Functional Specification

Orthodox

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1. Introduction

1.1 Overview

Due to the Covid-19 pandemic, many people had to find alternate means of exercise which didn't require leaving their homes or grounds. One such means of exercise was Mixed Martial Arts (MMA) training, such as shadowboxing and / or bag work. These exercises can be completed safely at home by an individual, or a group of people, and are a great source of cardio.

Our project aims to provide people with a means to practice MMA at home while ensuring they do not injure themselves in the process, through poor technique or form. As well as that, improving the technique and form of users will make them more advanced for when MMA gyms are allowed to reopen.

We will implement this idea by creating an app which will use pose estimation and computer vision to provide feedback on a user's striking technique, in regards to several different MMA strikes. Users will position themselves in front of their devices, in full view and orientated as directed by the app, and perform predefined exercises. The app will then return an analysis of the user's technique and recommendations.

A secondary goal of our project is to implement a simulation feature into the app. Using the camera of the device, the user will record themselves performing a predefined sequence of MMA techniques. The objective of this exercise is to provide a pseudo-simulation of an opponent, to practice and improve the users overall performance and technique. The results of this simulation will be displayed to the user once the exercise is completed.

Finally, there exists technologies which analyse the technique of fighter's strikes, however, these methods use expensive cameras and sensors, and therefore this technology is not readily available to the average person. We hope to enable people to make use of this technology in a more casual and inexpensive way.

1.2 Business Context

The target demographics for our project is beginners who wish to learn the basic skills in MMA and individuals who wish to improve on their existing MMA skills. The end goal is to create partnerships with fighting organizations that would greatly benefit from using our application. Organisations such as UFC and Belator could influence couches to use our product, especially during these times where trainers and fighters are unable to see each other.

However, putting the application on the market, inexpensively, for every individual, beginner or expert to utilise and enjoy is our main focus. Our aim is to create a universal and user friendly, easily accessible application, while also performing at a high level for those who are experienced in the sport. We believe that this application could thrive in the growing market of home workout applications.

1.3 Glossary

UFC - Ultimate Fighting Championship

MMA - Mixed Martial Arts

CNN - Convoluted Neural Networks

Technique Training - The feature in our application which will use pose estimation and computer vision to produce a feedback report on the form of user from a video stream, in regards to an array of exercises.

Simulated Opponent - A feature in our application which, when given a video of a user performing a routine, will produce a visual overlay of a simulated opponent fighting against the user while the user is performing their routine.

2. General Description

2.1 Product / System Functions

The function of our project is to provide a means of improving a user's technique and form in regards to several MMA exercises. The application will provide feedback based on the users technique, which is obtained through the video camera on the device, suggesting changes in their form, to prevent injury and provide a better technique in general.

We will provide a login feature, requiring users to login or create an account in order to use the application. Upon registration, we will request the users to enter personal information, such as height and weight, so that our models can adjust to their sizes. The user can refuse to provide these details, and the models will be provided generic values instead.

We will also implement the option for the user to keep a record of their progress and workouts completed. This process will be aided by saving the feedback reports in our database, produced for users post exercise.

As well as that, we aim to provide a simulation feature that a user may compete against. Similarly to the workout, the user will be shown a simulated opponent post workout, conveying where the opponent succeeded in making contact with the user, during combat, or vice versa.

2.2 User Characteristics and Objectives

Our aim is to have a friendly user interface that is easy to read and accessible. We aim to implement our project by creating a user friendly progressive web application. The user is expected to have access to a camera device and either a mobile or computer, in order to access the web app. The end user is also expected to have some prior knowledge of MMA as a sport. Our application will not provide the user with the fundamentals of MMA or provide ‘how to’ videos, as we are not experts in the sport. We will provide constructive feedback on form and suggest movements to be made throughout the workout. If the simulation feature was selected then the application will provide feedback on how well the user performed against the simulation.

2.3 Operational Scenarios

Use Case	**User Creates an account.**
Goal in Context	The user wishes to create an account
Preconditions	The user must have access to the web app and have an email account.

Success End Condition	The user successfully creates an account.
Failed End Condition	The user does not create an account.
Primary, Secondary Actors	User, Internet access, Database
Trigger	Register Button
Description	**Action**
Steps	
1	The user selects register button
2	The user fills in credentials
3	The user selects submit button
4	The user is sent an identification email
5	The user is verified and credentials are saved in the database
Extensions	
2a	User fills credentials in incorrectly
2b	User opts out of filling in credentials
4a	The user did not receive email

Use Case	**User starts Technique Training Workout**
Goal in Context	User begins workout
Preconditions	Camera must be facing the user
Success End Condition	The user starts workout routine
Failed End Condition	User fails to start the workout
Primary, Secondary Actors	Camera device
Trigger	Start workout button
Description	**Action**
Steps	
1	User selects a technique.

2	User sets up camera in correct position
3	User presses the start work out button.
4	User starts workout

Use Case	**User request feedback**
Goal in Context	User receives feedback post workout
Preconditions	User completed a workout
Success End Condition	User receives feedback in relation to the workout they have completed
Failed End Condition	User does not receive feedback or wrong feedback
Primary, Secondary Actors	Database, Web Server
Trigger	User selects Request Feedback button
Description	**Action**
Steps	
1	User completes the workout.
2	User selects the evaluate routine button.
3	User receives feedback on the workout.
4	User exits routine evaluation.
Extensions	
3a	Receives a visual overlay of the simulated opponent along with feedback on technique.
3b	User receives feedback on technique

2.4 Constraints

The project covers many disciplines and aspects of software engineering, such as app development, database management and of course machine learning. As a result, many constraints will be placed upon the design team and the project as a whole.

In terms of the constraints on the design team, some of the technologies of the project are unfamiliar to us. Time will have to be set aside to learn progessive web app development as our current knowledge is limited. Therefore, this places a constraint on the speed at which the web app can be developed and the quality of the web application.

Hardware constraints is another issue for this project. We hope to implement the striking estimation feature in real time. However, if the computational time of the pose estimation models and the respective algorithms is too long, then we may not be able to execute them in real time, as anticipated. Therefore, it is important that this feature is optimised for speed. However, this feature will have to be executed on the device of the user. This is the case as executing the feature server-side will result in delays due packet transmission delay and speed will be too reliant on WiFi signals. As a result, the speed of the users' device is another constraint to be dealt with. It is important that the device is fast enough for the applications' computational needs.

Moreover, we anticipate that the simulation feature of the application will take too long to execute for it to be implemented in real-time. This feature will be handled server-side, and thus be constrained by WiFi speeds and the computational speed of the server itself.

Finally, as we will be storing user information and intend on recording users and individuals with expertise in MMA, we will have to comply with the GDPR laws. To do this, we must ensure that the data collected is obtained and processed in a lawful, fair and transparent manner, and stored securely using encrypted measures.

3. Functional Requirements

Technical Training

Description

The key functionality of this app is to evaluate the form of a user's strike, using computer vision and pose estimation, and return the results to the user in a readable understandable manner. In doing so, the user can avoid injury and be able to use such skills in MMA gyms when they reopen, post COVID-19.

Criticality

High. This is the most important feature of the application, as providing feedback on user striking technique, in regards to several different MMA strikes, is the main focus of our application.

Technical issue

This feature will be one of the most difficult features to implement. In order to predict the form of users for a given strike, we will implement computer vision and pose estimation. The pose estimation will be aided by use of Google's pose estimation model BlazePose. This is a lightweight convolutional neural network architecture for human pose estimation that is tailored for real-time use on mobile devices. We hope to use GO and tensorflow to integrate this model with a progressive web application.

Blazepose predicts the location of 33 human body keypoints, on a given frame. This information will be used to calculate the form of the user in comparison to that of desired form. Issues could arise from the speed of the calculations, which may prevent use from accomplishing this task in real time.

Dependencies

This feature is not dependent on other features, however it is a key feature which other features depend on.

Simulated Opponent

Description

This is the secondary goal of the project. This feature allows users to practice their skills against a simulated opponent. Using the camera of the mobile device, through the app, the user will record themselves performing a predefined sequence of MMA techniques. This sequence will be explained to the user prior to the exercise and / or will be communicated audibly to the user during the course of the exercise. The objective of this exercise is to provide a pseudo-simulation of an opponent, to practice and improve the users overall performance and technique.

Criticality

High. This is a very important feature of the application, as it is one of the main focuses of the application.

Technical issue

This will most definitely be a difficult feature to implement, especially since there are multiple components which have to work in tandem. Firstly, computer vision will be used to feed the video of the user into the pose estimation algorithm, BlazePose. The output of this algorithm will be fed into a seperate machine learning algorithm which will use the position of the user in the frames to determine if they have left themselves vulnerable to the simulated opponent. The result of this will be fed to a separate feature which will deal with displaying the results to the user.

Technical issues could occur at each of these stages.

Dependencies

This feature is again not dependent on other features, however other features depend on the output of this feature.

Returning Feedback Report to User

Description

Once the user has completed a simulation workout or a technique training exercise, a feedback report will be generated and returned to the user. This feedback report will contain information on the success of the user in the exercise. This will be a short concise report, containing user centric information. The generated report will be saved in our database, for the user to return to in the future for comparison.

Criticality

Medium. It is important that the user is given feedback and results of the analysis. Without this feedback, the user will not be able to adjust and improve their overall form or technique.

Technical issue

The feedback report is generated using information produced by the pose estimation feature and/or the resulting simulation. If there are issues with this data then the produced report will be incorrect.

Dependencies

This feature is dependent on the simulated opponent feature and the technique training feature.

Displaying Graphical Overlay for Technique Training

Description

As described earlier, the technique training feature will contain both a real-time and a post-analysis component. This feature concerns the real-time component. During a technique training workout, the frames from the recording will be fed to the pose estimation and technique predicting models. The output of these models will be used to produce a graphical overlay over the original video, which will have to be played back to the user in real-time. The objective of this is to show errors in the users technique in an immediate fashion. This feature would be best used by a coach or partner who could tell and show the user the errors in technique displayed.

Criticality

Medium. This is quite a significant feature of the application, as it incentivises coaches, trainers and sparring partners to make use of the application. However, this function is not essential for the application to function.

Technical Issue

As this feature is to be executed in real-time, issues could arise from the speed of the models and the time it takes the algorithms to execute. If the models and algorithms take too long to execute for real-time implementation, then it would not be possible to implement this feature.

Dependencies

This feature is dependent on the Technique Training feature as it is contained within this feature. The Technique Feature uses this feature to display the results in real-time, and then return the results to feedback feature.

User registration

Description

After first opening the app, users will be asked to either sign in or create an account. Once users opt to create an account, they will be asked to provide an email and a password for the account. Passwords will be checked so that they fit our security criteria. Once the account is created, users may provide the application with some of their physical attributes, such as weight and height. These attributes, and all user information, will be encrypted and stored in our database.

Criticality

Medium. This feature is important for the functionality of the application. Users will not be granted access to the application unless they have an account. However, the application could still be used without user account implementation.

Technical issue

Medium. The issue with this function is the process of encrypting and storing user information. Measures will have to be put in place to ensure that the information is effectively encrypted.

Dependencies

This feature relies on the User Login feature, potential users reach this feature from the login page.

User Login

Description

Once the user opens the app, they will be prompted to either sign in or create an account. If the user has already created an account, they will sign in using the email and password they used when creating the account. This information will be verified against the user information in our database. Upon verification, they will be provided access to the app.

Criticality

Medium. It is important that users can access the app, and that the user is the only individual to have access to their account. However, as mentioned previously, the application could still provide it’s main functionality without user account implementation.

Technical issue

The issue with this feature is matching the plaintext email and password inputted by the user, with the encrypted credentials in the database. Moreover, precautions will have to be put in place to ensure that bad actors cannot access other users accounts.

Dependencies

This feature relies on the user registration feature, as without it no user accounts would exist. All of the app features rely on this feature being implemented correctly, so that users can access the app.

Updating user information

Description

Users will be given the option to update their information in the user information section of the app such as physical attributes and passwords. The corresponding information will have to be updated in the database.

Criticality

Low. This information helps increase the accuracy of the predictive models, which in turn will lead to a better user experience. However, without this feature the models will still be able to predict, but with a somewhat reduced accuracy.

Technical issue

This feature requires updated user information in the database, based on user IDs. Therefore, issues could arise from updating this information.

Dependencies

This feature is dependent on the implementation of the database and the user registration feature.

4. System Architecture

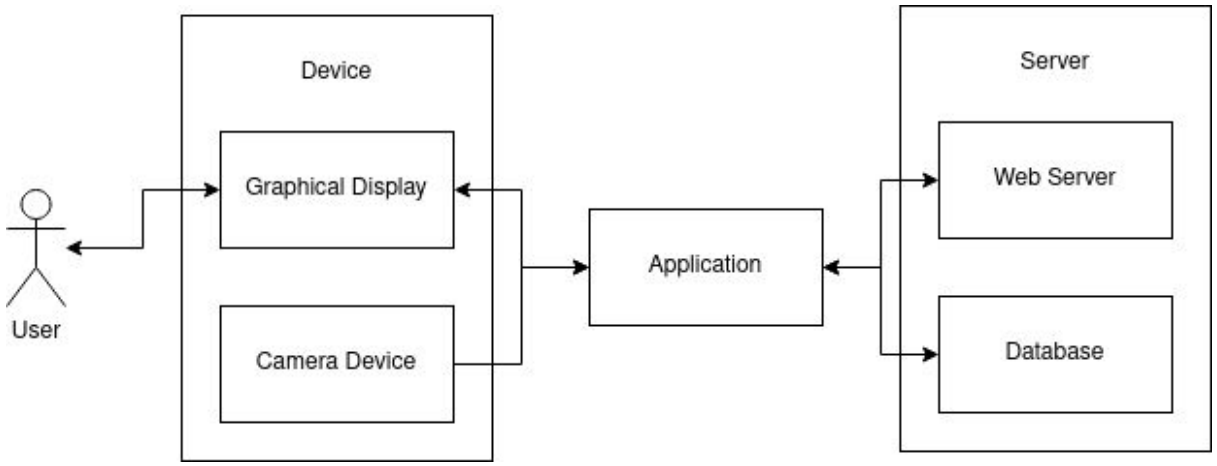

Fig 4.1 System Architecture

Device:

This component portrays the application and utilises the embedded camera. It acts as an interface between the user and the underlying application, displaying the features that our application will provide.

Application:

The application will allow for interactions with our underlying system architecture. It will allow the user to access features that our application will offer. It will communicate with the database and device, by way of the server, receiving and sending information to and from the database. It will be used as a means of communication between the user and our system, allowing the user to access historical workout feedback and utilise the embedded camera for their workout routine.

Server:

The application will call the server when major computations are needed to be completed, such as the comparison between the professional technique and a technique that has just been completed by a given user. The simulated opponent feature will run on the web server, since the device is not predicted to compute the required executions in time. The database server will store user credentials, feedback reports etc. in relational tables, and the professional technique, for the comparison to the users technique, in numpy arrays.

5. High-Level Design

5.1 Sequence Diagram

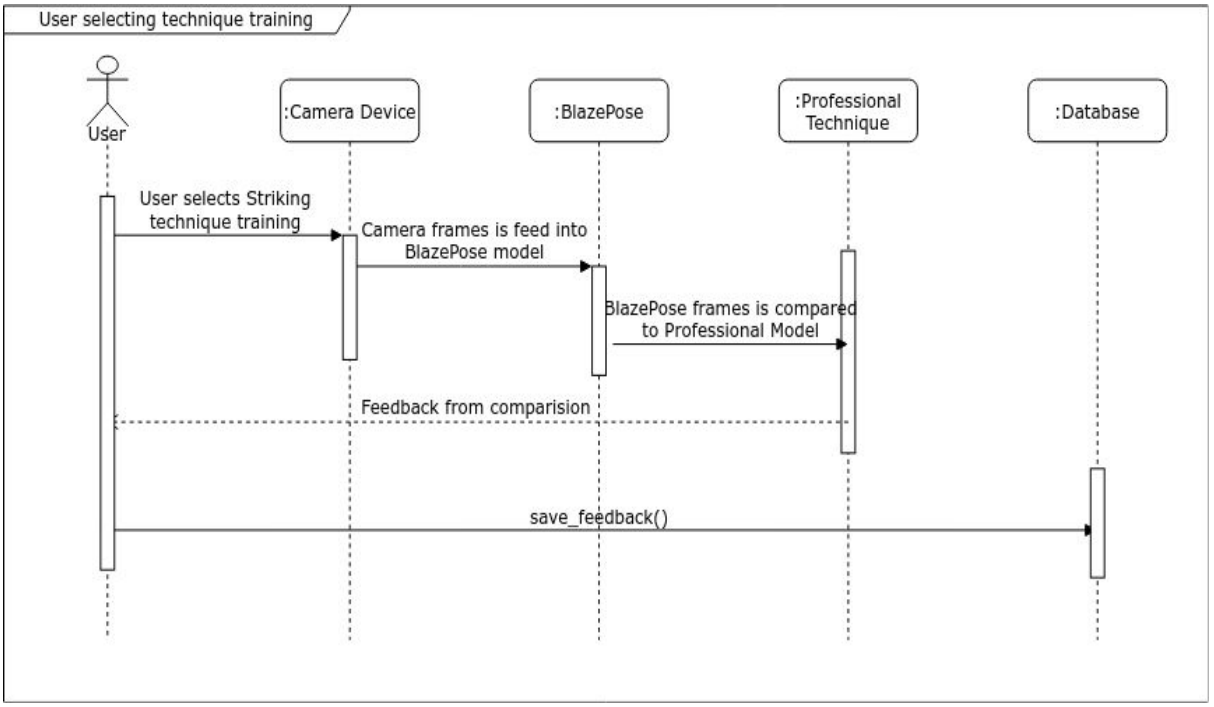

Fig 5.1 Sequence Diagram depicting the execution of Technique Training

5.2 Data Flow Diagram

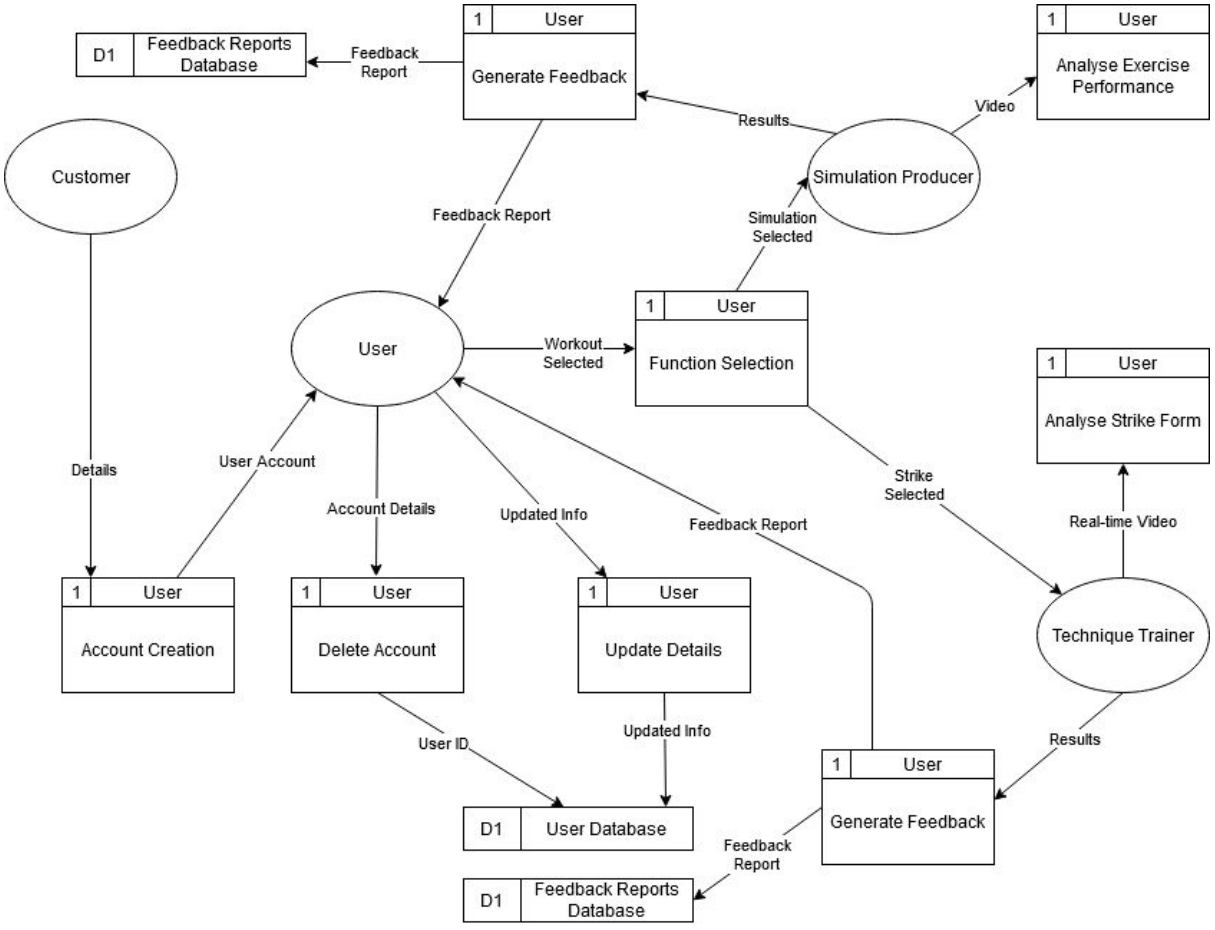

Fig 5.2 Data Flow Diagram of high level Web Application Design

5.3 High Level Design Diagram

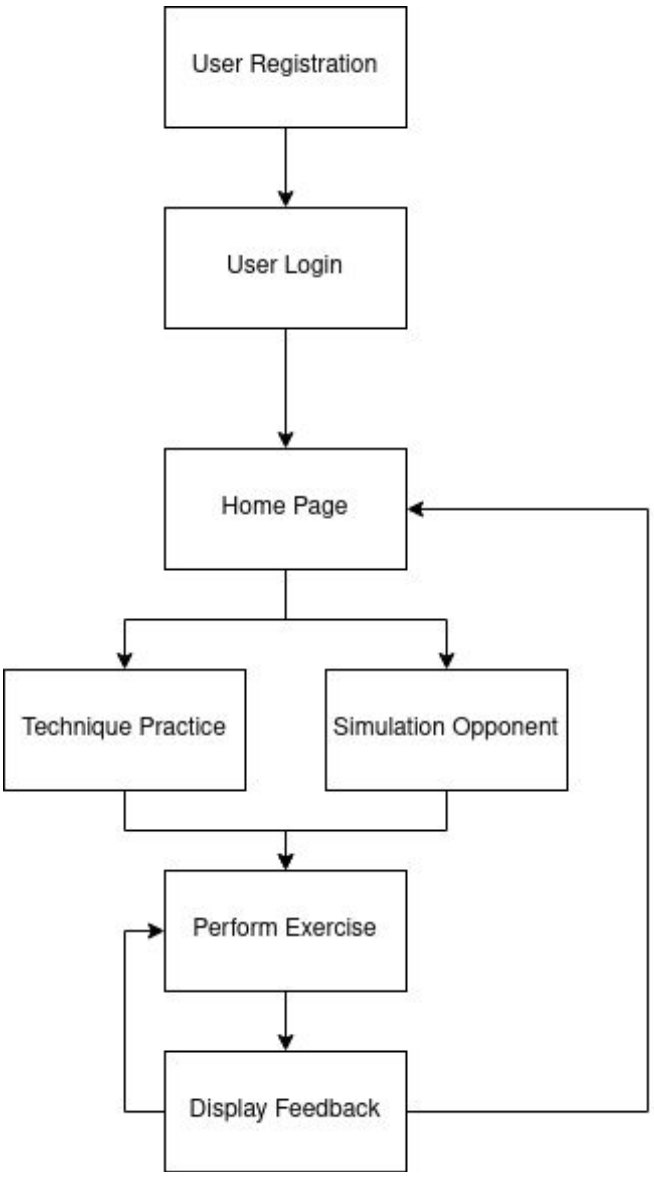

Fig 5.3 High Level Diagram of proposed design

User Registration

The user registers their account by providing email and password. The user will have the option to provide personal details such as weight and height. This information is then stored in our database.

User Login

Once the user registers their account, they can login using their credentials.

Home Page

This is the navigation page for the user once they login successfully. Here, the user has the option to proceed with either of the two options of workout routines or navigate to their feedback reports.

Technique Training

The user can commence the technique training workout after picking this routine from the home page.

Simulation Opponent

The user can start the simulation opponent after selecting the routine from the home page.

Perform Exercise

The user performs the routine that they have previously picked.

Display Feedback

The feedback is displayed post workout to the user. The user can then perform the exercise again or navigate back to the home page.

6. Preliminary Schedule

	Tasks In First Semester	Oct 26	Nov 2	Nov 9	Nov 16	Nov 23	Nov 30	Dec 7	Dec 14	Dec 21	Dec 28
1	Project Research										
2	Project Proposal										
3	Functional Specification										
4	Testing Implementation										
5	Pose Estimation Research										
6	Post Estimation Implementation & Testing										
7	Simulation Research										
8	Simulation Implementation & Testing										
9	Database Setup & Testing										
10	Encryption Implmentation										
11	Design UI										
12	Web Application Implementation										
13	Integration & System Testing										
14	Technical Manual										
15	User Manual										

	Tasks In Second Semester	Jan 11	Jan 18	Jan 25	Feb 1	Feb 8	Feb 15	Feb 22	Mar 1	Mar 8	Mar 15	Mar 22	Mar 29	Apr 5	Apr 12	Apr 19	Apr 26	May 3
1	Project Research																	
2	Project Proposal																	
3	Functional Specification																	
4	Testing Implementation																	
5	Pose Estimation Research																	
6	Post Estimation Implementation & Testing																	
7	Simulation Research																	
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11	Design UI																	
12	Web Application Implementation																	
13	Integration & System Testing																	
14	Technical Manual																	
15	User Manual																	

7. Appendices

BlazePose Blog:
https://ai.googleblog.com/2020/08/on-device-real-time-body-pose-tracking.html

Blazpose GitHub: https://google.github.io/mediapipe/solutions/pose.html

BlazePose Research Paper: https://arxiv.org/pdf/2006.10204.pdf