INFORMATICS INSTITUTE OF TECHNOLOGY

In Collaboration with

ROBERT GORDON UNIVERSITY ABERDEEN

Fitness Guardian: Exercise Posture Analysis with Exercise and Diet Recommendation System

Thesis Document by

Group 28

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Submitted in partial fulfillment of the requirements for the BSc (Hons) in Artificial Intelligence and Data Science degree at Robert Gordon University.

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i Declaration

We hereby certify that this project proposal and all the artifacts associated with it is our own work and it has not been submitted before nor is currently being submitted for any degree program.

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I have read the project proposal, and it is in accordance with the approved university project proposal outline.

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ii Acknowledgement

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Thank You.

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UI – User interface
UX - User experience

1. Introduction

1.1. Chapter Overview

This chapter presents the project by defining a particular issue that requires a machine-learning software solution. It highlights the significance of using machine learning, lays out the primary objectives, and specifies what the program will concentrate on.

The chapter outlines the fundamental project requirements, establishes a precise development schedule, and presents the selected technique. Finally, it summarizes the main ideas and sets up the next several chapters for a more in-depth examination.

1.2. Problem Domain / Background

Many individuals today suffer from poor injuries from the wrong ways of exercising and weightlifting with bad manners. It causes many health problems like back pain and muscle pains. Using the wrong posture while exercising will lead to shoulder and back injuries (*Stop making these common workout mistakes - Harvard Health*, 2018)

If people engage in exercises in incorrect postures it can lead to more issues like risk of injuries, muscle imbalances, pain and discomfort, and long-term health issues (*Why your poor posture increases likelihood of gym injuries*, 2023)

1.3. Problem Definition

In today's busy world, many people face issues such as being overweight and living unhealthy lives, affecting their physical and mental well-being. Even with many health and fitness apps available, the importance of doing exercises with the right posture and techniques is not stressed enough. People who exercise the wrong way might pick up unhealthy habits and not reach their fitness goals safely. To avoid these problems, some individuals consider hiring personal trainers or going to gyms. Yet many lack the ability to do so and prefer to engage in exercises at their own pace using openly available resources. In that context, while existing apps offer guidance for the exercise beginners, they often fall short in providing a complete solution for correcting posture. This lack can be a big drawback for users looking for a more complete approach to their health.

1.4. Research Motivation

As the health issues of each generation persistently rise as a global concern, the research team aims to break the continuous cycle of health problems and contribute to the creation of a healthier future generation. The focus of the research project lies in posture correction for exercises and recommendations for exercise and diet plans. Existing health and fitness apps often lack effective solutions for correcting exercise postures and struggle to tailor exercise plans to individual needs. In summary, the motivation for this research project is due to the application of dynamic machine vision, the importance of the problem domain, and the shortcomings noted in the applications of earlier studies.

1.5.Existing Work

Citation	**Technology / Algorithm**	**Limitations**	**Improvements to be implemented**
(Chen and Yang, 2020)	Multistage CNN with two branches	Real-Time feedback is not available, cannot be run on smartphones, unable to identify the area where the posture is wrong	Making the application available on mobile and improving the feedback given to the user by showing the specific area where the posture is wrong
(Conner and Poor, 2016)	Kinect V2 and body tracking	Made for a single exercise, does not show the specific place to correct	improving the feedback by showing the specific area where the posture is wrong, using of normal camera to identify human posture
(Kanase *et al.*, 2021)	Geometric algorithm	Cannot display the results in a GUI, unable to identify the part of posture that needs correction	Implementing a GUI platform for the application
(Nagarkoti *et al.*, 2019)	CNN model trained on COCO, optical flow tracking, Dynamic time warping, affine transformation	The estimation is based on 2D-dimensional motions and the accuracy of estimating exercises can be improved	Improving the accuracy of the model and identifying the feasibility of creating posture correction for 3D dimension using 2d input

(Hannan, 2022)	Key Point detection, Computer Vision, DNN	Predicts posture for only one Exercise.	Posture prediction for multiple exercises
(Rangari *et al.*, 2022)	Parsing Algorithms, LSTM, and RNN	Not accurate with some devices. Confusion between similar poses.	Introducing precise models to separate similar exercises
(Hande *et al.*, 2023)	SGD Algorithms	Inaccuracy of exercise posture from side viewpoints high	Making sure the accuracy is the same on side viewpoints
(Militaru, Militaru and Benta, 2021)	Rule-Based Algorithm	Cannot manage dynamic exercises, The robustness to some environment attributes is low.	Posture correction, and dynamic exercise posture correction

Table 1 Existing Work

1.6.Research Gap

1.6.1. Theoretical gap

Most of the given models only predict if the posture is correct or wrong and it does not suggest a way to correct the posture and even smaller corrections on postures might have a significant impact on exercises (Conner and Poor, 2016)

As in the Existing worktable, several performance gaps exist as mentioned in the research (Hannan, 2022) the posture correction is implemented for only a single exercise and so by making the application available for many exercises, we can increase its capabilities.

1.6.2. Performance gap

As mentioned in the research paper it is implemented to be accessed by the computer and needs high computational capabilities such as the usage of cuDNN. By making the model accessible by mobile application we can increase the reach of use (Chen and Yang, 2020)

And, as mentioned in (Rangari *et al.*, 2022) the prediction is not accurate in some devices. and as mentioned in (Militaru, Militaru and Benta, 2021) the computer vision algorithm is hardware intensive and so the video is only processed after the initial phase by making the predictions in real-time can eliminate this gap.

We can also improve the performance by improving the accuracy of predictions while the exercise is monitored from side viewpoints. (Hande *et al.*, 2023)

1.7. Contribution to the Body of Knowledge

1.7.1. Technological contribution

The application will use video processing techniques and recommendation theories. The key contributions are video-based posture correction and fitness and diet plan recommendations. The research team will be implementing posture correction for multiple exercises and alerting users of the specific place where the posture is being maintained incorrectly, it would require a robust and versatile model that can recognize and correct postures. To improve the model accuracy on the side viewpoints we will be looking into posture estimation on a 3d dimension.

1.7.2. Domain contribution

The team is using a user interface to give users a personal trainer-like experience through this. The core function of this app is to correct the postures of the user. For that, we gather information about the user's exercises by video and develop its knowledge to give the most effective exercise postures. We use a feature-rich application to give users well-personalized fitness plans. We hope to collaborate with fitness partners to increase the accuracy and get suggestions. For example, health status from generation to generation is getting weak and our team goal is to help break this chain using this app.

1.8. Research Challenge

- Identifying a way to detect postures while exercising and the specific area where the posture is wrong during exercise (neck, back, shoulders etc.). (Chen and Yang, 2020)
- Finding a suitable way to identify and inform the user of the wrong exercise forms.
- Most of the research papers are based on exercises to fix postures instead of posture correction for exercise activities. It is challenging to find such research papers and datasets.
- Posture correction must be accurate to correct the current exercise posture and pose detection must be quick without any lag. (Kwon and Kim, 2022)
- Either using images or videos to detect postures the most used angle of the video or image is frontal view. So fixing inaccuracy in pose detection appearing on side view inputs. (Hande *et al.*, 2023)

1.9. Research Questions

RQ 1: What are the most effective ways to use AI and ML to check a user's exercise posture and provide feedback?

RQ 2: What are the most effective ways to generate personalized exercise and diet plans based on a user's preference?

RQ 3: How to identify the specific area where the posture is wrong during the exercise?

RQ 4: How can we use technology to improve the development, testing, and deployment of our user interface?

1.10. Research Aim

Our research aims to develop an application that encourage individuals with limited knowledge of diet or exercise to start their journey toward a healthier lifestyle. This application addresses the dual problem of encouraging beginners to exercise safely and effectively and offering dietary advice that is specifically suited to their needs. Our goal is to create a comprehensive and easily accessible platform for long-term wellness improvement by providing users with personalized diet and exercise plans based on user data, real-time exercise feedback to prevent injuries from improper form, and educational resources..

1.11. Research Objectives

Research Objectives	Explanation	Research Questions	Learning Outcome
Problem Identification	**RO1:** Determine the main obstacles and challenges people encounter trying to achieve their health objectives. **RO2:** Examine the possible effects of improper exercise form on user safety and the avoidance of injuries.	**RQ1, RQ2**	LO1, LO3
Literature Review	**RO3:** Identify a technology to identify postures using Computer Vision **RO4:** Identify a technology to recommend exercise plans based on user preference.	**RQ1, RQ3**	LO3, LO4
SLEP	**RO5:** Making sure the data gathered has an open license or has been allowed to be used for research. **RO6:** Making sure the user's data will not be manipulated or shared without proper consent.	**RQ4**	

Data Gathering and Analysis	**RO7:** Gathering Image or Video Datasets of Exercises. **RO8:** Gathering Datasets with Exercise Plans. **RO9:** Gathering user requirements using survey questionnaires.	**RQ1, RQ2**	LO1, LO3
Research Design	**RO10:** Design a high-level system architectural design. **RO11:** Identifying the software tools needed to implement the system. **RO12:** Designing a model to identify postures using key points. **RO13:** Designing a model to extract the angle between vectors to train the model.	**RQ3**	LO2, LO3, LO4
Implementation	**RO14:** Implementing a model to predict postures. **RO15:** Implementing a model to provide feedback on the posture. **RO15:** Implementing an algorithm to suggest an exercise and diet plan according to user input. **RO16:** Implementing an interface for the user to interact with the models.	**RQ1, RQ3**	LO2, LO3, LO4
Testing and Evaluation	**RO16:** Utilize test results to improve the application's functionality and design. **RO17:** Evaluating the accuracy of the model using test cases. **RO18:** Evaluating the usability of the product using usability testing and user feedback	**RQ1, RQ2**	LO2, LO4

Table 2 Research objective

1.12. Project Scope

1.12.1. In Scope

- Posture correction using video input for Exercise.
- Exercise and diet recommendation based on user preference.
- Implementing an interface for the user to interact with the system.

1.12.2. Out Scope

- Posture correction for every exercise possible.
- Creation of a new Exercise plan and Diet plan.
- Not suitable for children.

1.12.3. Prototype Diagram

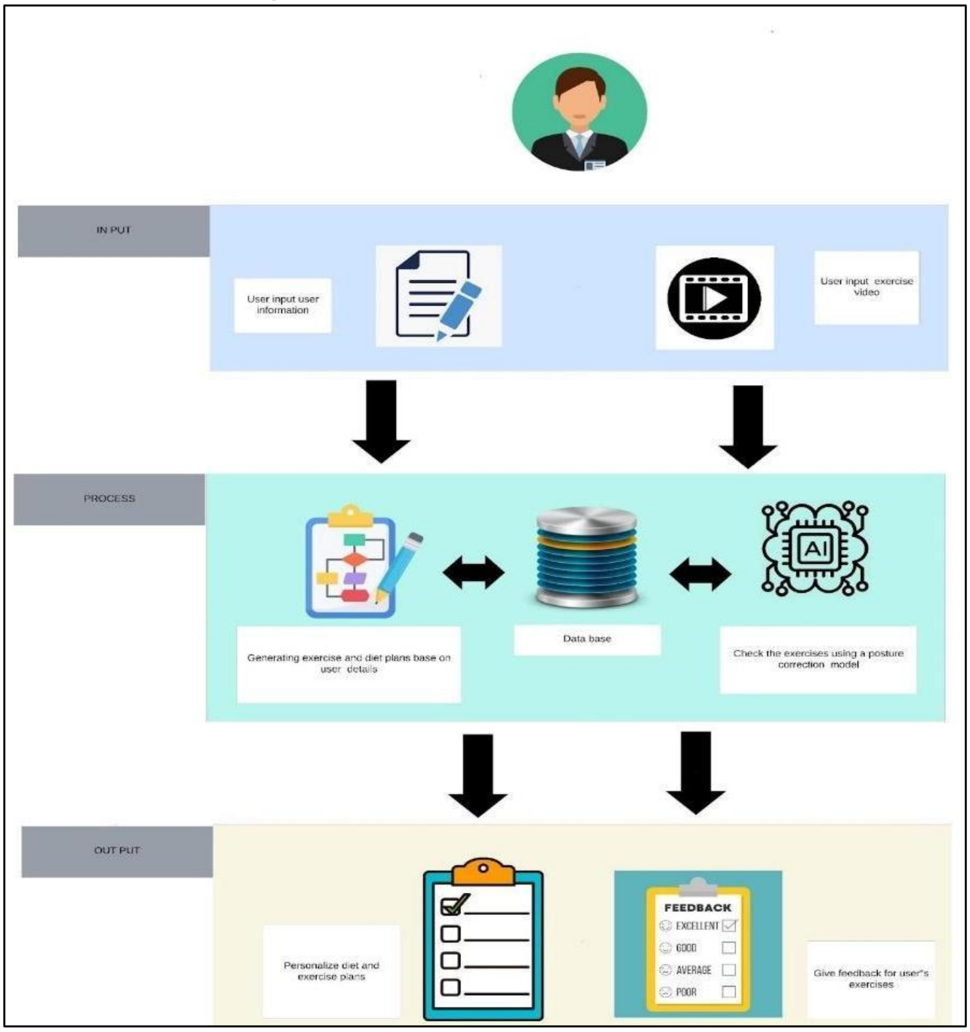


Figure 1 Prototype picture..

1.13. Resource Requirements

1.13.1. Hardware Requirements

- **CPU** (Intel Core i5 / AMD Ryzen 5) or above- To get high performance while training the model.
- **8GB VRAM** (NVIDIA GTX 1660 / AMD Radeon RX 570) or above - To train a machine vision algorithm due to its high image computational abilities.
- **16GB RAM** or above - To run, train the application, and train the model.
- **Storage (256GB SSD / 500GB HDD)** or above - To store datasets and software applications needed for training.

1.13.2. Software Requirements

- **Python** - The main language to build the system as it provides a vast number of libraries used for Artificial intelligence.
- **SQL** - To connect and manage the databases and retrieve information.
- **VS-code** - To create and design webpages utilizing live servers.
- **Microsoft Word** - For documentation purposes.
- **Google Drive** - To backup documents and to save and run Google Collab.
- **Figma** - To collaborate and design wireframes of the system.
- **Google Collab** - For training the model to utilize free computational power.
- **TensorFlow** - For pre-processing the dataset and training the model.
- **GitHub** - To backup codes and files to prevent loss of data, and corrupt files and datasets.
- **Windows OS / Mac OS** - As the operating system to run the software applications.

1.13.3. Data Requirements

- **Qualitative Data:** The dataset needed to train the posture correction model will be in an image or video format.
- **Quantitative Data:** The data set with exercise and diet plans will be in quantitative format.

1.13.4. Skill Requirements

- Research Skills
- Report Writing
- Critical thinking
- Risk management.
- Collaboration with team

1.14. Chapter Summary

This chapter addresses the widespread problem of poor form during exercise, emphasizing the underlying problems associated with it, such as injuries and unfulfilled fitness goals. This chapter introduces an innovative machine learning-based system that aims to provide personalized exercise routines and correct posture. The main objective is to improve the functionality of current fitness programs and provide users with the tools they need to follow safe and efficient exercise regimens.

2. Literature Review

2.1. Chapter Overview

This chapter aims to conduct a literature review on the technologies and techniques that can be implemented in the project.

2.2. Concept Map

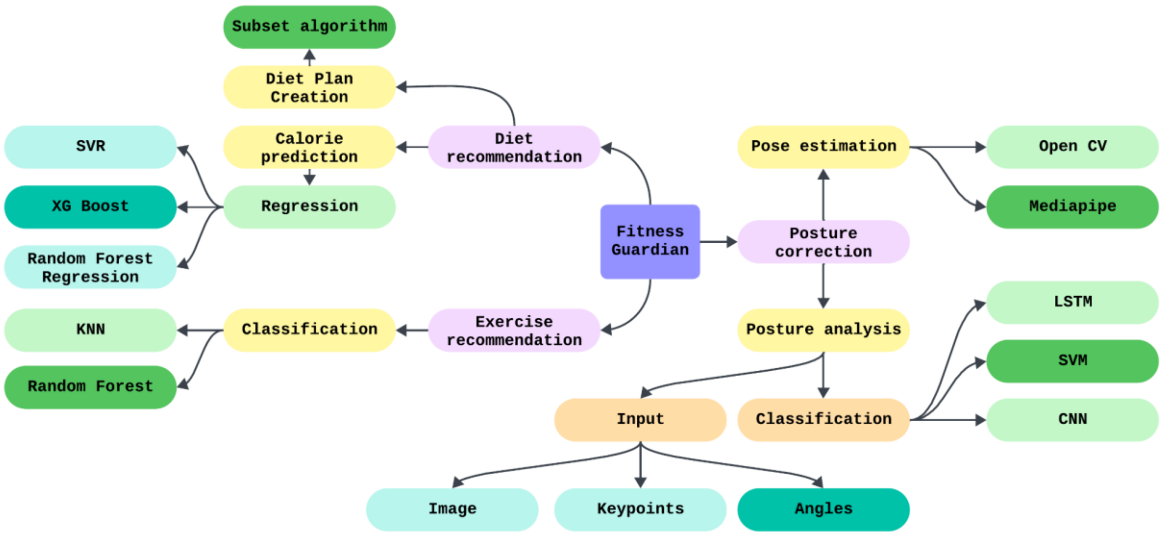


Figure 2 Concept map.

2.3. Problem Domain

The fitness industry's growth leads to injuries due to lack of supervision. AI offers personalized training, reducing risks. Injuries stem from poor technique and overuse, highlighting the need for caution and proper guidance. Computer vision aids in personalized training, especially in posture correction.

2.4. Existing Work

Real-time exercise posture correction					
Research	Author	Year	Dataset	Model used	Metric
Research on Body Posture Correction and Hand Gesture Detection Leveraging Federated Learning and Media Pipe	Rijul Singhal, S Srihari, Advit Gandhi, Prakash C O, Sivaraman Eswaran, Hardik Modi.	2023	-	Sequential Architecture VGG-19 Architecture Media Pipe and Neural Network	Accuracy =70%

Posture Tracking Meets Fitness Coaching: A Two-Phase Optimization Approach with Wearable Devices	Han Zhou, Yi Gao, Wenxin Liu, Yuefang Jiang, Wei Dong,	2020	eight volunteers doing nine exercises	SVM	Accuracy =96.7%
Neural Network-Based Rehabilitation for Posture Correction	Unzila Jawed, Aiman Mazhar, Faiza Altaf, Abdul Rehman, Dr. Sarmad Shams, Engr. Ali Asgha	2019	896 sample data	Neural Network in NI LabVIEW 2018 Software Creating Neural Network in MATLAB R2018b Software	Accuracy =70%
LogRF: A Novel Method for Human Pose Estimation Utilizing Skeleton Landmarks for Physiotherapy Fitness Exercise Correction	Ali Raza, Nagwan Abdel Samee, Maali Alabdulhafith, Azam Mehmood Qadri, Iqra Akhtar.	2023	Multi-class exercise dataset	LogRF method	Accuracy =94%
Diet and Exercise recommendation system					
Diet and Workout Recommendation Using ML	S. Sadhasivam, M.S.Sarvesvaran, P. Prasanth, L. Latha	2023	-	K – Means Clustering Random Forest Classification	Accuracy =95.7%
Predicting the risk of obesity and meal planning to reduce obesity in	Rajdeep Kaur, Meenu Gupta, Rakesh Kumar.	2022	Obesity dataset with attributes	Random Forest, Support Vector Machine, K Nearest Neighbor,	Accuracy =95.7%

adulthood through artificial intelligence.			description and values	XG Boost, Gradient Boosting, Bagging meta-estimator.	

Table 3 Existing work

2.5.Technology/Approach/Algorithm Review

2.5.1. Posture analysis model.

Maintaining posture contributes a lot in our daily lives, even more so while doing exercise and using deep learning models to identify posture of a human is still a hurdle to overcome.

In a Research done by (Singhal *et al.*, 2023)using yoga as a preface they have converted a person's pose into 33 points with x, y, z coordinates which are major joints in a human body, as for hands alone they have marked 21 points with x, y, z coordinates by calculating the degree of angle between joints they are able to identify postures Sequential Architecture, VGG-19 Architecture and Media Pipe with Neural Network are tested while neural network provides an accuracy of 70% they suggest that additional layers would likely eliminate the restrictions.

In another research done by (Jawed *et al.*, 2019) using Microsoft Kinect360 with LabVIEW they have extracted the human skeleton structure with 20 joints and using Sub VI angle between joints are also calculated. Using 896 data backpropagation neural network with 14 feature inputs and 7 posture output. In another research done by (Zhou *et al.*, 2020) used geometric sensor reading to correct posture. They have used SVM to predict the exercise type which had average precision of 96% among 9 exercises.

In another research done by (Raza *et al.*, 2023) based on physiotherapy they have done feature selection from human exercise poses by doing this they have extracted a data set with 33 body landmarks with x, y, z coordinates by using these 133 features as input and LogRF model they have eliminated novel features and identified important ones. By analyzing 20 distinct features they have identified a clear separation which led them to use random forest, logistic regression, gated recurrent unit and (LSTM) for their multi model approach.

2.5.2. Recommendation system

In research done by (Sadhasivam *et al.*, 2023) to identify the type of diet and exercise they have taken age, weight and height, health details and diet regimen as inputs and splitting the dataset into 70-30 they have used K-Means clustering and random forest Classification to identify the type of diet and exercise into categories such as weight loss, weight gain and healthy.

In another research done by (Kaur, Kumar and Gupta, 2022) to use artificial intelligence, predict obesity risk and arrange meals to minimize obesity in adulthood. This study has highlighted the relationship between nutrition, obesity, and the development of many health complications such as PCOS, diabetes, cardiovascular disease, and certain types of cancer. This study has acknowledged the urgent need for effective interventions and proposes a novel way to accurately predict the risk of obesity using a variety of complex Machine Learning (ML) algorithms, including Gradient Boosting (GB), Bagging meta-estimator (BME), XG Boost (XGB), Random Forest (RF), Support Vector Machine (SVM), and K Nearest Neighbor (KNN).

2.6. Tools and Techniques

2.6.1. Image/Video processing

Media pipe and OpenCV is commonly used for image processing. Media pipe has the capability to extract skeletal key points from an image or video using it we can extract 33 key points in a 3D plain such as x, y, and z and open cv is used to transform images. Such as cropping, resizing changing color format and more.

2.6.2. Deep learning/ Machine learning frameworks

TensorFlow and scikit-learn provides high-level APIs like keras for simplified model building and provides more control over the functionalities. It also provides various ways to record and visualize the training process.

2.7. Chapter Summary

This chapters' aim was to find out the most recent/advanced technological implementations. The findings were listed in a simple manner and the concept map was made.

3. Methodology

3.1. Chapter Overview

This chapter introduces our project methodology, which focuses on developing and evaluating an application using computer vision and machine learning to correct posture during exercises. It outlines the key components such as research methods, data collection techniques, and the project timeline.

3.2. Research Methodology

Research Philosophy	The Research philosophy we are choosing is **positivism** as the effectiveness of the system can be measured after use using live or experimental data sets. As it focuses on uses of measurable statistical data.
Research Approach	Our research approach is **deductive** because of the top-down reasoning as we will train the model using exercises of multiple persons to gather common features to identify if the new exercise input is wrong or not.
Research Strategy	We will be using a **quantitative** survey as the research Strategy. As we will be able to identify the requirements in a numerical format and we will be able to access a high number of participants.
Research Choice	**Multi method** was chosen as the research choice as we will be using qualitative and quantitative aspects. We can identify the accuracy and train the model using numerical data and visual images.
Time zone	**Cross sectional** data is considered as the Time zone as the datasets will be used one time, but longitudinal data might be needed to further improve the system.

Table 4 Research methodology

3.3. Development Methodology

3.3.1. Life Cycle Model

Agile will be used as the life cycle model because it is iterative and flexible. Since it is an iterative progression of creating a working software even after the implementation and product delivery the customer is always included in the decision making related to the product features and due to this customer retention will be high.

3.3.2. Design Methodology

OOAD will be used as the design methodology because it provides a systematic and well documented approach to the system using designs such as use case model and object model. which has proved to be beneficial for large scale and complex projects.

3.3.3. Evaluation methodology

Mixed-Methods Evaluation will be conducted to evaluate the product as it has qualitative and quantitative aspects to be evaluated. The product accuracy and statistical data can be evaluated via quantitative aspects and the usability of the product can be evaluated via qualitative aspects.

3.4. Project Management Methodology

Kanban, an agile project management methodology that focuses on continuous flow and work-in-progress, will be used. it performs effectively in dynamic project environments because of its responsiveness and flexibility. Because of its scalability and emphasis on decreasing work-in-progress, it can readily adapt to various project sizes while still delivering results on time. Many industries have adopted Kanban because of its iterative and incremental strategy, which reduces project risk concerns.

3.4.1. Gantt chart

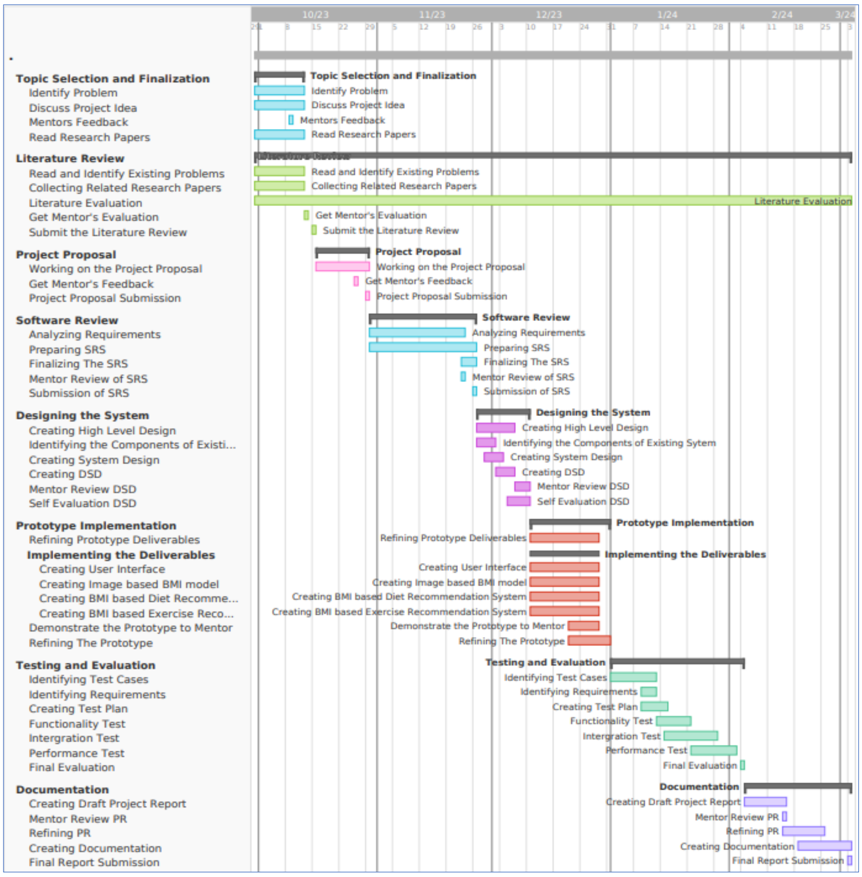


Figure 3 Gantt Chart

3.4.2. Deliverables

Deliverable	Date
Semester 01	
Submission of literature review	Week 3
Submission of the Project Proposal to the supervisor	Week 4
Submission of the Project Proposal	Week 5
Submission of the SRS to the supervisor	Week 8
Submission of the SRS	Week 9
Semester 02	
Introduction Chapter Submission	Week 14
Methodology Chapter Submission	Week 16
SLEP Chapter Submission	Week 17
System Architecture & Design Chapter Submission	Week 18
Implementation Chapter Submission	Week 19
Testing Chapter Submission	Week 20
Evaluation Chapter Submission	Week 21
Documentation and Final Report Submission (Final Thesis)	Week 23

Table 5 Deliverables

3.5. Chapter Summary

In this chapter the research methods, adopting a positivist approach, deductive reasoning, and a quantitative survey strategy were discussed. Development methodologies include Agile for flexibility and OOAD for systematic design. Evaluation utilizes Mixed-Methods Evaluation. Kanban is chosen for project management. The chapter emphasizes a structured approach to achieve project goals.

4. Software Requirements Specification

4.1. Chapter Overview

This chapter's objectives are to list the stakeholders, obtain their requirements, outline the procedure for obtaining these requirements, and evaluate the information gathered. The chapter's opening Rich Picture, which also provides an overview of the project's stakeholders, shows the internal and external factors that are present in the system. This chapter also focuses on the study of requirement elicitation approaches. Subsequent topics in this chapter will include functional requirements, non-functional requirements, use case diagrams, and context diagrams.

4.2. Rich Picture

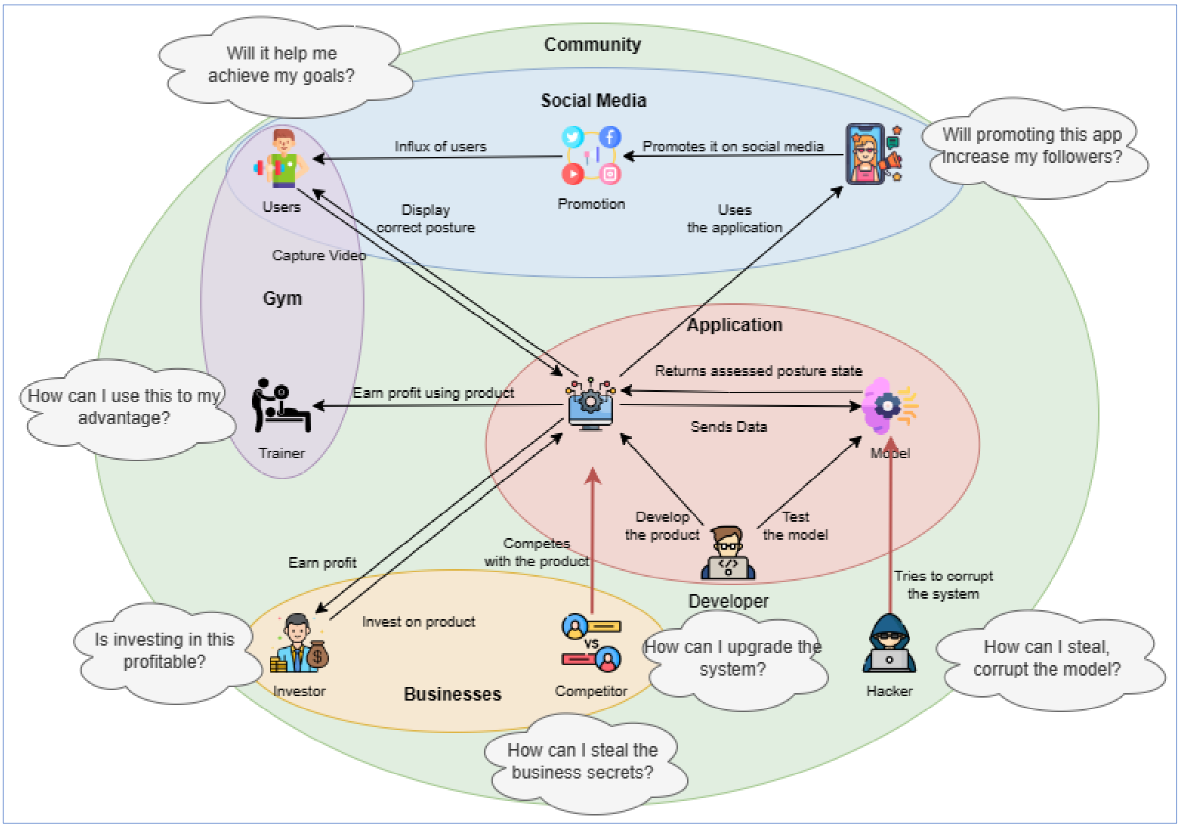


Figure 4 Rich Picture

4.3.Stakeholder Analysis

4.3.1. Onion model

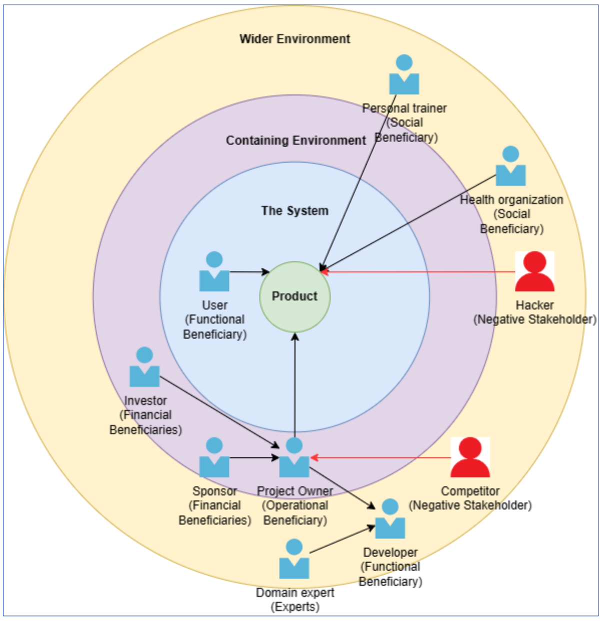


Figure 5 Onion Model

4.3.2. Stakeholder Viewpoints

Stakeholder	Role	Benefits
User	Functional Beneficiary	Improves machine learning models enhances algorithm efficiency
Project Owner	Operational Beneficiary	Provides strategic direction, ensures project viability
Sponsor	Financial Beneficiary	Offers financial backing, enhances project visibility
Investor	Financial Beneficiary	Provides funding, supports project growth and scalability
Developer	Functional Beneficiary	Builds project functionality, contributes to product development
Domain Expert	Expert	Offers specialized insights, ensures accuracy in project scope
Personal Trainer	Social Beneficiary	Validates exercise form accuracy, promotes the product.
Health Organization	Social Beneficiary	Endorses health-related credibility promotes public wellness
Hacker	Negative Stakeholder	Poses security threats, a potential risk to project integrity
Competitor	Negative Stakeholder	Tries to steal market strategy or product ideas.

Table 6 Stakeholder Viewpoints

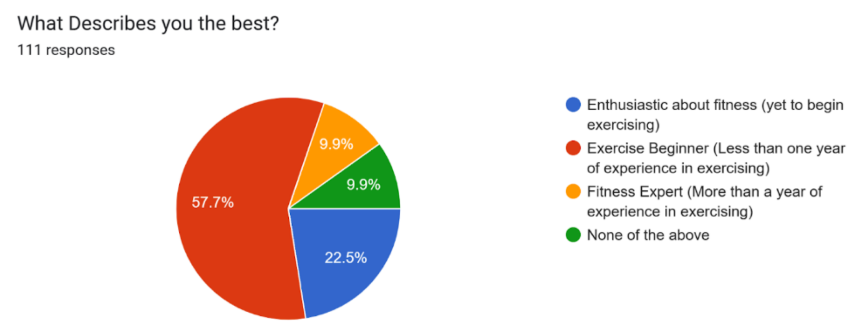
4.4.Selection of Requirement Elicitation Techniques

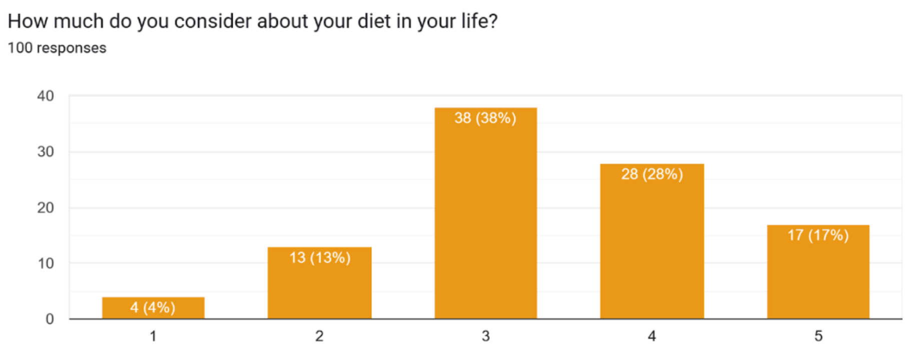
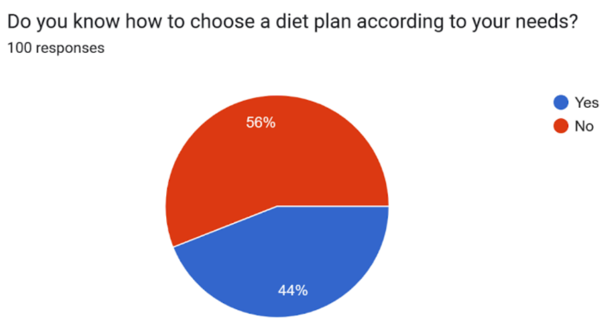
Based on the stakeholder's identification literature review, interviews and questionnaires have been selected as requirements gathering instruments. The reason to choose and relevant stakeholders are mentioned below.

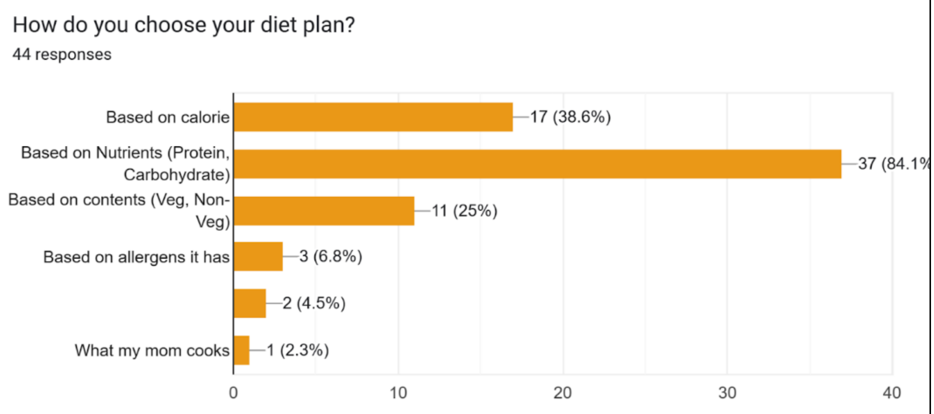
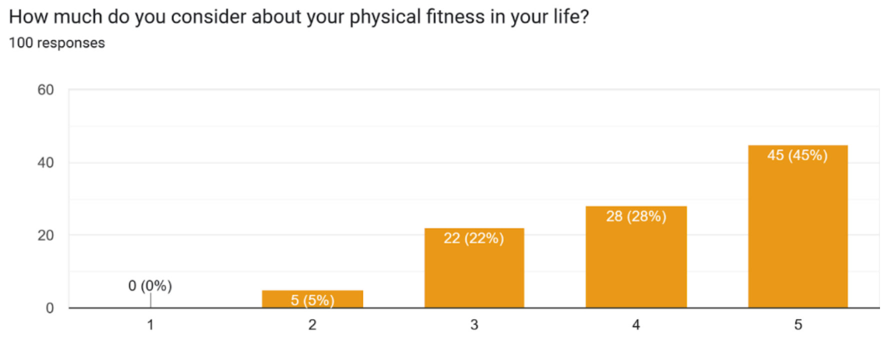
Method 1: Literature Review
Literature review is an essential method for requirement analysis in software development. By examining research papers, articles and publications related to the problem domain it helps to understand the similar projects, identifying the existing solutions and any gaps or limitations. This method ensures that it is well informed and effective.
Method 2: Interviews
Interviews provide a direct and interactive information gathering from stakeholders. This method will help to dive into key stakeholders' perspectives, expectations, and requirements. Although any misunderstandings, underlying specifications can be solved and build a connection with stakeholders and team members to approach a collaborative environment.
Method 3: Questionnaire
Questionnaire as a requirement elicitation method offers a structured and scalable approach to get information from a set of stakeholders. By making a well-crafted set of questions user needs, preferences and expectations can be measured. This method will cover a large audience while allowing stakeholders to express their true opinions anonymously. Analyzing responses from questionnaires will provide quantitative data that is important for development.

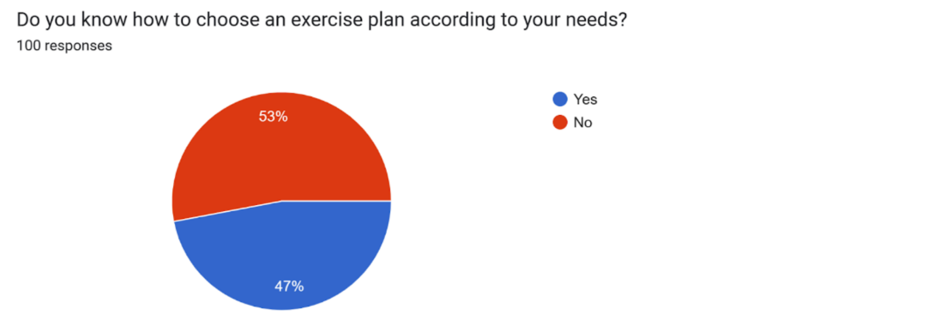
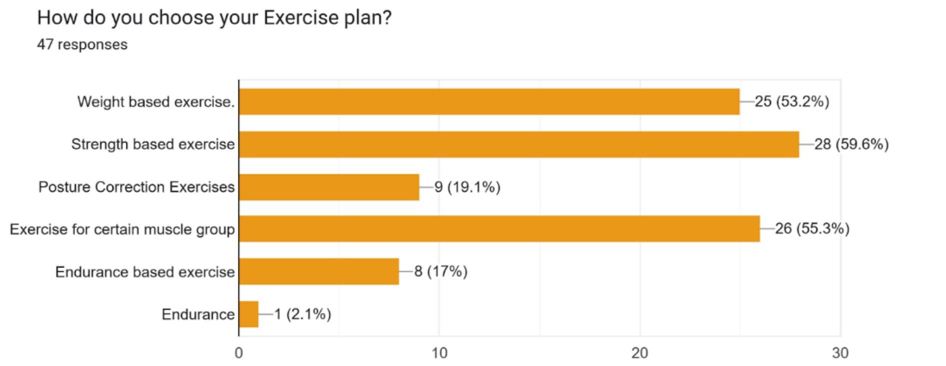
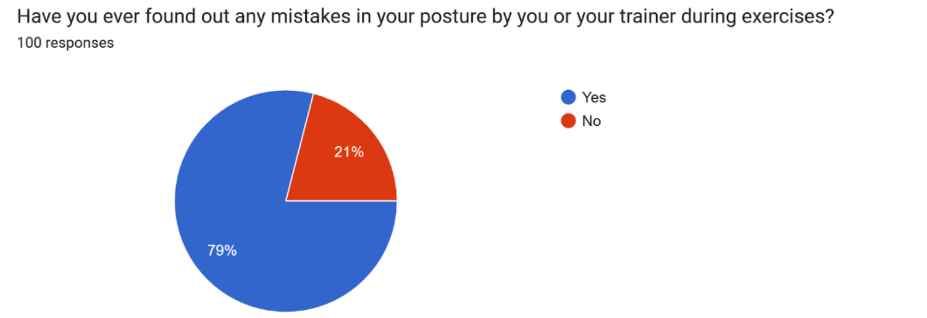
Table 7 Requirement Elicitation Techniques

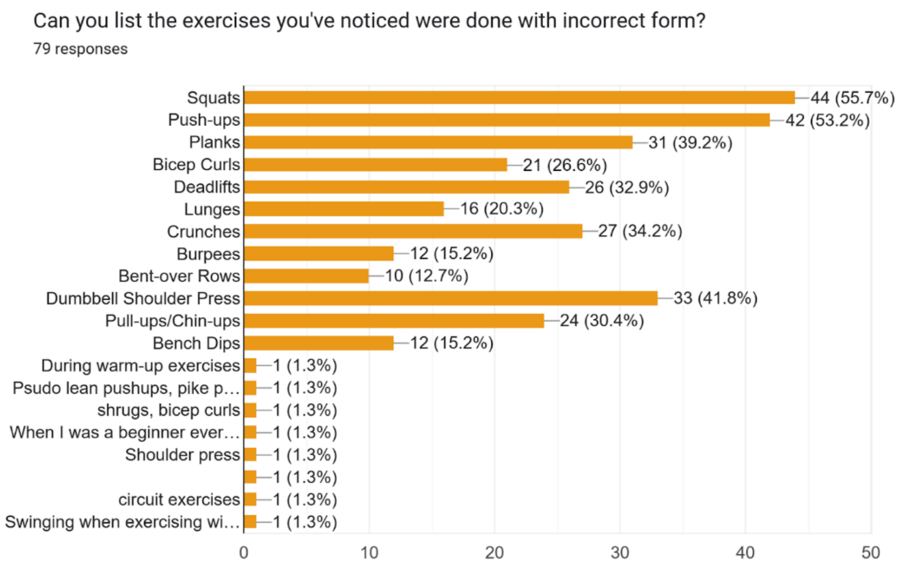
4.5.Discussion of Results

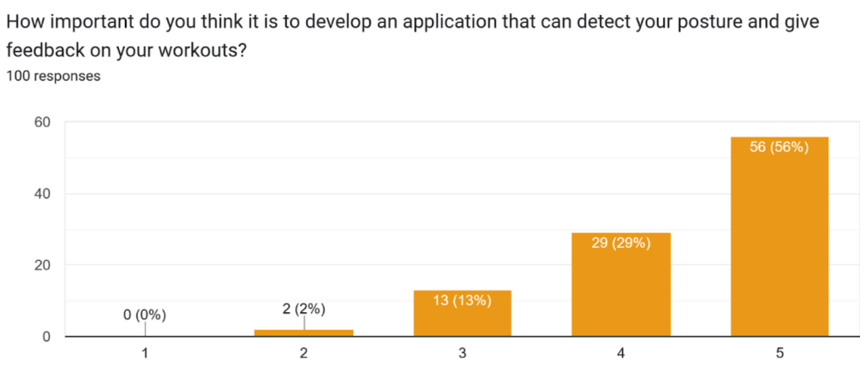
Question No.1	What describes you best?
AIM of Question	To identify the people interested in physical fitness / do exercises
Observation	
Conclusion	The survey result indicates that everyone submitting the response is interested in physical fitness or exercise beginners.

Question No.2	How much do you consider your diet in your life?
AIM of Question	To identify the number of people who care about their diet
Observation	
Conclusion	The average of the graph slightly bends towards the right side so in context we can assume that people mostly care about their diet in daily life
Question No.3	Do you know how to choose a diet plan according to your needs?
AIM of Question	To assess if people can choose their own diet plan
Observation	
Conclusion	The survey result indicates that more than half of the respondents don't know how to choose their own diet plan
Question No.4	How do you choose your diet plan?
AIM of Question	To identify on what basis people, choose their diet plan

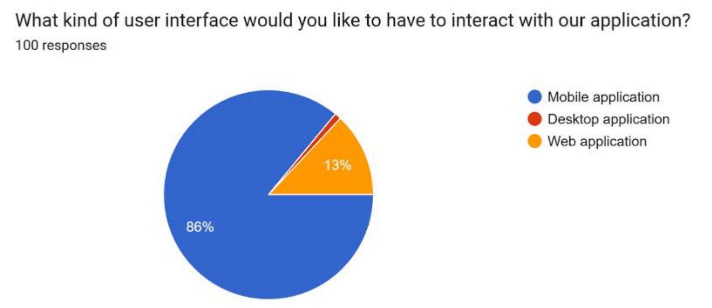
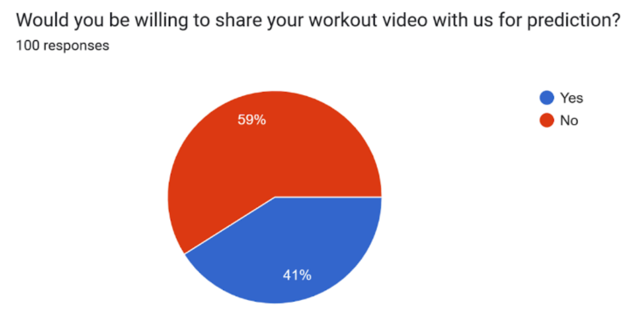
Observation	
Conclusion	The survey result indicates that people choose their diet based on its Nutrition factor or calorie
Question No.5	How much do you consider your physical fitness in your life?
AIM of Question	To identify how much the people care about their physical fitness in their daily life
Observation	
Conclusion	The survey result indicates that high proportion of the surveyed population care about their physical fitness
Question No.6	Do you know how to choose an exercise plan according to your needs?
AIM of Question	To assess if people can choose their own exercise plan

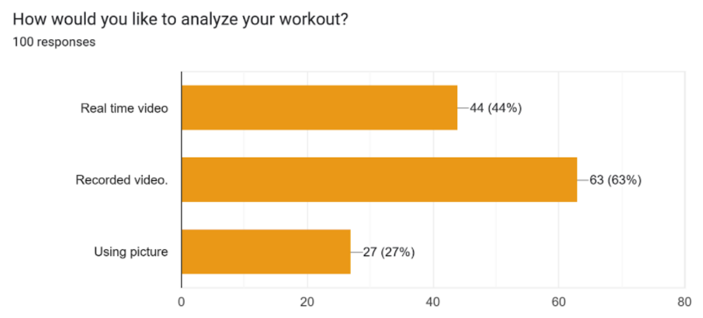
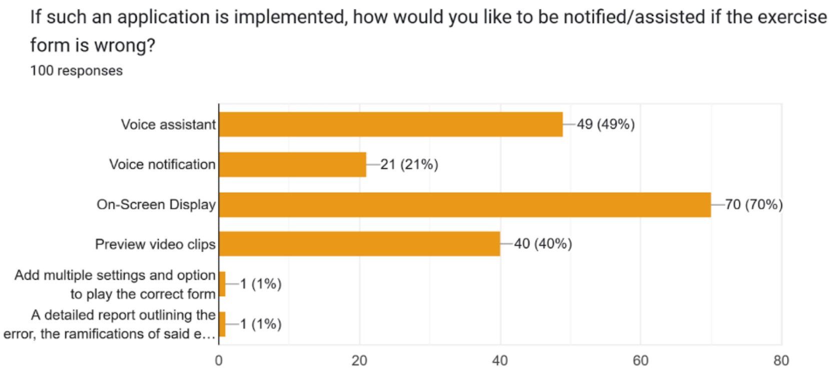
<table>
<tr><td>Observation</td><td>
</td></tr>
<tr><td>Conclusion</td><td>The survey result indicates that more than half of the respondents don’t know how to choose their own exercise plan</td></tr>
<tr><td>Question No.7</td><td>How do you choose your Exercise plan?</td></tr>
<tr><td>AIM of Question</td><td>To identify on what basis people, choose their diet plan</td></tr>
<tr><td>Observation</td><td>
</td></tr>
<tr><td>Conclusion</td><td>The survey results indicate that a high proportion of people choose strength, weight, and muscle group-based exercises</td></tr>
<tr><td>Question No.8</td><td>Have you ever found any mistakes in your posture by you or your trainer during exercises?</td></tr>
<tr><td>AIM of Question</td><td>To identify if the respondents have identified their incorrect form during exercises</td></tr>
<tr><td>Observation</td><td>
</td></tr>
</table>

<table>
<tr><td>Conclusion</td><td>The survey result indicates that a vast majority of the respondents have noticed that they have used incorrect posture during exercises</td></tr>
<tr><td>Question No.9</td><td>Can you list the exercises you have noticed were done with incorrect form?</td></tr>
<tr><td>AIM of Question</td><td>To identify the exercises which are usually done in incorrect form and give importance to it</td></tr>
<tr><td>Observation</td><td>


</td></tr>
<tr><td>Conclusion</td><td>Squats, pushups, planks, dumbbell shoulder press, and crunches has been identified to be the exercises which are highly done wrong</td></tr>
<tr><td>Question No.10</td><td>How important do you think it is to develop an application that can detect your posture and give feedback on your workouts?</td></tr>
<tr><td>AIM of Question</td><td>To identify the importance of the proposed solution</td></tr>
<tr><td>Observation</td><td>


</td></tr>
</table>

Conclusion	A High percentage of respondents have mentioned the given solution as important
Question No.11	What kind of user interface would you like to have to interact with our application?
AIM of Question	To identify the type of interface respondents will want to use to interact with our application
Observation	
Conclusion	A High percentage of respondents have chosen mobile application as their preferred user interface
Question No.12	Would you be willing to share your workout video with us for prediction?
AIM of Question	To identify the amount of importance to give the data received from the user
Observation	
Conclusion	A High number of participants do not wish to share their videos directly.
Question No.13	How would you like to analyze your workout?
AIM of Question	To identify the most preferred methods to analyze the workout video by the respondent

Observation	
Conclusion	A High percentage of respondents prefer real-time or recorded video to analyze their workout.
Question No.14	If such an application is implemented, how would you like to be notified/assisted if the exercise form is wrong?
AIM of Question	To identify the preferred way method on how the respondent wishes to be assisted when the exercise is performed in the wrong way
Observation	
Conclusion	A High percentage of respondents prefer to analyze the video by looking at the On-screen display, voice assistant, or preview video clips.
Question No.15	What are the functions you would like to add to our app?
AIM of Question	To identify the additional features respondents would like to add to our application

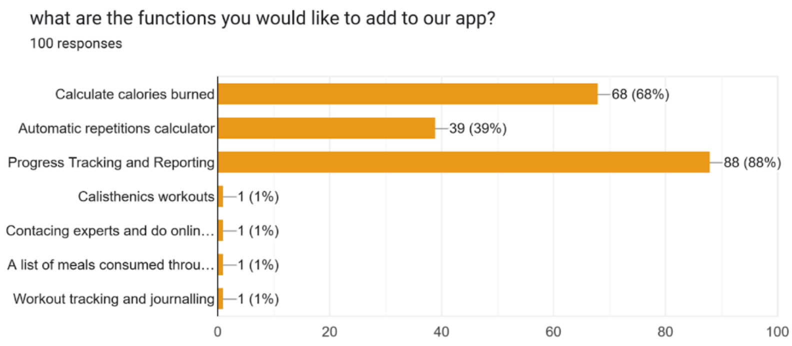
Observation	
Conclusion	A high number of respondents prefer to have a Progress teaching and reporting function and calculate the number of calories burned

Table 8 Discussion of results

4.6.Summary of Findings

Findings	**LR**	**Interview**	**Questionnaire**
The application to identify wrong postures is highly advantageous and reduces injuries to oneself	✓	✓	✓
The model/models should be able to analyze incorrect postures of multiple exercises which beginners tend to do wrong	✓	✓	✓
The model should be able to identify the exercise done from various angles.	✓	✓	
Providing educational content on ways to fix the exercise form is advantageous		✓	✓
Progress tracking of the user’s growth is highly advantageous		✓	✓
Recommending a diet and exercise plans is highly beneficial for beginners		✓	✓
Many people wish to analyze exercise by uploading recorded workout video via Mobile application	✓	✓	✓
The feedback for the posture is given On-screen and preferred	✓		✓

Table 9 Summary of findings

4.7.Context Diagram

This diagram shows the interactions between the system and its external entities of the fitness guardian, and it helps to identify the scope of the system and the major data flows.

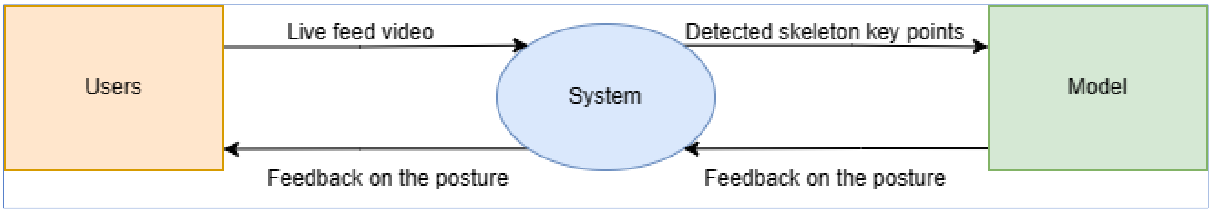


Figure 6 Context diagram.

4.8.Use Case Diagram

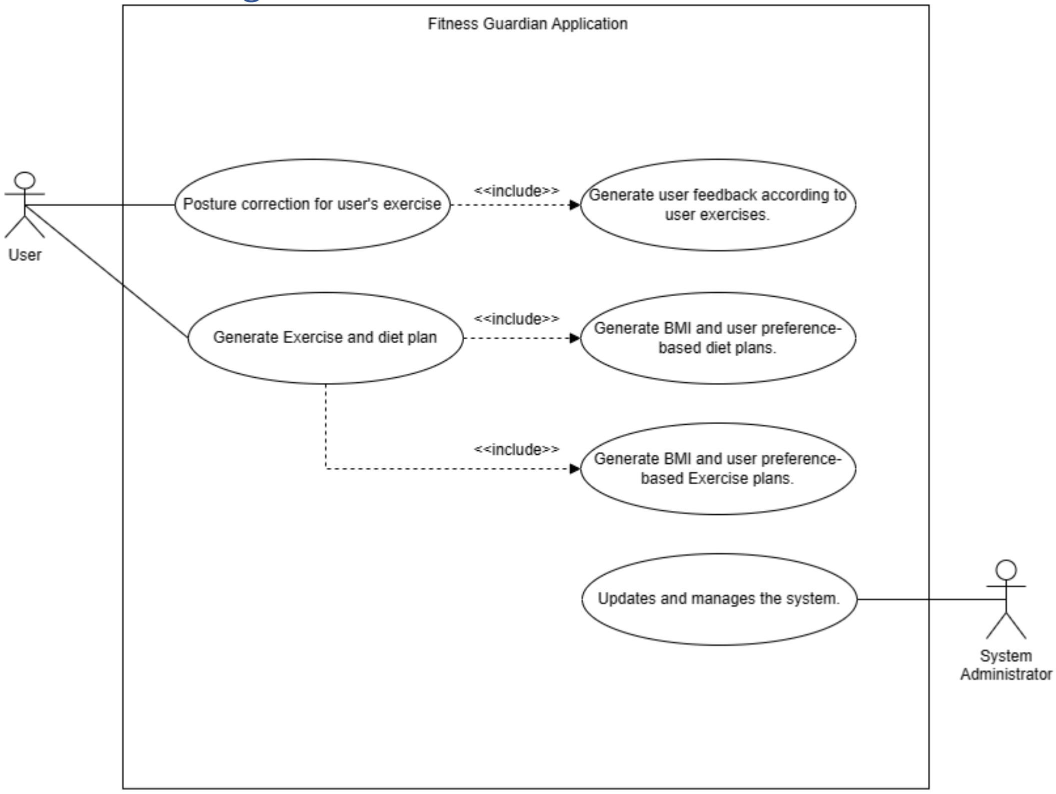


Figure 7 Use case diagram.

Use Case ID	01
Use Case Name	**Posture correction for user's exercise**
Overview	The system corrects user exercise forms by analyzing exercise videos for correct posture.
Participating Actor(s)	User
Pre-conditions	Train a posture correction model for a certain exercise

Main Flow	**Actor** 1. The user uploads a video of their exercise for posture correction. 2. The system analyzes the video using the posture correction model to identify any incorrect posture. 3. Once the posture correction analysis is completed, the user receives feedback on their exercise form. **System** 1. Receives the exercise video input from the user. 2. Analyzes the video using the trained posture correction model to detect errors. 3. Generate a feedback report outlining identified posture errors and areas for improvement.
Alternate Flows	None
Extended use cases	None
Included use cases	Generate user feedback according to user exercises.
Post-conditions	The user receives feedback detailing errors in their exercise video to aid in posture correction.

Use Case ID	**02**
Use Case Name	**Generate Exercise and Diet Plan**
Overview	The system generates personalized exercise and diet plans based on user inputs and BMI.
Participating Actor(s)	User
Pre-conditions	System generates pre-created exercise and diet plans based on user preference and BMI.
Main Flow	**Actor** 1. The user provides the personal details required for BMI calculation. 2. Submits the information for BMI determination and plan generation. **System** 1. Receives user input and calculates BMI based on provided information. 2. Utilizes the calculated BMI and user inputs to retrieve corresponding exercise and diet plans from the database. 3. Generates personalized exercise and diet plans tailored to the user's BMI range and preference.

Alternate Flows	None
Extended use cases	None
Included use cases	• Generate BMI and user inputs based Diet plans. • Generate BMI and user inputs based Exercise plans.
Post-condition	BMI and user preference-based exercise and diet plans are generated and provided to the user based on their information and calculated BMI.

Use Case ID	**03**
Use Case Name	**Updates and System Management**
Overview	The System Administrator performs system updates and manages the system efficiently.
Participating Actor(s)	System Administrator
Pre-conditions	The system and model for posture correction exercises are in place.
Main Flow	**Actor** 1. The System Administrator assesses the system's performance and identifies areas for improvement. 2. Develop strategies and implement measures to enhance system efficiency. 3. Initiates system updates and ensures proper management of system resources. **System** 1. Receives guidance and directives from the System Administrator. 2. Executes the necessary system updates and management tasks as directed. 3. Ensures smooth operation and adherence to the specified system management protocols.
Alternate Flows	None
Extended use cases	None
Included use cases	None
Post-conditions	The system is updated, efficiently managed, and optimized, ensuring users receive enhanced experiences meeting their needs.

4.9. Functional Requirements

The **MoSCoW** method will be used for prioritizing the most crucial aspects of the project for initial implementation.

FR	Requirement and Description	priority
FR01	Detection of incorrect postures during exercises	**Must Have**
	The system should accurately detect incorrect postures.	
FR02	Multi-angle posture assessment	**Must Have**
	the Ability to assess and correct postures from various angles to ensure comprehensive correction.	
FR03	Personalized corrective guidance	**Must Have**
	Provide personalized feedback and corrective suggestions tailored to individual user postural needs.	
FR04	Intuitive user interface	**Must Have**
	Develop an easy-to-use interface to give feedback on the incorrect postures	
FR05	Progress tracking and analytics	**Should Have**
	Track user progress over time and provide analytics to monitor improvements in posture.	
FR06	Recommendation of exercise plans	**Should Have**
	Recommending exercise plans based on user preferences	
FR07	Recommendation of diet plans	**Should Have**
	Recommending diet plans based on user preferences	
FR08	Voice-guided instructions	**Could Have**
	voice-guided instructions for posture correction exercises.	
FR09	Social sharing of progress	**Could Have**
	Enabling users to share their posture correction progress on social media platforms	
FR10	AI-driven adaptive feedback	**Could Have**
	a Desirable feature using AI to adaptively adjust feedback based on user response and progress.	

Table 10 Functional requirement

4.10. Non-Functional Requirements

NFR	Requirement and Description	Specification	Priority
NFR01	The system should correctly identify incorrect postures and provide feedback. Accuracy in identifying incorrect posture is vital in assisting the user.	Accuracy	**Must Have**
NFR02	Smooth process of the input video. Visual input contains a large amount of data, smooth processing of data and improving performance improves user satisfaction.	Performance	**Should Have**
NFR03	The system should be implemented in a way that the user data will be secured or encrypted. As it contains sensitive information	Security	**Should Have**
NFR04	The Application Should be easy to use and navigate and the feedback mechanism should be easy to understand by the user	Usability	**Could Have**
NFR05	The developer should be able to add more models or upgrade the system in the future in an easier manner.	Maintainability	**Could Have**

Table 11 Nonfunctional requirement

4.11. Chapter Summary

The project stakeholders and their involvement were described at the beginning of the chapter. Many requirement-gathering techniques were examined and used. The system's context and basic use cases have then been given. Prioritizing the function, non-functional needs were done after gathering them from the Use case definition.

5. Social, Legal, Ethical and Professional Issues

5.1. Chapter overview

Evaluation of all kinds of outside influences on the developed program is aided by the SLEP analysis. We now have the chance to view the environment within this project in its entirety thanks to this. [Ethical, Professional, Social, and Legal] SLEP.

5.2. SLEP Issues and Mitigation

1.1.1. Social Issues and Mitigation

- **Accessibility**: Ensuring the app is accessible to users of all abilities, including those with disabilities or limited access to technology
- **Health Inequality**: Addressing differences in healthcare access and resources among marginalized communities ensures that the app's benefits reach those who need them most.
- **Cultural Sensitivity**: Tailoring the app's recommendations and content to diverse cultural backgrounds fosters user engagement.
- **Privacy and Data Security**: Implementing robust privacy measures to protect user data builds trust and confidence in the app, safeguarding users' sensitive information.
- **Social Support and Motivation**: Incorporating features that promote social support, such as community forums and virtual coaching, enhances user engagement.

5.2.1. Legal Issues and Mitigation

- **Obtain data from reliable sources**: Acquire information from reliable official sources and research papers, making sure to properly credit and reference them in the project thesis.
- **Privacy and Data Security**: Gather information in an ethical manner, making sure to abide by the sources' terms and conditions and not sharing or distributing any information to unaffiliated third parties.
- **Adhere to Legal Guidelines in Healthcare**: When creating healthcare products, only consult legally licensed and certified medical professionals for advice.
- **Licensing and Intellectual Property Compliance**: To ensure compliance with licensing agreements and intellectual property regulations, use legally authorized software tools during the product's creation.

- **Accountability**: The project team is accountable for the project's successful completion and takes full responsibility for managing all issues and difficulties that arise throughout the project.

5.2.2. Ethical Issues and Mitigation

- **Ensure Privacy and Data Confidentiality**: Maintaining the privacy of user information and confidentiality of user data and not sharing or selling it to third parties without permission.
- **Transparency**: Being transparent about the information sources, the philosophy behind the application's recommendations and any conflicts of interest.
- **Promote User Autonomy**: Providing user's meaningful choices and options regarding their health goals to respect their autonomy.
- **Secure Informed Consent**: Requiring users to give their informed consent before sharing personal health information or engage in any exercise or diet recommendations made by the app.
- **Uphold Ethical Standards**: Respecting ethical standards in all aspects of app creation and operation including honesty in advertising, precise in information and accountability for misconduct or any errors.

5.2.3. Professional Issues and Mitigation

- **Ensure Data Transparency and Security**: Transparency about data collection and usage, coupled with robust privacy and data security safeguards, are essential for building user confidence and trust.
- **Offer Adequate Notice**: The participants who completed the questionnaire were given enough notice to provide them enough time to adequately prepare for the deadlines.
- **Utilize Legal Software Tools**: The project is developed without the use of any illegal or illegally obtained software tools.
- **Adhere to Standards**: The project is completed in compliance with industry and academic standards throughout.
- **Implement Version Control**: Developers use version control systems like GitHub to write and manage code.

5.3.Chapter Summary

This chapter listed potential social, legal, ethical, and professional issues and the mitigatable ways.

6. System Architecture & Design

6.1. Chapter Overview

This chapter covers the basic system design architecture & design for the implementation. It includes discussions on design paradigms, components, sequence diagrams, class structures, UI/UX design, and the process flowchart.

6.2. Design Goals

Design Goals	Description
User Friendly	There must be a user-friendly app interface to interact with users and UX must be focused on usability and accessibility of the program to give best user satisfaction.
Performance	The system must function efficiently and rapidly to give optimal feedback to the user movements and exercises.
Accuracy	System should detect key points of the body and track movements accurately.
Security	User data must not be accessed by third parties and filter sensitive data for better privacy.
Iteration	Incorporate with users to improve system development using their feedbacks

Table 12 Design Goals

6.3. System Architecture Design

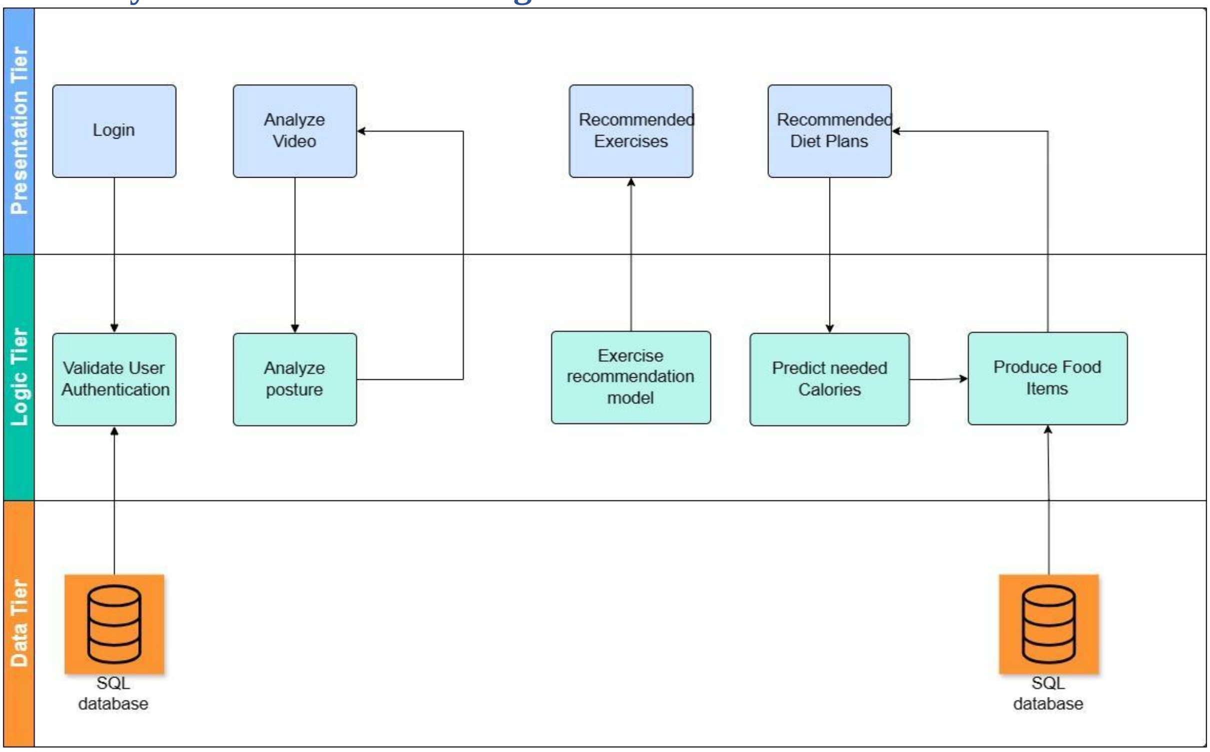


Figure 8 System Architecture Design

- **Presentation Tier:**
  - **Login:** Enables user to sign into the app

- **Analyze Video:** Enables user to input exercise video to receive feedback.
- **Exercise Recommendation:** Enables user to input options and receive exercise recommendations.
- **Diet Recommendation:** Enables user to input options and receive diet recommendations.

- **Logic Tier:**
  - **Validate user Authentication:** Checks if the user profile exists in the database.
  - **Analyze Posture:** Analyzes the exercise video to provide feedback.
  - **Exercise recommendation**: Identifies exercises to recommend to the user using Random Forest model.
  - **Predict Calories:** Predicts calories needed for user based on user preference.
  - **Produce Food items:** Creates a set of food items based on the calories needed using Subset algorithm.
- **Data Tier:**
  - **SQL database:** Stores user credentials
  - **SQL database:** Stores food items

6.4. System Design

6.4.1. Choice of Design Paradigm

OOAD was chosen as the preferred design Paradigm. It emphasizes the use of objects which are instances of classes, to represent real-world entities and their interactions within a system. Using OOAD the project is easily scalable, easy to understand, has high code reusability and flexibility.

6.4.2. Component Diagram

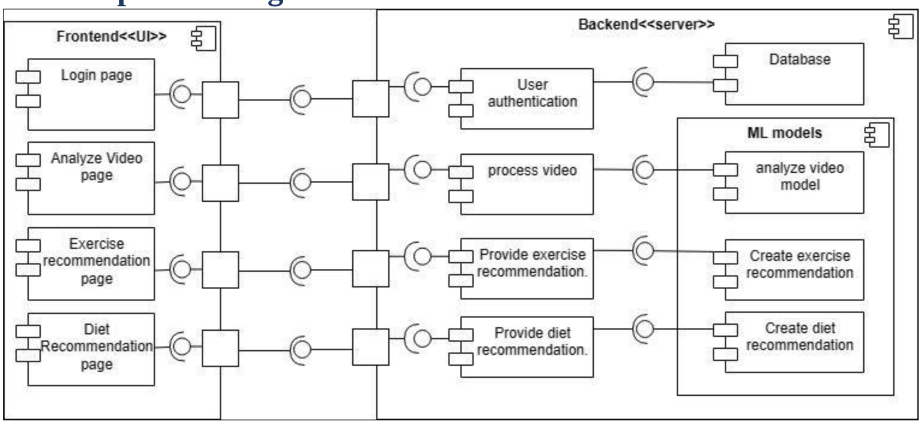


Figure 9 Component Diagram

6.4.3. Class Diagram

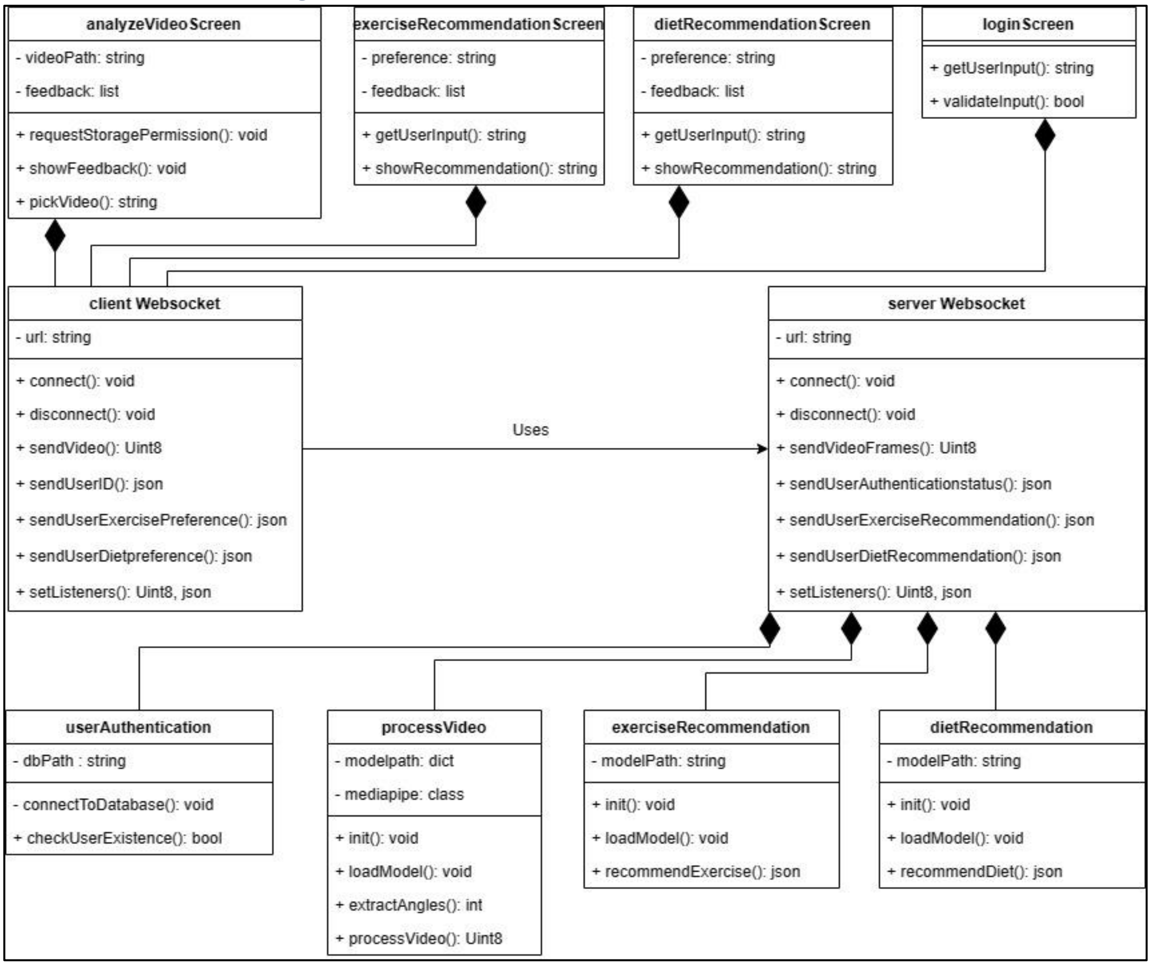


Figure 10 Class Diagram

6.4.4. Sequence Diagram

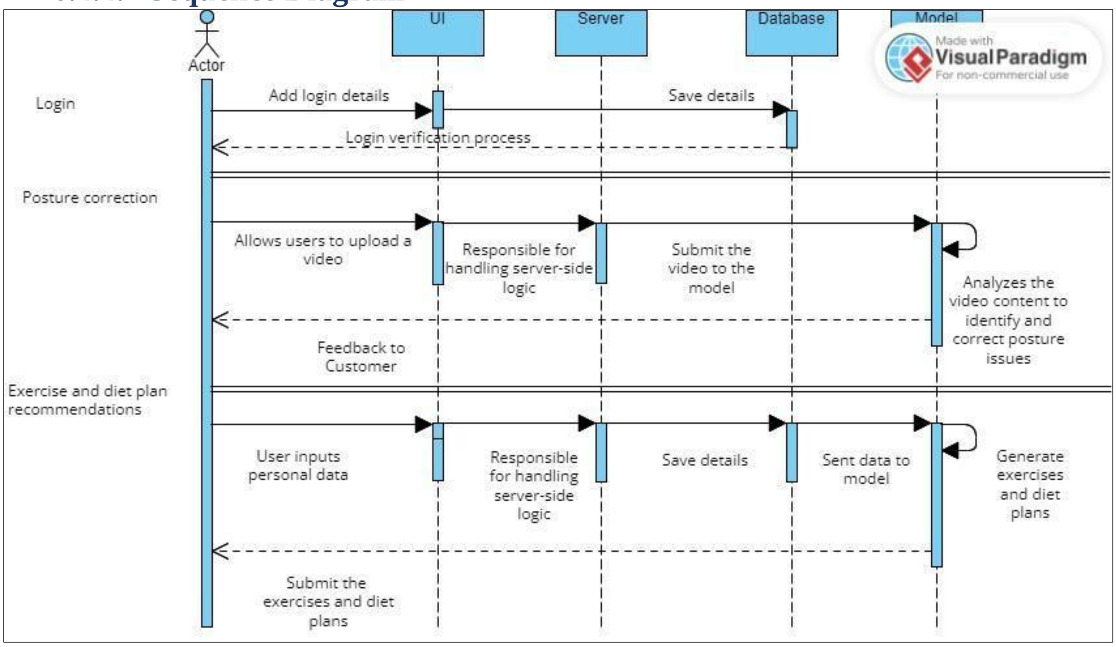


Figure 11 Sequence diagram.

6.4.5. UI Design

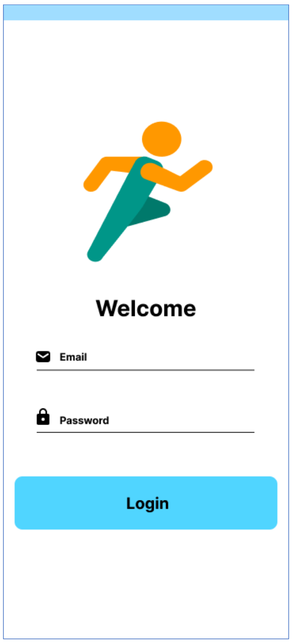


Figure 15 Login Page

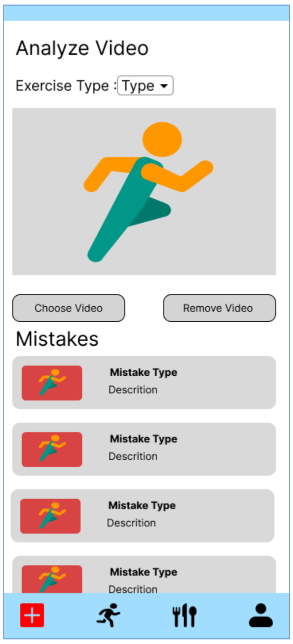


Figure 14 Posture analysis Page

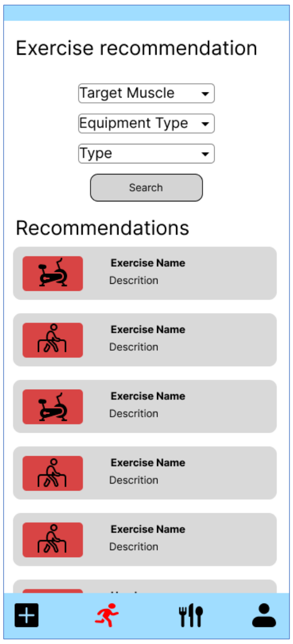


Figure 13 Exercise recommendation Page

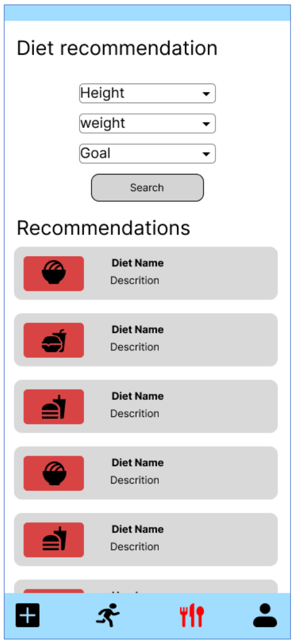


Figure 12 Diet Recommendation page

6.4.6. User Experience

Ease of use: the main components are easily accessible due to its simple design using bottom bar tabs.

Real Time content delivery: With the use of WebSocket the content will be delivered to the user in real time.

Feedback and rating: Collect user feedback and rating to gather user insights and improve the product.

6.4.7. Process Flow Chart

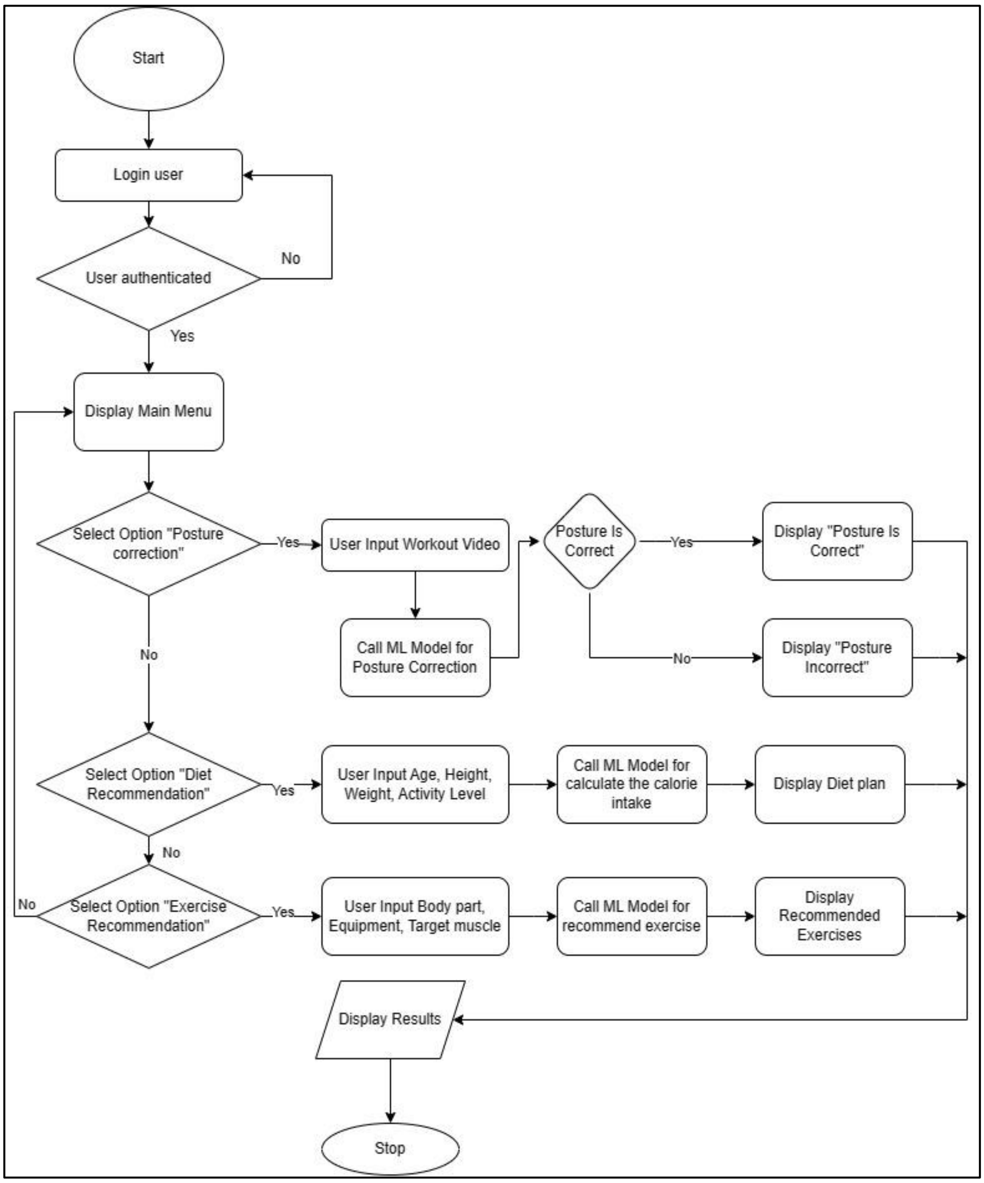


Figure 16 Process Flow chart.

6.5. Chapter Summary

In this chapter we defined and designed the system components and the flow of interactions with the user enabling us to identify and objectify the program fundamentals.

7. Implementation

7.1.Chapter Overview

In this chapter, we delve into the intricacies of the tools and programming languages employed to construct the models for posture correction, personalized diet generation, and exercise plans. A comprehensive examination of the technology stack, encompassing the frameworks and languages utilized, is presented. The chapter also elucidates the dataset employed in the project, shedding light on the pivotal role it plays. Additionally, the methodologies harnessed throughout the project development lifecycle are scrutinized, providing insights into the approach taken to achieve the project's objectives.

7.2.Technology Selection

7.2.1. Technology Stack

Several technologies were used in the process of developing the posture correction model in order to expand and improve its functionalities. The posture correction models were strengthened by the project's extensive use of scikit-learn (sklearn), Media pipe, and other relevant libraries. Flask API was utilized to enable the deployment and integration of these models, guaranteeing smooth functionality and accessibility within the project's framework.

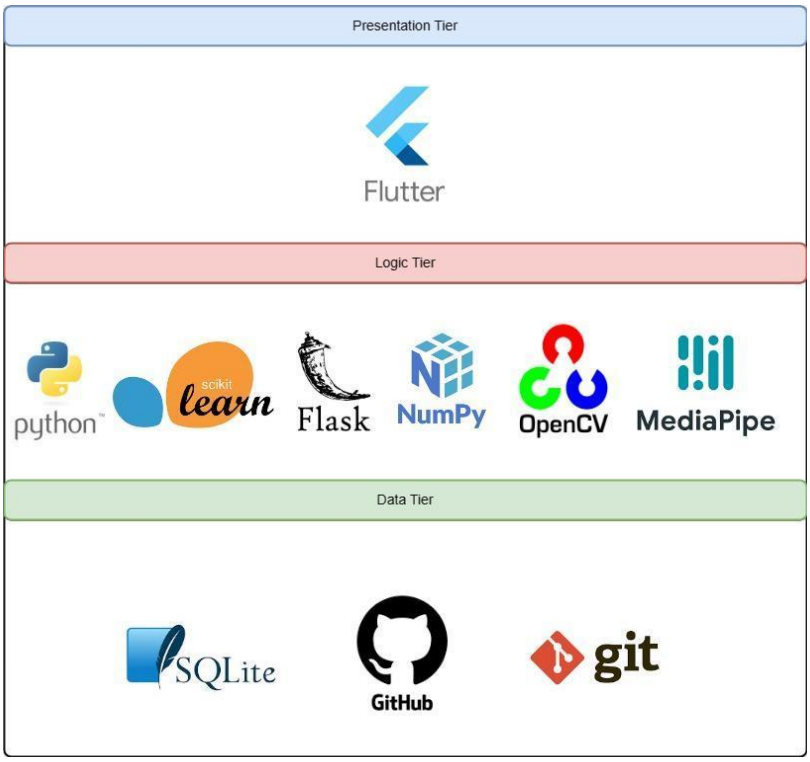


Figure 16 Technology Stack

7.2.2. Data Selection

Building the posture correction model required careful consideration of the dataset selection process. The selection of datasets specifically designed for the development of the posture correction model in this project was guided by a thorough analysis of related literature and previous projects.

Component	Dataset	Description
Posture analysis	Dataset was newly created.	Dataset consists of 17 columns. Column 1-16 has angles of the subject in each frame. Column 17 has the label defining the correctness of the posture which is true or false.
Exercise Recommendation	Exercise dataset	Exercise with columns such as exercise name, target body part, instructions, and needed equipment
Diet Recommendation	Calories dataset	This dataset has columns such as age, weight, height, gender, Body Mass Index (BMI), activity level, calories needed to maintain weight, BMI categories.

Table 13 Datasets

7.2.3. Selection of Development Framework

- Frontend

The mobile app's user interface was crafted using Flutter, a versatile framework that ensures a seamless and responsive design. Flutter provides a robust foundation for creating an appealing and user-friendly interface. Additionally, various Flutter plugins and libraries, including Google Fonts, were incorporated to enhance the visual aesthetics and incorporate icons and graphics, contributing to an enriched user experience.

- Backend

Flask is used to create the backend of the application it connects with the frontend application through a WebSocket. It receives the inputs from the user, uses the relevant model, produces the results, and sends them back to the front end.

7.2.4. Programming Language

For the front-end flutter dart was used due to its OOP principles and the ease of implementation facilitated by its widget tree structure. Applications made by flutter can be written only once and it can run on multiple platforms.

For the backend and to train and deploy the model python was chosen as the desired library due to its extensive collection of libraries, such as TensorFlow, PyTorch, and scikit-learn, which simplify machine learning tasks and deployment processes.

7.2.5. Libraries

Name	Version
Mobile Application	
Flutter	3.19.0
Dart	3.3.0
Socket io client	2.0.3
File picker	6.1.1
Server side	
Flask	2.3.1
Flask-Socket IO	5.3.6
AI models	
OpenCV python	4.7.0.72
Media pipe	0.10.7
Pandas	2.0.0
NumPy	1.24.3
Scikit Learn	1.3.0

Table 14 Used Libraries

7.2.6. IDE

Jupyter Notebook was used for python machine learning-related tasks and VS code was used to create the front-end using flutter.

7.2.7. Summary of Technology Selection (Tabular Format)

Component	Tool	Version
Programming Language	Python	3.11.0
	Dart	3.3.0
Design	Figma	-
IDE	PyCharm	2023.3.4
	VS Code	1.87.1

Table 15 Technology selection

7.3. Implementation of Core Functionalities

7.3.1. Analyze Posture

```
Input: video path
Output: prediction

cap ← cv2.VideoCapture(video path)

WHILE cap.isOpened() DO
   success, image ← cap.read()
   IF NOT success THEN
      BREAK
   END IF

   image_rgb ← cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
   results ← pose.process(image_rgb)

   IF results.pose_landmarks THEN
      landmarks ← results.pose_landmarks

      data_dict ← {}
      FOR landmark IN mp_pose.PoseLandmark DO
         x_key ← f"{landmark.name} _Point_x"
         y_key ← f"{landmark.name} _Point_y"
         z_key ← f"{landmark.name} _Point_z"
         visibility_key ← f"{landmark.name} _visibility"

         data_dict[x_key] ← []
         data_dict[y_key] ← []
         data_dict[z_key] ← []
         data_dict[visibility_key] ← []

         FOR index IN RANGE (len(landmarks.landmark)) DO
            data_dict[x_key]. append(landmarks.landmark[index].x)
            data_dict[y_key]. append(landmarks.landmark[index].y)
            data_dict[z_key]. append(landmarks.landmark[index].z)
            data_dict[visibility_key]. append(landmarks.landmark[index].visibility)
         END FOR
      END FOR

      df ← pd.DataFrame(data_dict)
      angles_df ← pd.DataFrame()

      angle_types ← ['Right_Elbow', 'Left_Elbow', 'Right_Shoulder', 'Left_Shoulder',
                     'Right_Knee', 'Left_Knee', 'Right_Hip', 'Left_Hip', 'Neck']
      FOR angle_type IN angle_types DO
         angle_columns ← [f'{side}_{angle_type} _Point_x' for side IN ['RIGHT', 'LEFT']]
         angle_columns += [f'{side}_{angle_type} _Point_y' for side IN ['RIGHT', 'LEFT']]
         angles_df[f'Angle_At_{angle_type}'] ← df[angle_columns]. apply (self.calculate_angle, axis=1)
      END FOR
```

```
      prediction ← model.predict(angles_df)
      image ← draw_line_and_send(image, landmarks)
      Return prediction, image.

   END IF
END WHILE
```

7.3.2. Exercise Recommendation

```
BEGIN

INPUT (user_body_part, user_equipment, user_target)

data ← pd.get_dummies(data, columns=['bodyPart', 'equipment', 'target'])
X ← data.drop(columns=['name', 'secondaryMuscles', 'Predicted_Level', 'gifUrl', 'instructions'])
y ← data[['name', 'secondaryMuscles', 'Predicted_Level', 'gifUrl', 'instructions']]

X_train, X_test, y_train, y_test ← train_test_split(X, y, test_size=None, random_state=42)

model ← RandomForestClassifier(n_estimators=100, random_state=42)
model.fit(X_train, y_train)

matching_exercises ← data[(data['bodyPart'] == user_body_part) AND (data['equipment'] ==
user_equipment) AND (data['target'] == user_target)]

WITH open("exercise_model.pkl", "wb") AS f:
   pickle.dump(model, f)

WITH open("exercise_model.pkl", "rb") AS f:
   model = pickle.load(f)

PRINT("Please provide the following information:")
body_part ← input("Body Part: ")
equipment ← input("Equipment: ")
target ← input("Target: ")

user_inputs ← {
   f'bodyPart_{body_part}': 1,
   f'equipment_{equipment}': 1,
   f'target_{target}': 1
}

input_df ← pd.DataFrame([user_inputs])

training_columns ← model.feature_names_in_.tolist()

input_df ← input_df.reindex(columns=training_columns, fill_value=0)

predictions ← model.predict(input_df)
```

```
PRINT("\nExercise Details:")
PRINT("Name:", predictions[0][0])
PRINT("Secondary Muscles:", predictions[0][1])
PRINT("Predicted Level:", predictions[0][2])
PRINT("GIF URL:", predictions[0][3])
PRINT("Instructions:", predictions[0][4])

END
```

7.3.3. Diet Recommendation

```
Input: Gender, Height, Weight
Output: Food Item List

BEGIN
   INPUT (user_age, user_gender, user_weight, user_height)
   BMI = user_weight / (user_height ** 2)
   IF user_gender == "M":
      user_BMR = (10 * user_weight) + (600.25 * user_height) - (5 * user_age) + 5
   ELSE IF user_gender == "F":
      user_BMR = (10 * user_weight) + (600.25 * user_height) - (5 * user_age) - 161
   ELSE
      end
   Load model = ('best_model.pkl')
   User Inputs = [[user_age, user_weight, user_height, BMI, user_BMR]]
   Predict = Predict needed calories
   rounded_value = round (Predict [0] / 50) * 50

   READ csv.
   csv_file_path = 'Foods.csv'
   data = read_data_from_csv(csv_file_path)
   FOR i=1 to (1000):
      shuffled_data = data.sample(frac=1). reset_index(drop=True)
      result = subset_sum_pandas(shuffled_data, target)

      IF result is not None:
         return result.
      ELSE
         return None
      END IF
   END FOR
END

FUNCTION subset_sum_pandas(data, target):
   subset = copy(data)
   subset['Selected'] = 0

   WHILE TRUE:
      random_index = random.randint(0, len(subset) - 1)
      subset.at [random_index, 'Selected'] = 1
      current_sum = subset.loc[subset['Selected'] == 1, 'Calories']. sum()

      IF current_sum == target:
         return subset.loc[subset['Selected'] == 1, ['Food', 'Serving']]
      ELIF current_sum > target:
```

```
        subset.at [random_index, 'Selected'] = 0
      END IF
   END WHILE
END FUNCTION

target_calories = rounded_array
result = subset_sum_random_pandas(data, target_calories)

DISPLAY

IF Result is not NON
   print (f"Foods and Servings to achieve {target_calories} calories:")
   print(result)
ELSE:
   print (f"No combination found to achieve {target_calories} calories.")
END.
```

7.4.GitHub URL to Implementation

URL: [Aadhil21/DSGP-Group28 (github.com)]

7.5.Chapter Summary

This chapter explores the selection of technologies, datasets, and implementation. Through a thorough examination of the technology stack and implementation processes for the overall project and the individual components

8. Testing

8.1. Chapter Overview

The chapter begins by establishing testing objectives and goals, followed by a discussion of testing criteria for determining software testing effectiveness. It also discusses model evaluation, including how to compute accuracy, F1 Score, precision, and recall with a confusion matrix. Furthermore, it covers benchmarking, functional testing, module and integration testing, and nonfunctional testing, such as accuracy testing, and performance testing.

8.2. Objectives and Goals of Testing

The goals of software development testing include detecting and avoiding flaws, guaranteeing compliance with functional and non-functional requirements, improving product reliability and quality, and improving the user experience. Testing also resolves system faults and security concerns, which reduces development risks while fulfilling stakeholder and end-user expectations.

8.3. Testing Criteria

Evaluating the quality of code represents a crucial facet of the testing process. The assessment of a product's quality encompasses several dimensions, including:

1.**Reliability**: Reliability, defined as the chance that a system will function without failure for a certain length of time, is dependent on both the frequency of errors and the software's accessibility.

2.**Maintainability**: This dimension gauges how easily software can be maintained over time. Factors influencing maintainability include the size, consistency, structure, and complexity of the underlying codebase.

3.**Testability**: Reflecting the degree to which software facilitates testing endeavors, testability is contingent on the extent to which one can control, monitor, isolate, and automate testing processes.

4.**Performance**: The term 'performance' describes how efficiently an application utilizes its resources. This aspect of code quality significantly influences customer satisfaction, reaction times, and the scalability of the software.

8.4. Model Evaluation

Separate model evaluation criteria were taken for the classification and regression type models by evaluating them on test sets.

Component	Model Used
Posture analysis	SVM, KNN
Exercise Recommendation	Logistic Regression Random Forest Classifier
Diet Recommendation	XGboost Regression

8.4.1. Classification Models:

Confusion Matrix:

		Predicted	
		0	1
Actual	0	True Negative	False Positive
	1	False Negative	True Positive

Classification Report:

- **Precision**,

Precision:

$$\text{Precision} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Positives}}$$

- **Recall**,

Recall:

$$\text{Recall} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Negatives}}$$

- **Accuracy**,

Accuracy:

$$\text{Accuracy} = \frac{\text{True Positives}+\text{True Negatives}}{\text{Total Instances}}$$

- **F1 score,**

F1 Score:

$$\text{F1 Score} = \frac{2\times\text{Precision}\times\text{Recall}}{\text{Precision}+\text{Recall}}$$

8.4.2. Regression Models:

- **Mean Absolute Error (MAE):**

Mean Absolute Error (MAE):

$$\text{MAE} = \frac{1}{n}\sum_{i=1}^{n}|y_i - \hat{y}_i|$$

- **Mean Squared Error (MSE):**

Mean Squared Error (MSE):

$$\text{MSE} = \frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$$

- **Root Mean Squared Error (RMSE):**

Root Mean Squared Error (RMSE):

$$\text{RMSE} = \sqrt{\text{MSE}}$$

8.4.3. Confusion Matrix (Accuracy/F1 Score/Precision/Recall)

8.4.3.1. Analyze posture.

Metric	Value
True Positive	Posture correctly classified as correct
True Negative	Posture correctly classified as incorrect
False Positive	Posture incorrectly classified as correct
False Negative	Posture incorrectly classified as incorrect

- **Push-up**

  Classification report and Confusion Matrix

```
Accuracy Score: 0.8434
Classification Report:
              precision    recall  f1-score   support

           0       1.00      0.65      0.79       513
           1       0.78      1.00      0.88       624

    accuracy                           0.84      1137
   macro avg       0.89      0.83      0.83      1137
weighted avg       0.88      0.84      0.84      1137
```

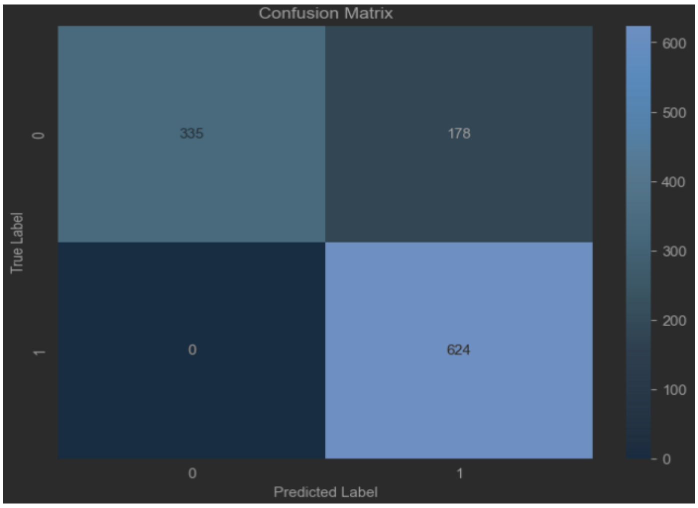
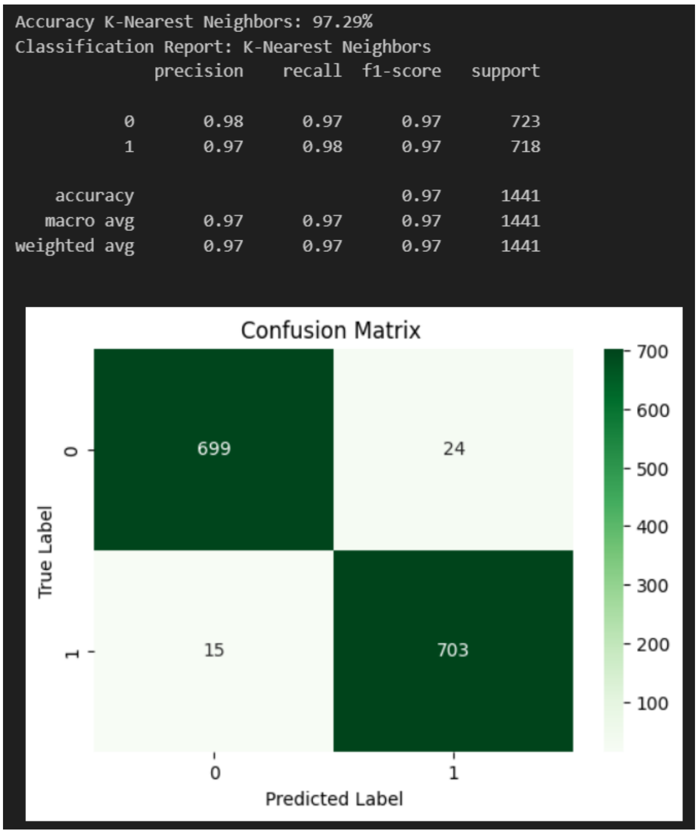


Figure 17 Pushup model confusion matrix, classification report

- **Sit-up**
  Classification report and Confusion Matrix



```
Accuracy K-Nearest Neighbors: 97.29%
Classification Report: K-Nearest Neighbors
              precision    recall  f1-score   support

           0       0.98      0.97      0.97       723
           1       0.97      0.98      0.97       718

    accuracy                           0.97      1441
   macro avg       0.97      0.97      0.97      1441
weighted avg       0.97      0.97      0.97      1441
```


Figure 18 Situp model confusion matrix, classification report

- **Mountain climbing**
  Classification report and Confusion Matrix

```
Accuracy Support Vector Machine: 76.82%
Classification Report: Support Vector Machine
              precision    recall  f1-score   support

           0       0.82      0.73      0.77       771
           1       0.72      0.81      0.77       670

    accuracy                           0.77      1441
   macro avg       0.77      0.77      0.77      1441
weighted avg       0.77      0.77      0.77      1441
```

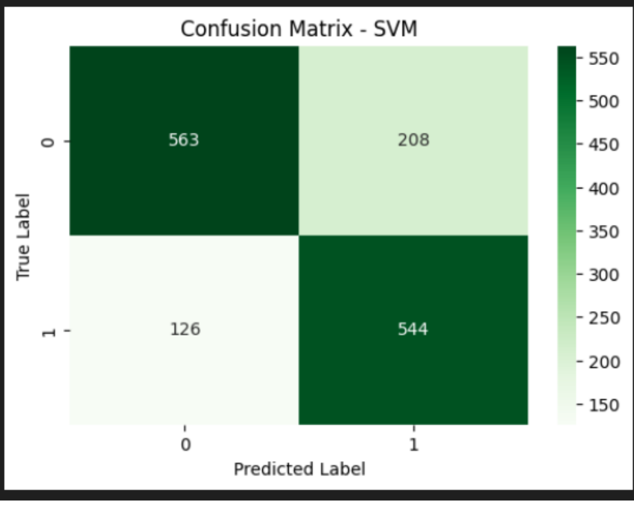


Figure 19 Mountain climb model confusion matrix, classification report

- **Pull-up**
  Classification report and Confusion Matrix

```
Accuracy Support Vector Machine: 77.45%
Classification Report: Support Vector Machine
              precision    recall  f1-score   support

           0       0.81      0.74      0.77       749
           1       0.74      0.81      0.78       692

    accuracy                           0.77      1441
   macro avg       0.78      0.78      0.77      1441
weighted avg       0.78      0.77      0.77      1441
```

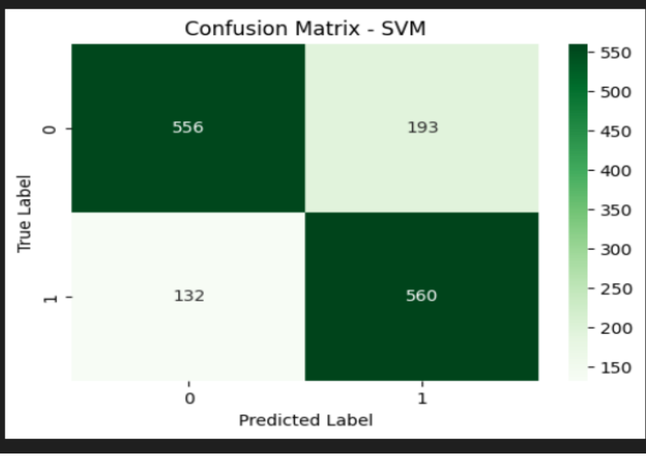


Figure 20 Pullup model confusion matrix, classification report

- **Squat**

  Classification report and Confusion Matrix

```
Accuracy K-Nearest Neighbors: 96.67%
Classification Report: K-Nearest Neighbors
              precision    recall  f1-score   support

           0       0.97      0.96      0.97       692
           1       0.96      0.97      0.97       749

    accuracy                           0.97      1441
   macro avg       0.97      0.97      0.97      1441
weighted avg       0.97      0.97      0.97      1441
```

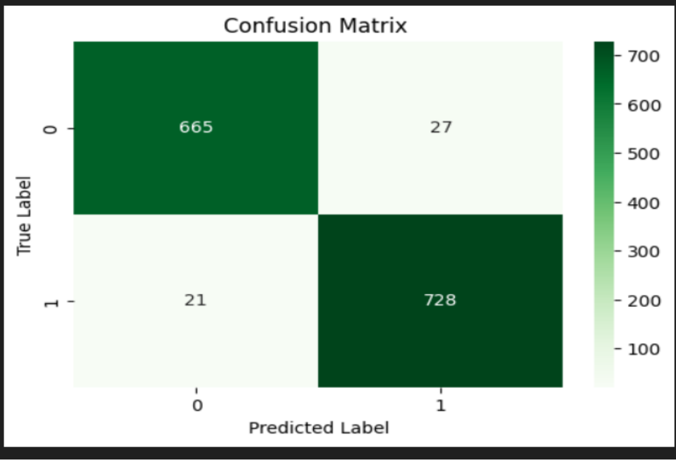


Figure 21 Squat model confusion matrix, classification report

8.4.3.2. Exercise recommendation.

Classification report

Accuracy: 0.8458904109589042

	precision	recall	f1-score	support
Beginner	0.62	0.22	0.33	95
Expert	0.00	0.00	0.00	3
Intermediate	0.86	0.97	0.91	486
accuracy			0.85	584
macro avg	0.49	0.40	0.41	584
weighted avg	0.82	0.85	0.81	584

Figure 22 Exercise recommendation model classification report

Confusion matrix

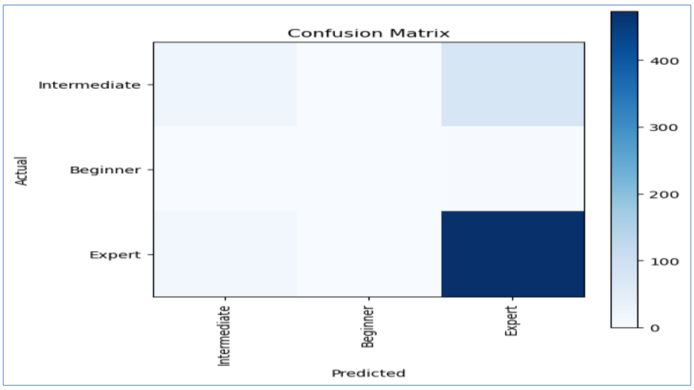


Figure 23 Exercise recommendation model confusion matrix

8.4.4. Regression performance metrics

8.4.4.1. Diet Recommendation

Boston test

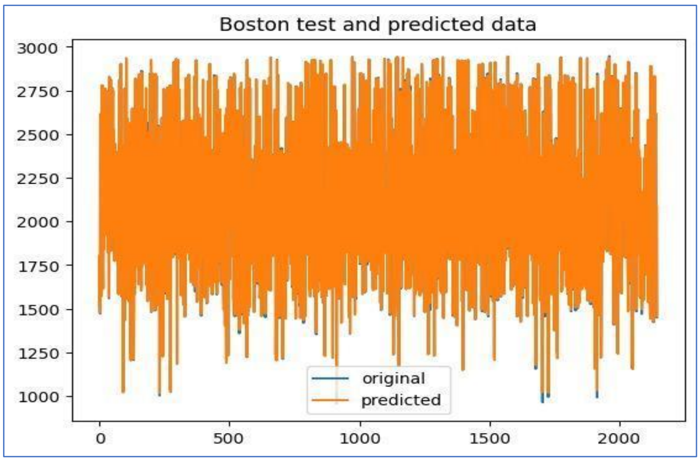
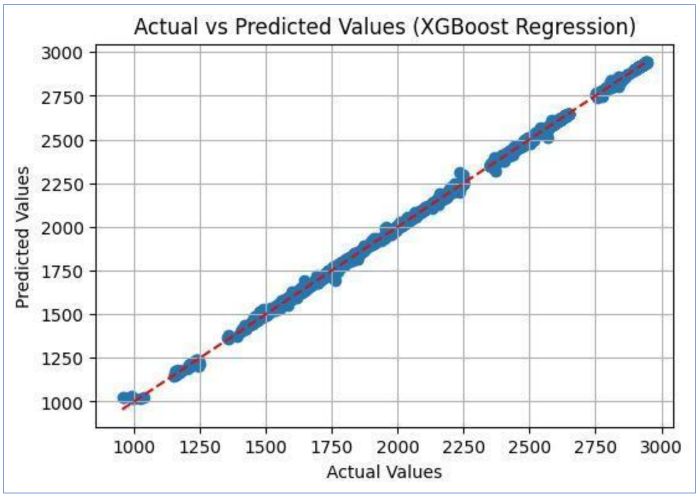


Figure 24 Boston test

Actual values vs Predicted values.



MAE, MSE, RMSE, R-squared

```
Mean Absolute Error: 4.004020341123387
Mean Squared Error: 57.17411816709504
Root Mean Squared Error: 7.56
R-squared: 0.9996387348295614
```

Figure 25 MAE,MSE,RMSE,R^2 for calorie prediction

8.5.Benchmarking

Component	Relevant comparison	Comparison
Analyze posture	(Militaru, Militaru and Benta, 2021)	The testing was done on a test dataset which includes 20%of the train dataset. Our model got close to 88% accuracy.
Exercise Recommendation	(Annapoorna *et al.*, 2023)	The testing was done on a test dataset which includes 20%of the train dataset.

		Our model got close to 85% accuracy which indicates the model is doing relatively well
Diet Recommendation	(Panwar *et al.*, 2023)	The testing was done on a test dataset which includes 20%of the train dataset. Our model has an MAE of 4.0 which is close to the benchmarked comparison model.

Table 16 Benchmarking

8.6.Functional Testing

There are various methods for testing that can be applied. All these strategies have advantages and disadvantages of their own. Here are a few typical methods.

- **Manual testing**: In this method, a person evaluates the product by hand. This may take more time and be less effective.
- **Black box testing**: In this type of testing, the software architecture and source code are not accessible to the tester. The functional requirements, user interface, and other external criteria are the focus of this test.
- **White box testing**: This type of testing entails a tester who has access to the software architecture, design, and source code. Here, the design, maintainability, and quality of the source code are evaluated.

However, since access is not required, black box testing is the best testing strategy for functional testing.

Test case	Description	Input	Expected outcome	Output	Status
1	Login Functionality	Username, Password	Successful login and redirection to the user dashboard	User redirected to the dashboard page	Pass
2	Posture Correction Model	Various posture data samples	Correct identification of poor posture and recommendation for correction	Posture correction recommendation	Pass
3	Exercise Recommendation Model	User profile (age, gender, weight, fitness level)	Personalized exercise recommendations tailored to user preferences and fitness goals	Recommended exercise regimen	Pass

4	Diet Recommendation Model	User profile (age, gender, weight, height, activity level)	Accurate calculation of daily calorie needs based on user profile and fitness goals	Recommended daily calorie intake for achieving fitness goals	Pass

Table 17 Test Cases

8.7. Module and Integration Testing

- Evaluating each component individually before integrating them
- Evaluating the models with test datasets
- Fix errors encountered during integration testing.

8.8. Non-Functional Testing

8.8.1. Accuracy Testing

- Compare predicted results with actual outcomes.
- Assess model performance across different scenarios.
- Implement feedback for continuous improvement.

8.8.2. Usability Testing

User Interface (UI):

- Evaluate the design and layout to ensure simple navigation.
- Consider visual aspects like colors, typography, and icons.
- Evaluate the layout's structure and label clarity.
- Ensure that all users have access to accessibility features.

User Experience (UX):

- Evaluate overall satisfaction and effectiveness.
- Prioritize simplicity of use and responsiveness.
- Provide feedback tools for user activities.
- Provide customizing choices to ensure a personalized experience and ease of use.

8.8.3. Performance Testing

- Output Prediction: The model appears to have performed well, as evidenced by the high accuracy of the posture correction prediction.
- Time-consuming: For posture correction exercises, time calculations are crucial to high accuracy of the model guarantees useful recommendations.

8.8.4. Load Balancing

- Assess the system's capacity to manage various loads and traffic.
- Determine the system's reaction time and resource utilization under varying load situations.
- Monitoring and analyzing performance indicators can help you identify possible bottlenecks and improve resource allocation.

8.9.Limitations

Limitation	Possible Solution
The posture correction model may not accurately identify all instances of poor posture. Ex: the model is not created for a 360-degree view, so occasionally the predictions may be off.	Enhance the posture correction algorithm by incorporating additional features or data Implement a feedback mechanism where users can provide corrections or annotations to improve model performance over time.
The exercise recommendation model may provide generic recommendations that do not fully align with users' individual preferences and goals.	Enhance the model with personalized recommendation algorithms that consider users' specific fitness objectives, preferences, and levels. Allow users to provide feedback on recommended exercises to refine future recommendations.
The diet recommendation model may not accurately estimate calorie needs for individuals with unique metabolic rates or dietary requirements.	Incorporate more sophisticated algorithms that account for individual factors such as metabolic rate, activity level, and dietary preferences. Provide users with the option to input additional data points or consult with a nutritionist for personalized recommendations.
The login functionality may be vulnerable to security threats such as brute force attacks or password guessing.	Implement strong password policies. Regularly update and patch system vulnerabilities to protect against potential security breaches.

Table 18 Limitations and possible solution

8.10. Chapter Summary

Addressing gaps in posture correction, exercise, and food recommendations models. The proposed solutions include algorithm improvements and feedback methods. Strengthening login security with strong regulations and frequent upgrades reduces vulnerabilities.

9. Evaluation

9.1. Chapter Overview

This section includes an evaluation of the system by domain and technical expert, as well as an appraisal of the authors' own performance. Implemented and functional and non-functional requirements are also added.

9.2. Evaluation Methodology and Approach

Collaborating with technical specialists and health professionals, the system that uses machine learning models to correct posture during exercises can be evaluated. Their opinions can offer insightful information on how well the system works.

9.3. Evaluation Criteria

- Project Concept
- Project Scope
- System design and Architecture
- Solution and Prototype
- UI and UX

9.4. Self-Evaluation

Criteria	Author's evaluation
Project Concept	The main idea behind the project is to create a smartphone application to help people improve their posture while exercising. It also includes individualized exercise and diet recommendations based on individual user data, with the goal of improving overall fitness and well-being.
Scope of the project	The project involves creating a mobile application using Flutter for frontend development and Flask for backend operations. The primary goal is to create effective posture correction functionalities while also providing consumers with individualized workout and diet suggestions. Which will be advantageous to the users.
System Design, Architecture, and implementation	The system architecture uses a client-server model, with Flutter for frontend rendering and Flask for backend logic. This architectural solution promotes scalability and maintainability while allowing for smooth communication between components. The implementation phase is characterized by rigorous attention to detail, resulting in a robust system with an intuitive user interface.
Solution and Prototype	A detailed prototype has been successfully created, demonstrating the application's posture correction capabilities and individualized recommendations. Despite the prototype's functional completeness,

	further modification is needed to improve performance and user experience.

Table 19 Self evaluation

9.5.Selection of Evaluators

Group	Affiliation	Reason
Technical domain expert	Software Engineer	We need a technical expert for providing technical support.
Medical domain expert	Doctor	We need a health expert for providing health knowledge support.

9.6.Evaluation Results

Question	
1.What do you think about the overall project?	
Person	Feedback
Technical domain expert	The project has a lot of potential. A major demand in health and fitness is addressed by the creative idea of developing a mobile app that offers individualized exercise and food advice together with posture correction.
Medical domain expert	Overall, this project has a lot of promise. With easily available technology, it can enable individuals to enhance their posture and general well-being. Recommendations for nutrition and exercise that are integrated based on user data provide value and may improve health outcomes.

Question	
2.What do you think about the scope of the project?	
Person	Feedback
Technical domain expert	The project's scope appears suitably ambitious. It provides consumers with a complete solution by covering important topics including diet advice, customized exercise, and posture correction.
Medical domain expert	The project's scope seems extensive and in line with addressing the various facets of health and wellness. It is admirable that the system integrates individualized exercise, dietary advice, and posture correction to offer customers comprehensive support.

Question	
3.What do you think about the design, architecture, and implementation of the project?	
Person	Feedback
Technical domain expert	The project's design, architecture, and implementation are crucial from a technical standpoint. A seamless and captivating user experience depends on a well-considered architecture and user-friendly design. Refinement and iteration based on user feedback will be necessary to ensure success.
Medical domain expert	Particularly in a health-related setting, the project's architecture, design, and execution are critical to its usability and efficacy. To maximize user engagement and health benefits, design and implementation must promote accuracy, simplicity, and accessibility.

Question	
4.What do you think about the Solution and prototype of the project?	
Person	Feedback
Technical domain expert	The solution and project prototype offer a strong basis for additional development and improvement. To improve functionality and fix any usability concerns, it is critical to get user feedback and iterate the prototype. To further guarantee the solution's dependability and efficacy, further testing and validation should be conducted.
Medical domain expert	Satisfied with the dashboard and interface the team has produced.

Question	
5.How do you evaluate the performance of the machine learning models used for posture correction?	
Person	Feedback
Technical domain expert	Metrics including accuracy, precision, recall, and F1 score are evaluated to determine how well posture correction machine learning models perform. To

	guarantee robustness and generalizability, it is essential to train the models on a variety of datasets and conduct thorough validation. Furthermore, it is crucial to continuously monitor and enhance the models considering user input and empirical data.
Medical domain expert	It is necessary to evaluate the accuracy of machine learning models in identifying and rectifying postural defects to evaluate their performance for posture correction. To make sure the models are safe and effective; it is crucial to validate them against professional opinions and actual situations. Furthermore, including user comments and clinical insights can aid in model improvement and long-term performance enhancement.

9.7.Limitations

Person	Suggestion
Medical domain expert	Try adding more exercises and train a model using multiple angles.
Technical domain expert	Work on the found bugs and try to improve the prediction score.

9.8.Evaluation on Functional Requirements

Requirement ID	Requirement and Description	Evaluation	Priority
FR01	Detection of incorrect postures during exercises	Implemented	Must Have
FR02	Multi-angle posture assessment	Implemented	Must Have
FR03	Personalized corrective guidance		Must Have
FR04	Intuitive user interface	Implemented	Must Have
FR05	Progress tracking and analytics		Should Have
FR06	Recommendation of exercise plans	Implemented	Should Have
FR07	Recommendation of diet plans	Implemented	Should Have
FR08	Voice-guided instructions		Could Have
FR09	Social sharing of progress		Could Have
FR10	AI-driven adaptive feedback		Could Have

Table 20 Implemented FR

9.9.Evaluation on Non-Functional Requirements

Requirement ID	Requirement and Description	Evaluation	Priority
NFR01	The system should correctly identify incorrect postures and provide feedback.		Must Have
NFR02	Smooth process of the input video.	Implemented	Should Have
NFR03	The system should be implemented securely.	Implemented	Should Have
NFR04	The application should be easy to use and navigate.	Implemented	Could Have
NFR05	The system should be maintainable and upgradable.	Implemented	Could Have

Table 21 Implemented NFR

9.10. Chapter Summary

The project is for an app designed for fitness novices that focuses on posture correction, individualized activity, and diet suggestions. The evaluation provided useful insights into the system's technical elements, usability, and efficiency. Evaluators' feedback will help steer future enhancements and revisions.

10. Conclusion

10.1. Chapter Overview

This chapter provides a summary of the key findings and outcomes of the research conducted in this study.

10.2. Achievements of Research Aims & Objectives

The aim of this research project was to develop a mobile application using Flutter for the frontend and Flask for the backend, to help exercise beginners. The application integrates posture correction, exercises, and diet recommendations to promote a healthy lifestyle. The project successfully achieved its aim by delivering a functional mobile application that provides users with posture correction exercises and personalized diet recommendations.

Description	Status
LR	
Conducting a comprehensive literature review	Completed
SRS	
Carrying out a software requirement gathering	Completed
Design	
Designing the system architecture	Completed
Development	
Developing the model and the user interface	Completed
Testing	
Testing the models and the user interface	Completed
Evaluation	
Evaluating the model and the user interface	Completed

10.3. Utilization of Knowledge from the Course

Module	Description
Database Systems	Principles of database systems applied in designing the backend database for storing user data and recommendations.
Web Technology	Knowledge of web technologies applied in developing the frontend of the mobile application using Flutter.
Programming Fundamentals	Basic programming concepts and logic applied in developing the frontend and backend of the mobile application.
Data Structures and Algorithms	Data structures and algorithms applied in developing AI models for posture correction and diet recommendation.
Artificial Intelligence	Principles of AI applied in developing posture correction and diet recommendation models.
Machine Learning	Implementation of machine learning algorithms for posture correction and personalized diet recommendations.
Data Science Group Project	Collaborative project experience applied in developing and integrating various components of the mobile application.

10.4. Use of Existing Skills

The existing skills of Python programming, object-oriented programming (OOP) concepts, and machine learning (ML) knowledge were used throughout this project.

- **Python Programming**: Utilized Python for backend development using Flask, as well as for scripting and automation tasks.
- **Object-Oriented Programming (OOP)**: Applied OOP principles for structuring and organizing code, increasing modularity, and promoting code reusability for both frontend and backend development.
- **Machine Learning (ML)**: Integrated ML algorithms and models for posture correction and diet recommendation functionalities, leveraging existing ML expertise to enhance the app's effectiveness and accuracy.

10.5. Use of New Skills (Technical skills should be given preference)

During the project, the team acquired and applied various new technical skills, including:

- **Flutter Development**: Learning and implementing Flutter for mobile application frontend development.
- **Flask Backend**: Acquiring proficiency in Flask for backend development and API creation.
- **Machine Learning**: Developing skills in machine learning for creating posture correction and diet recommendation models.
- **Database Management**: Gaining knowledge in database management for storing user data and recommendations.
- **Integration**: Learning to integrate frontend and backend components seamlessly for a cohesive user experience.

10.6. Achievement of Learning Outcomes

- Gain insights into mobile app development using Flutter and backend development using Flask.
- Understand and implement machine learning models for posture correction and diet recommendation.
- Enhance critical thinking skills through project development and testing.
- Improve collaboration and communication skills through team-based project work.

10.7. Problems and Challenges Faced

Problems	Solution
Identification of suitable machine learning algorithms for posture correction and diet recommendation.	Conducted thorough research to identify appropriate machine learning algorithms.
Integration complexities between Flutter frontend and Flask backend.	Implemented clear communication channels between frontend and backend teams to address integration challenges.

10.8. Deviations

Scope Reduction: The project underwent a scope reduction due to constraints in resources and time, necessitating the prioritization of essential features and functionalities. At the initial stage the objective was to identify which angle is wrong in the wrong posture, but the implemented model only identifies if the posture is correct or wrong.

Change in Front end framework: The initial plan was to create an application in react native but due to it not supporting object-oriented programming the frontend framework was changed to Flutter.

10.9. Limitations of the Development

- **Low Amount of Data**: Limited availability of data for training machine learning models may have affected the accuracy and robustness of the posture correction and diet recommendation functionalities.

- **Resource Constraints**: Constraints in terms of time and budget impacted the depth and scope of the project, potentially limiting the implementation of additional features or optimizations.

10.10. Future Enhancements

- Expansion of exercise and diet database for broader user coverage.
- posture analysis model identifying the angles associated with the wrong posture.
- Integration of real-time posture tracking using mobile sensors.
- Incorporation of user feedback mechanisms for continuous improvement.
- Implementation of gamification elements to enhance user engagement.

10.11. Achievement of the contribution to body of knowledge

- **Mobile user interface:** by creating a mobile application we have increased the reach of our application towards the users.
- **Posture analysis for individual frame:** by classifying images frame by frame, we have implemented a model which classifying posture for each frame instead of each repetition of exercises.

- **Exercise recommendation**: by implementing a novel model we have implemented a recommendation system to help exercise beginners choose their exercises. It will be helpful to create personalized exercise plans.
- **Diet recommendation**: by implementing a novel model we have implemented a recommendation system to help exercise beginners choose their diet. It will be helpful to create personalized diet plans.

10.12. Individual Contribution

Team member	Contribution
A. Aadhil Ahmed	Frontend in Flutter, Posture analysis model - Pushup
Demini Rajakaruna	Posture analysis models - Sit up, Mountain climbing, Pull up, Squats
Chulan Shammika	Exercise recommendation system - Exercise according to intensity and User preference
Sanuka Jayasinghe	Diet recommendation system - Calorie prediction, Diet Ingredient generation

Table 22 Individual Contribution

10.13. Chapter Summary

Provides an overview of achievements, challenges, future enhancements, individual contributions, and key findings.

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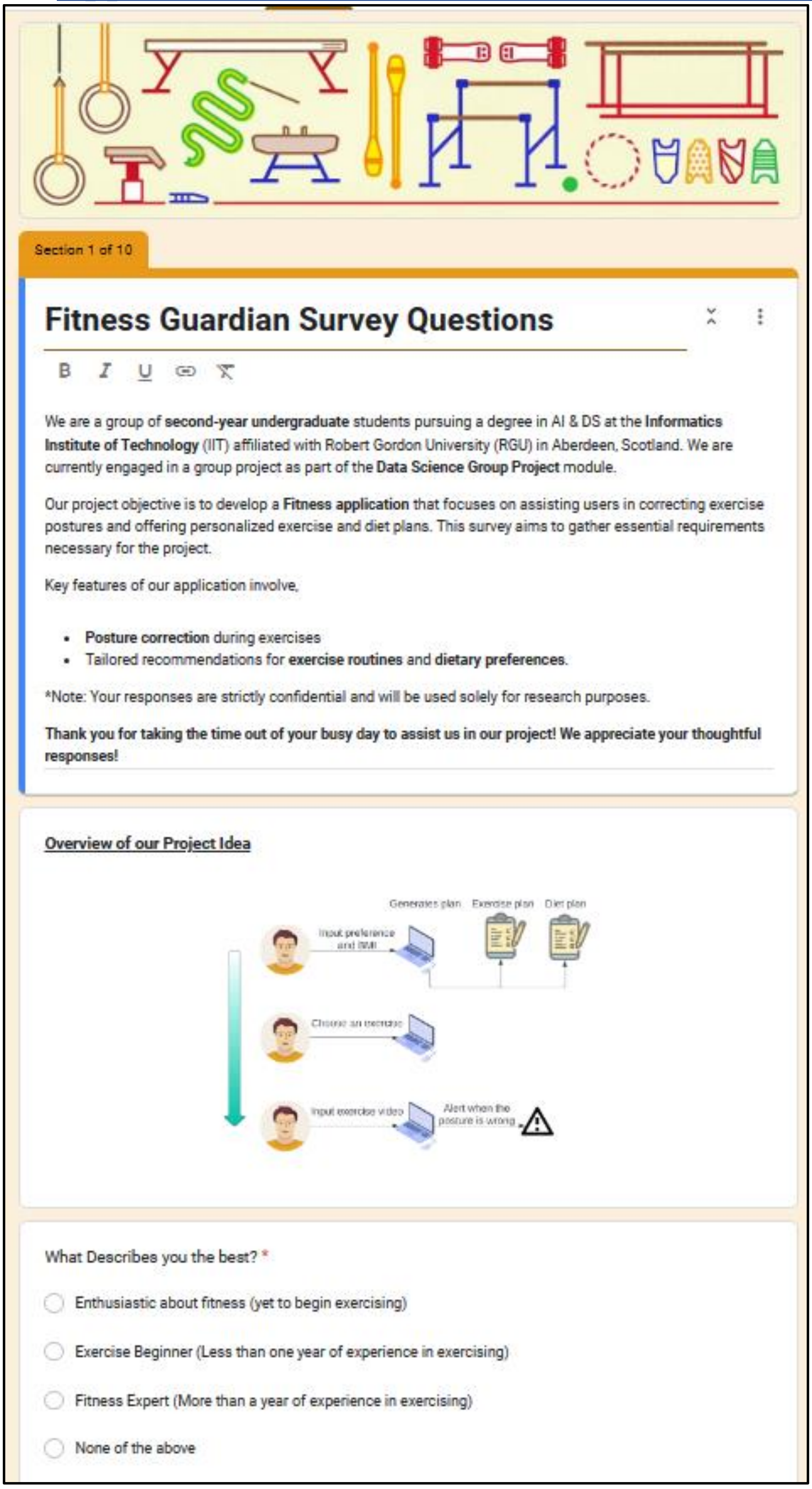
II. Appendix Part 2 – Other Relevant Information



Section 1 of 10

Fitness Guardian Survey Questions

We are a group of **second-year undergraduate** students pursuing a degree in AI & DS at the **Informatics Institute of Technology** (IIT) affiliated with Robert Gordon University (RGU) in Aberdeen, Scotland. We are currently engaged in a group project as part of the **Data Science Group Project** module.

Our project objective is to develop a **Fitness application** that focuses on assisting users in correcting exercise postures and offering personalized exercise and diet plans. This survey aims to gather essential requirements necessary for the project.

Key features of our application involve,

- **Posture correction** during exercises
- Tailored recommendations for **exercise routines** and **dietary preferences**.

*Note: Your responses are strictly confidential and will be used solely for research purposes.

Thank you for taking the time out of your busy day to assist us in our project! We appreciate your thoughtful responses!

Overview of our Project Idea

What Describes you the best? *

- ◯ Enthusiastic about fitness (yet to begin exercising)
- ◯ Exercise Beginner (Less than one year of experience in exercising)
- ◯ Fitness Expert (More than a year of experience in exercising)
- ◯ None of the above

Figure 26 Survey Questions

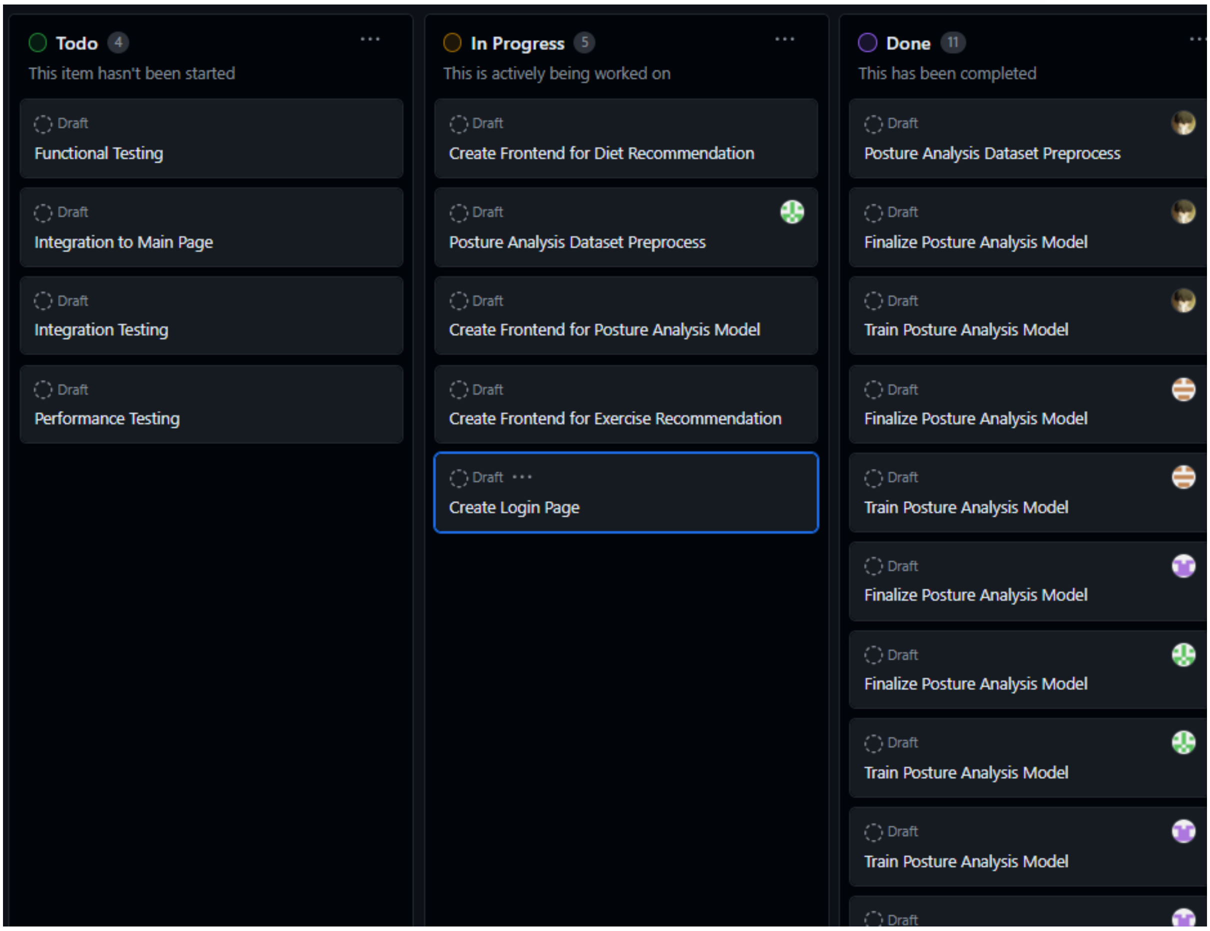


Figure 27 Project management.