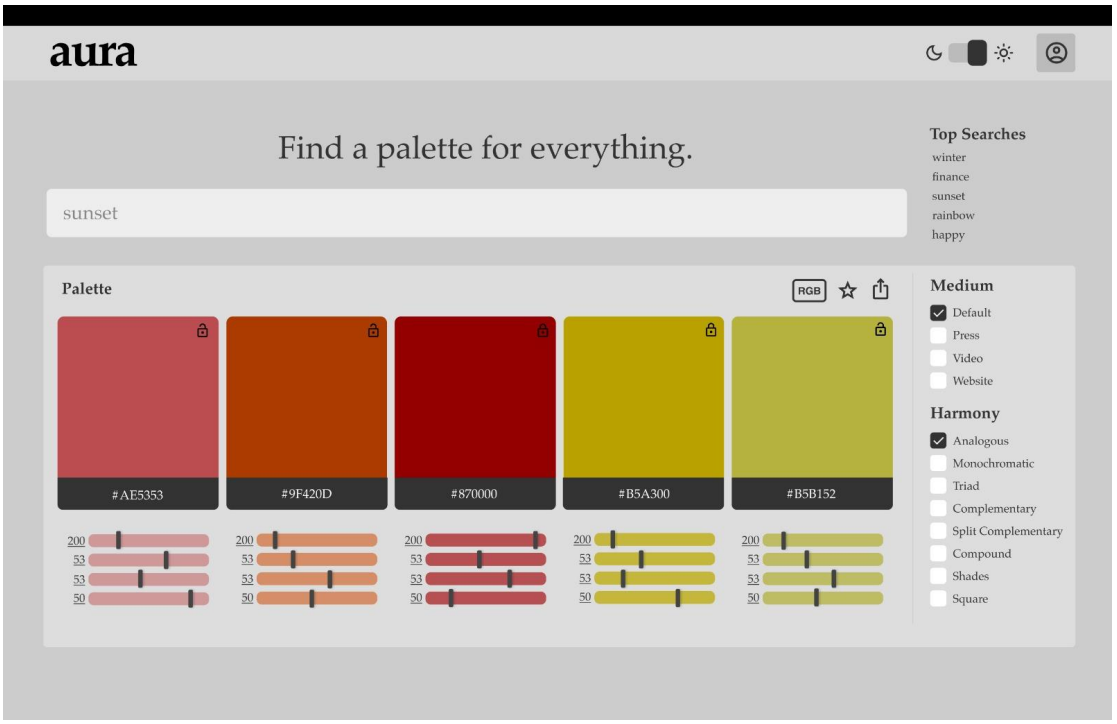
Users will be able to login to their accounts if they have or they can navigate to Sign Up page. A password recovery system will also be provided to registered users.

2.5.5.2 Sign Up Page



In this page, we will ask users their name, email address and password to register them to our system. These users will be able to save and favorite their generated palettes in their repository provided.

2.5.5.3 Color Palette Display Page

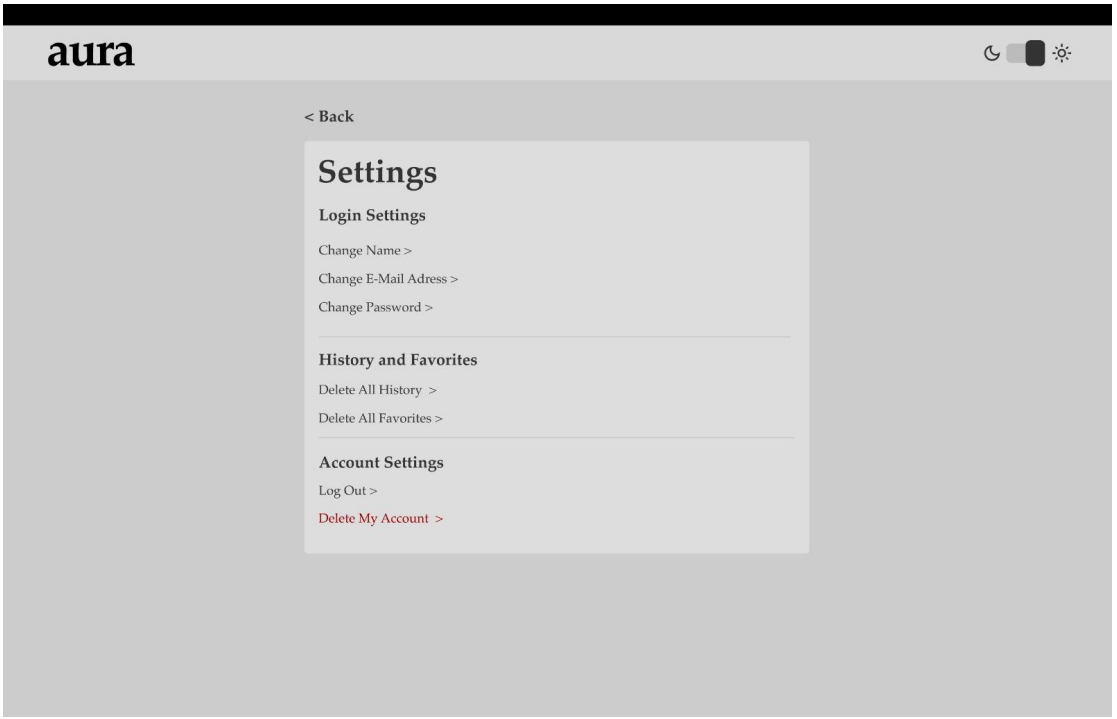


Generated palettes will be displayed on this page, along with palette adjustment settings. Users will be able to adjust the color values to make specific modifications. Also, users will be able to generate a new palette with new keywords and inputs.

2.5.5.4 User Repository Page

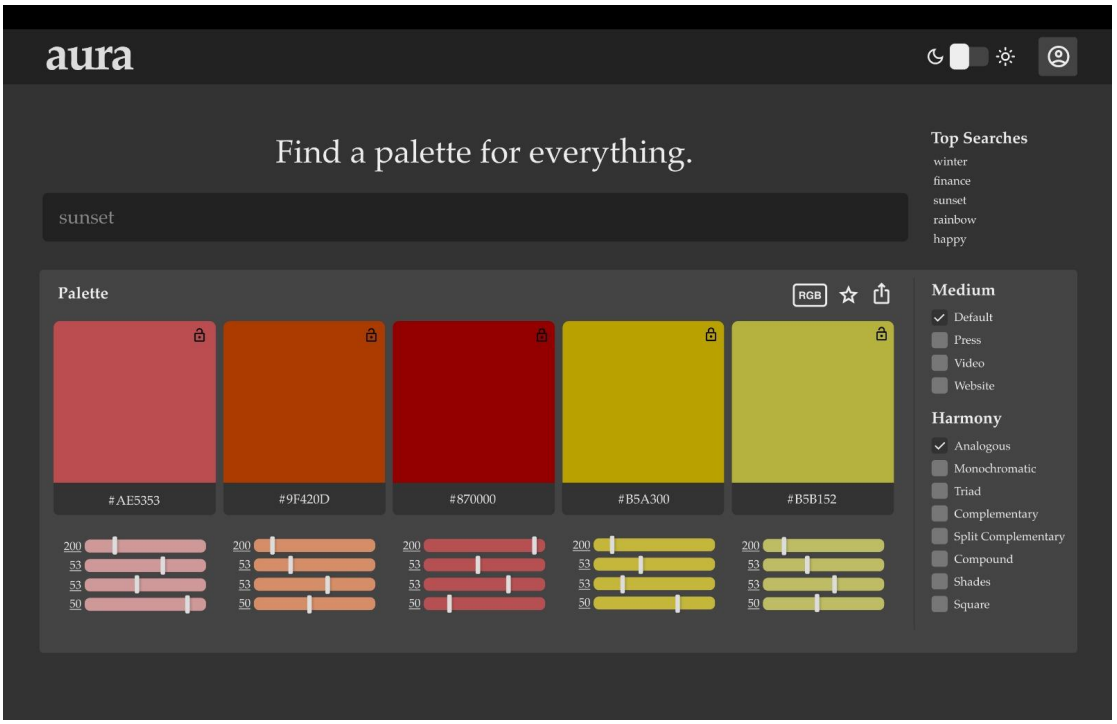
This page is only for registered users. These users will be able to display all generated palettes from their account so far. Also, their “favorite” palettes will be displayed separately for further use.

2.5.5.5 Account Settings Page



This page is only for registered users. These users will be able to change their account information such as name, email and password. Also, they will be able to delete their generated palette history or their favorite palettes.

2.5.5.6 Color Palette Display Page (Dark Mode)



We are planning to create a dark mode version of our website too. This is an example of a dark mode version of a mostly used page.

3. Other Analysis Elements

3.1 Consideration of Various Factors in Engineering Design

During the analysis stage of The Aura Palette project, along with certain technical issues and implementation plans, varying external factors that affect the design of the project were discussed. These factors can be seen in Table 1.

Table 1: Factors that can affect analysis and design.

	Effect level	Effect
Public health	0	None
Public safety	3	Privacy concerns account creation through email
Public welfare	0	None
Global factors	7	Deciding relation between color and keywords/moods, addressing designers' needs
Cultural factors	5	Deciding relation between color and keywords/moods and how culture affects this relation
Social factors	6	Ethical concerns regarding certain inputs like swear words
Environmental Factors	0	None
Economic Factors	2	Website will be free to use and developed using open-source tools

The given factors in the Table are discussed in detail in further sections.

3.1.1 Public Health

It was determined that the project will not be affected majorly by public health factors nor affect these factors due to differences in focus areas.

3.1.2 Public Safety

Safety must be an important aspect of every application that will be used by the public. Aura Palette is no exception. In the initial beginning stage, there are no personal information requirements like email or birthdate. However, the user will enter parameters such as where

the palette will be used but none of these inputs will be saved nor they affect the privacy of the user in a manner similar to names. While the project would not affect public safety directly due to the subject area, it will meet public safety standards by meeting up with user privacy expectations. In the next stage, if the user wants to create an account to be able to save the palettes, their emails would be required and, in that stage, protecting the privacy of user's becomes crucial.

3.1.3 Public Welfare

The Aura Palette will not be directly affected by public welfare.

3.1.4 Global Factors

The project will be available to everyone from anywhere with internet access so any designer from any country can use the Aura Palette for inspiration. In other words, the Aura Palette can be used to address designer's needs in every part of the world. Global factors will also affect the project in such a way that the colors and the words that relate to these colors will be determined by the appreciation levels of people [2].

3.1.5 Cultural Factors

The project being affected by cultural factors was an issue to be solved. Color in two different cultures can have different meanings. A study suggests that this cultural difference does not matter as the only case that is critical is whether the color is appreciated or not [2]. While the effect of culture is lower than expected, it is not completely ineffective.

3.1.6 Social Factors

Social factors will play a critical role in the project as they can lead to ethical issues. The user can try to enter keywords that can be derogatory to certain groups of people in such a way that it can promote racism, xenophobia, sexism, etc. To prevent the promotion of these kinds of issues, the application will have certain filtering.

3.1.7 Environmental Factors

The environmental factors will not affect the project nor will they be affected by the project.

3.1.8 Economic Factors

The Aura Palette will be open to everyone's use for free. During the development, free resources like Adobe API will be used to prevent economic constraints.

3.2 Risks and Alternatives

During analysis, several risks regarding both the development and end-product came up. For these risks, possible solutions were discussed to find alternative methods for development or improve the functionality of the project. In Table 2 risks and possible solutions to solve these risks can be seen.

The first critical risk that was found regarding the project was the possibility that the user would not like the output palette result. While the user may not like the palette due to personal preference, the other possible reason is the wrong classification by the machine learning algorithm. Due to these two different reasons, two kinds of solutions are developed. The first kind of solution for this risk is the option of customization. By adding the required functionality using Adobe Color API, the user can make adjustments to the color and palette by changing hue, saturation, brightness or change the harmony type. This ability can also be used even when the user likes the palette but has to meet certain conditions like a company's advertisement color requirements. The second and more critical solution involves the improvement of the classification algorithm. After a palette is returned to the user, the user can give feedback and determine whether the keywords provided matched with the palette. The feedback can be used in training the dataset in an incremental way.

Another critical risk that involves classification of colors and keywords is determining the accuracy. One possible reason for this could be that validation criteria was determined wrong due to errors in training and validation datasets. To solve this issue different kinds of datasets can be used. Another method to solve this is to first enter training data that is labeled for emotion and mood and in the next step assign these labels a color instead of direct color as a label.

Table 2: Risks

	Likelihood	Effect on the project	B Plan Summary
Risk 1: User does not like the recommended palette.	Depends on user preference and possible errors in classification	Wrong classification of colors OR user may no be satisfied with the application	Add customization option OR add a feedback mechanism
Risk 2: Incorrect validation	Depends on dataset	Low accuracy	Alternative datasets or labels

3.3 Project Plan

For the current semester, we, as a team, set up several project goals for ourselves. These all were recorded into our project manager tool. The goals are the following:

Project Goals:

- Create an easily usable solution for designers and people who love to create
- Deliver high-quality reports
- Write a viable algorithm for our ML model
- Find and utilize a viable dataset for our ML model
- Create a color palette network/algorithm that provides:
    - meaningful and accurate results
    - different results to different users
- To learn, analyze the technology, and improve ourselves

Provided below is the Gantt chart of our project plan. After several attempts, a good quality gantt chart couldn't be inserted here. For better visibility, you can access the following link.

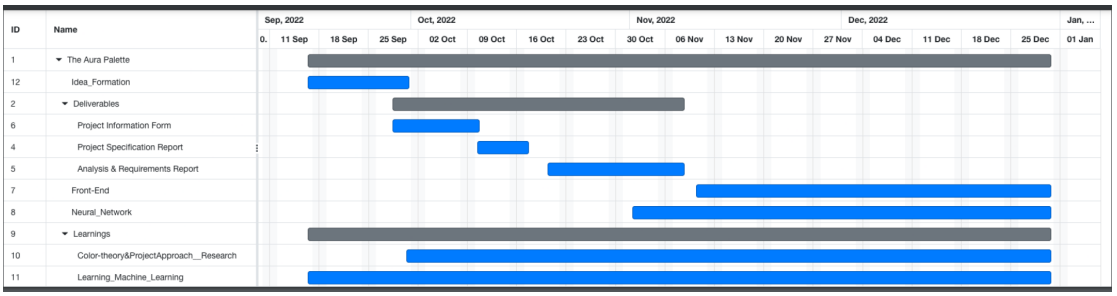


Figure 7. Gantt Chart

Furthermore, we have several deliverables this semester:

- Project Information Form
- Project Specification Report
- Analysis and Requirements Report

For all deliverables, all team members contribute an equal amount of effort. Plus, there are 2-3 reviewers responsible for reviewing the report for the last time before submitting it to instructors and supervisors.

Moreover, after finishing the deliverables, we have two main working packages, frontend and neural network sides, where we will divide into 2 teams and one team-lead. For the implementation of the frontend and UI/UX, members of the team: Ayda Yurtoğlu and Can Avşar are responsible. For the second part, creating the neural network model and training it with the appropriate datasets and algorithms, Zeynepnur Cavcar and Ata Seren are responsible. Suleyman Hanyyev will be working on both sides, mainly on the neural networks. The team also understands that some parts may not have the same work weight as the others, so we always try to balance the workload of each other.

We are using GitHub to track the progress of each task of each team member and have a logbook to keep a record of everything we have done for each week/deliverable.

3.4 Ensuring Proper Teamwork

Since the start of the project, we as a team decided to stop and use the following products mainly:

- Github
- Google Workspace
- Whatsapp
- Discord
- Logbook

- Github provides a place where we can all contribute our code to. For every WP we will have a separate branch. The method of fixing bugs will also be working on a different branch. Furthermore, with Github's new feature called Projects, we do not have a need for another project management tool. Choosing it eliminated less burden of keeping everything on track.

- Google Workspace serves as an archive and a place where we can all work on the deliverables. Since they allow coworking/co-writing at the same time, everyone can see each other's contributions and be motivated to deliver more.

- Whatsapp is mainly used for quick communications and reminders about specific deadlines or meetings

- Discord is a place where we have our own server and it serves as an archive. We also constantly have meetings there.

- Our logbook is a tool advised by our instructors and we are planning to use it constantly to update our contributions and keep notes of our meetings.

From the start of the project, we analyzed our skills and abilities to perform to our maximum. We also furthermore understood that the busy university schedule we are surrounded by will not give the members of the team the same availability. Thus, we constantly try to adjust and find a way that works for everyone. This allows everyone to be an equal and important part of the project.

3.5 Ethics and Professional Responsibilities

As a team, we are aware of our ethical and professional responsibilities while building our project. To start with, everyone will treat each other equally and show respect to each other. We will be open-minded and willing to listen to other opinions while sharing ours. We will discuss different points of view to come to a conclusion and comply with the team's decisions. To be on track, everyone is responsible for following our Discord channel and WhatsApp group, our most used communication platforms. Everyone will try their best to answer queries related to them from these channels as fast as possible. In addition, everyone is responsible for following and attending the meetings on time. It is okay for some of us to miss meetings if there is something urgent, but no one will exploit this and make up excuses not to attend a meeting. As professionals, we also will not spend more time on a task than needed to work on fewer tasks. Hence, we will also ensure that we are helping and supporting other people on the team when needed. Our team members are aware of these ethical and professional responsibilities and they are willing to fulfill them throughout the year.

3.6 Planning for New Knowledge and Learning Strategies

Our project will require us to constantly learn and develop our skills. To accomplish this, we came up with several learning strategies. The first one is asking for help from professionals. We have already had meetings with experts in machine learning, our supervisor's TA, and an associate who is giving lectures on this topic. We discussed our potential ways of implementing the project and will continue to have meetings with them for further upgrades. We are in contact with the design lead of our innovation expert's company. She is guiding us on how to build a product that can be usable by designers and what features would improve it. We also contacted three graphic design instructors at Bilkent University to discuss our ideas and we will keep in touch with them in the upcoming months.

Academic research is one of the main pillars of our learning strategies. Each one of us in the team needs to improve in color theory and machine learning. Thus, we are going through Bilkent library's database and searching on Google Scholar to find the resources that will guide us in these topics. We need an understanding of both of these subjects to come up with a feasible solution to our problem. So far, we have found many useful papers for us to decide on implementation [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11].

Lastly, we are utilizing internet sources to gather more information. For example, LinkedIn is a great place to acquire knowledge about new developments in machine learning. We have found several projects that were similar to ours such as projects that convert text to 3D models or create artwork with keywords. During implementation, we will be using Stack Overflow overwhelmingly, as it is an outstanding platform for programmers to find answers for their code. We will benefit from the documentation of the libraries that we will be using and the datasets we found on the internet as well.

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