Software Design Document ————

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1 Introduction

1.1 Purpose of this Document

The purpose of this system is to detect the movement which will catch by the Kinect camera which will be analyzed to get the dimensions of x y z and the joints. System will be trained at first to make the classifier more accurate then there will be some testing subject to test whether the system is accurate or not then test with a real data by which will classify the movement into right and wrong then correct the wrong on real time. The Kinect could capture 30 frames for each 22 joints per second. Better than sensors because sensors are expansive need a lot of them just to detect one joint. The sensors are not accurate as the Kinect and they need to be synchronized to work with each other.

1.2 Scope of this Document

The technique that we use is directed to help the people who are looking for the best way to train their body without fearing of injures and gaining the best body fit look. The system is very simple to access and use it. System will detect the body and track its motion. Preprocessing and joints extraction by static analysis, dividing the frames into right and wrong. The people who will use it will have guided instructions, how to do the exercise with the best way and correct for them any wrong move. All this will be available due to the 30 frames captured for every 22 joints per second. That will enhance the future of the training technique scope.

1.3 Overview

First, we will use the Kinect camera to detect the body of the person who is doing the exercise, 30 frames will be detected for the 22 joints per each second by the Kinect. The video will be taken by a Kinect camera The training phase is to increase the accuracy of the classier Using the SVM KNN DTW algorithms which will achieve a high accuracy The camera will analyze and extract the joints in the frames of the video . The algorithms will be used to train the classifier on detecting and correcting the movements. Moreover, the rendering system will compare with the data set of the wrong movements, clustering abnormal movements.

1.4 Reference Material

In the system we use the weight inserted by the user to recommend the maximum weight in Kilograms the weight-lifter can use to minimize the injuries and to get the maximum benefit from the workout. The recommendation also depends on how experienced the user is in the weightlifting world. The user will have the option to choose from five different levels explained as follows:
Beginner
Stronger than 5 percent of lifters. A beginner lifter can perform the movement correctly and has practiced it for at least a month.
Novice
Stronger than 20 percent of lifters. A novice lifter has trained regularly in the technique for at least six months.
Intermediate
Stronger than 50 percent of lifters. An intermediate lifter has trained regularly in the technique for at least two years.
Advanced
Stronger than 80 percent of lifters. An advanced lifter has progressed for over five years.
Elite
Stronger than 95 percent of lifters. An elite lifter has dedicated over five years to become competitive at strength sports.
Using the weight and the level chosen the system will recommend the weight differently for males and females based on the tables below.

1.5

Male Dumbbell Lateral Raise Standards (kg)

☐ Show bodyweight ratios

BW	Beg.	Nov.	Int.	Adv.	Elite
50	1	5	11	19	30
55	2	6	12	21	32
60	2	6	13	22	33
65	3	7	14	24	35
70	3	8	15	25	37
75	4	9	16	26	38
80	4	9	17	27	39
85	4	10	18	29	41
90	5	11	19	30	42
95	5	11	20	31	43
100	6	12	21	32	45
105	6	12	21	33	46
110	7	13	22	34	47
115	7	14	23	35	48
120	7	14	24	35	49
125	8	15	24	36	50
130	8	15	25	37	51
135	9	16	26	38	52
140	9	16	26	39	53
All	3	9	17	27	39

1.5.1

Female Dumbbell Lateral Raise Standards (kg)

☐ Show bodyweight ratios

BW	Beg.	Nov.	Int.	Adv.	Elite
40	1	4	7	12	18
45	2	4	8	13	19
50	2	5	8	14	20
55	2	5	9	14	20
60	2	5	9	15	21
65	3	5	10	15	21
70	3	6	10	16	22
75	3	6	10	16	22
80	3	6	11	16	23
85	3	6	11	17	23
90	3	7	11	17	24
95	4	7	12	18	24
100	4	7	12	18	25
105	4	7	12	18	25
110	4	8	12	19	25
115	4	8	13	19	26
120	4	8	13	19	26
All	2	5	10	15	21

1.5.2

Male Dumbbell Shoulder Press Standards (kg)

Show bodyweight ratios

Bodyweight	Beginner	Novice	Intermediate	Advanced	Elite
50	6	11	19	28	38
55	7	13	21	31	42
60	9	15	24	34	46
65	11	17	26	37	49
70	12	19	29	40	52
75	14	21	31	42	55
80	15	23	33	45	58
85	16	25	35	47	61
90	18	26	37	50	64
95	19	28	39	52	66
100	21	30	41	55	69
105	22	32	43	57	71
110	23	33	45	59	74
115	25	35	47	61	76
120	26	36	49	63	78
125	27	38	50	65	81
130	29	39	52	67	83
135	30	41	54	69	85
140	31	42	55	71	87
All	13	21	32	45	60

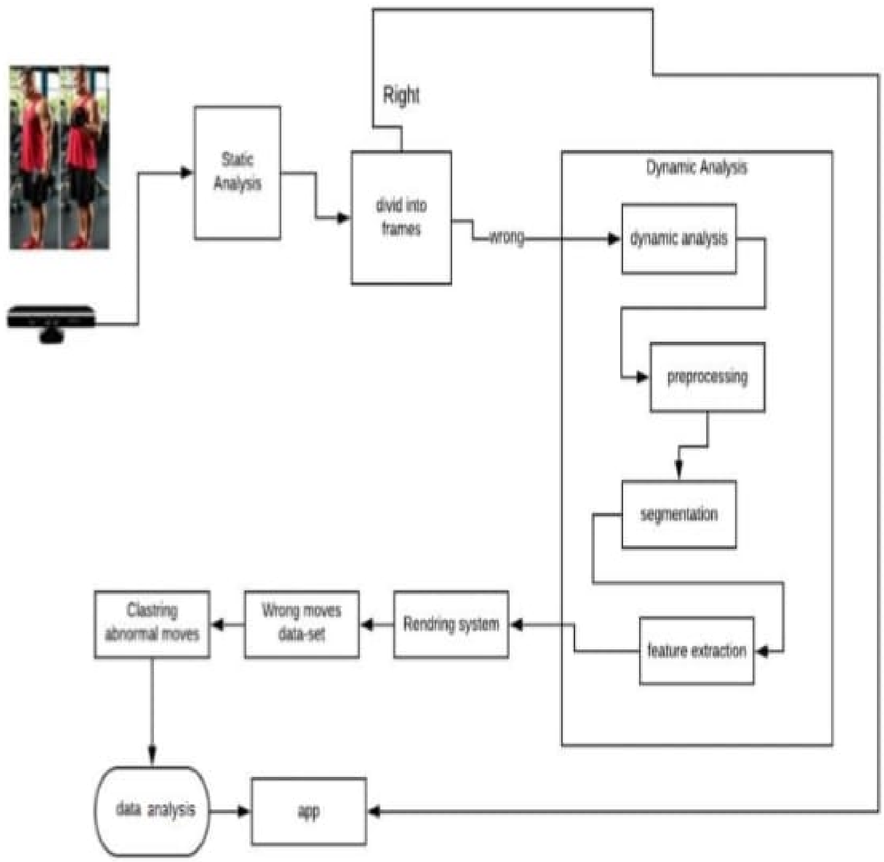
1.5.3

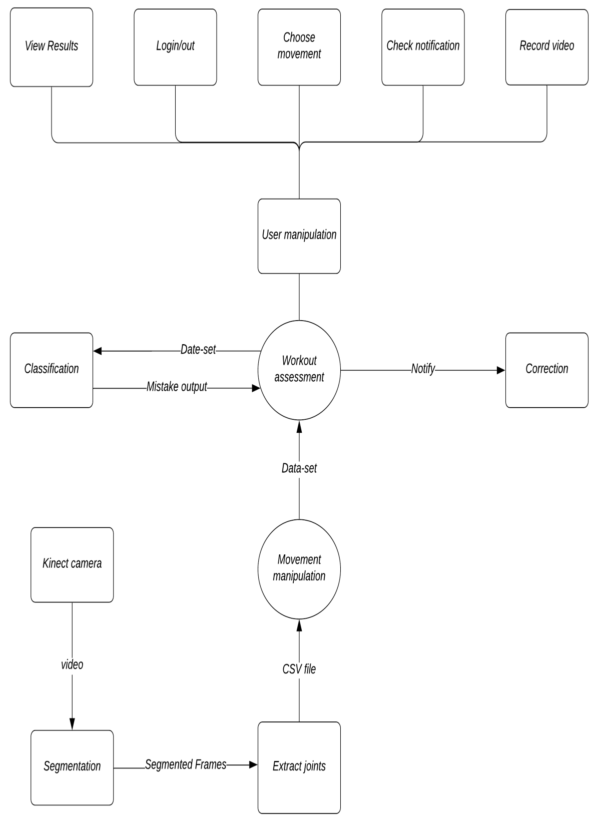
Female Dumbbell Shoulder Press Standards (kg)

Show bodyweight ratios

Bodyweight	Beginner	Novice	Intermediate	Advanced	Elite
40	3	6	11	17	23
45	4	7	12	18	25
50	4	8	13	19	26
55	5	9	14	20	28
60	5	9	15	22	29
65	6	10	16	23	30
70	6	11	17	24	31
75	7	11	17	25	32
80	7	12	18	25	33
85	8	13	19	26	34
90	8	13	20	27	35
95	9	14	20	28	36
100	9	14	21	29	37
105	10	15	21	29	38
110	10	15	22	30	39
115	10	16	23	31	39
120	11	16	23	31	40
All	6	10	16	23	31

2 System Overview




View Results
Login/out
Choose movement
Check notification
Record video
User manipulation
Classification
Date-set
Mistake output
Workout assessment
Notify
Correction
Data-set
Kinect camera
Movement manipulation
video
CSV file
Segmentation
Segmented Frames
Extract joints

3 System Architecture

3.1 Architectural Design

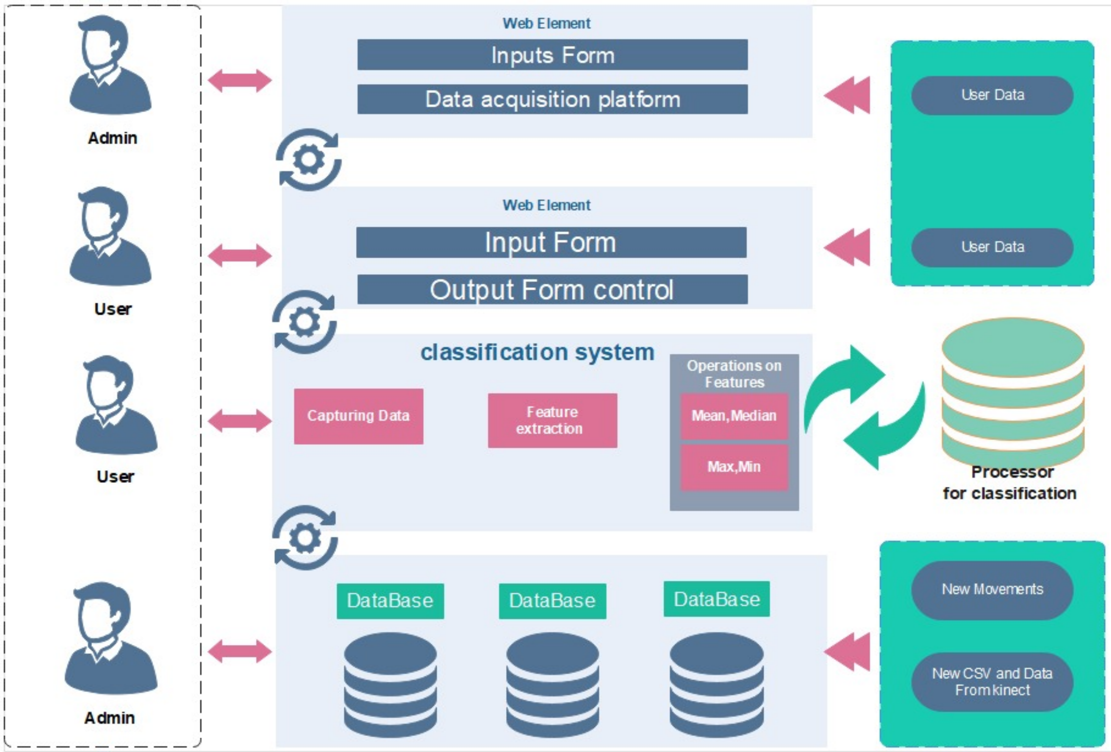
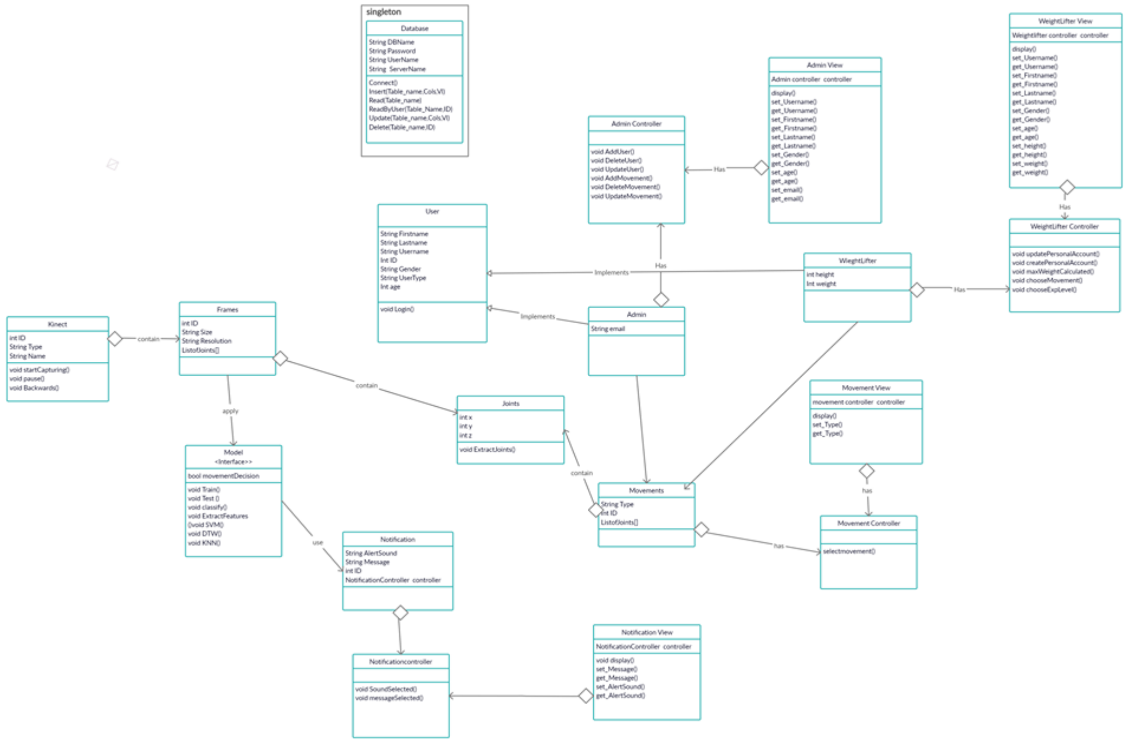


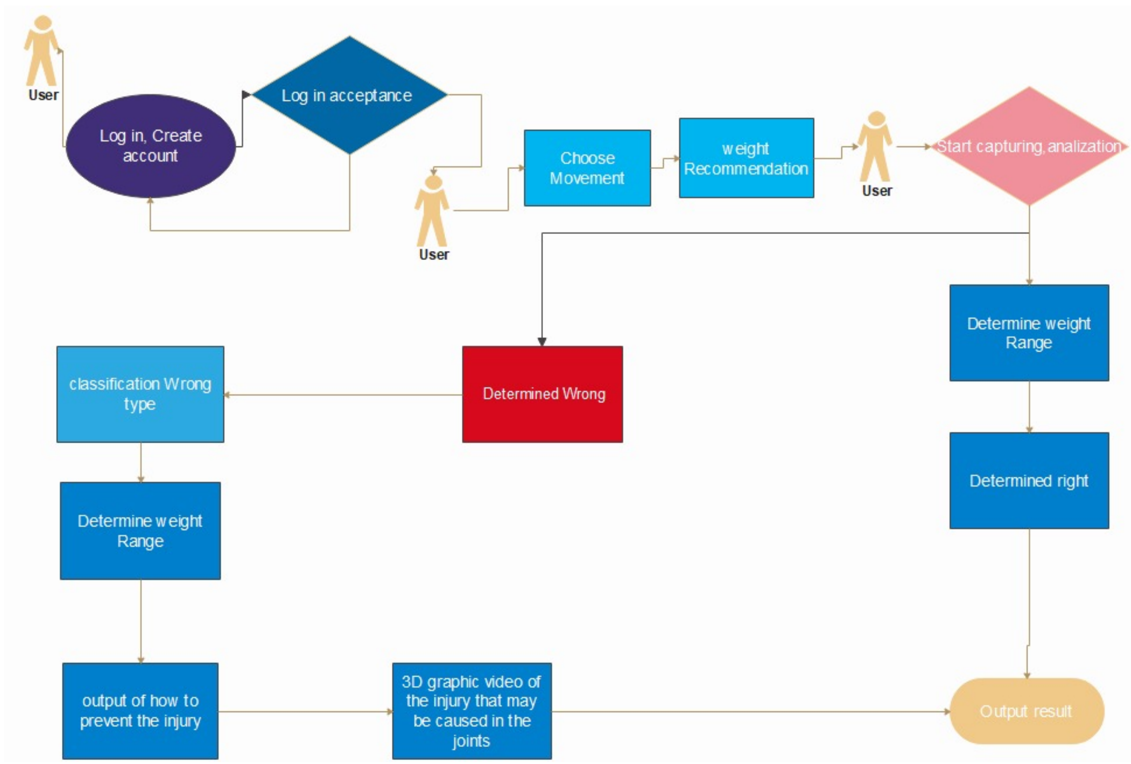
Figure 1: Architectural Design

3.2 Decomposition Description

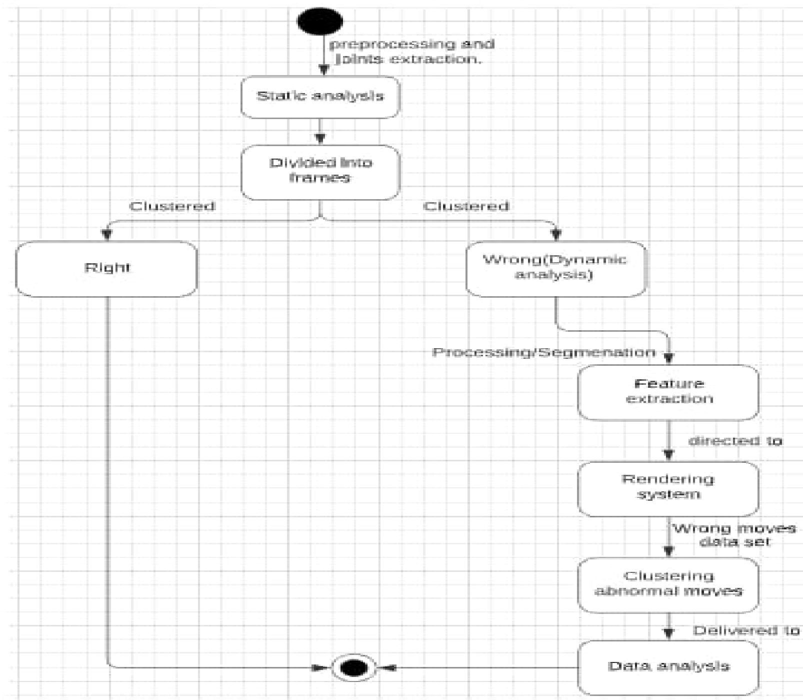
3.2.1 class diagram



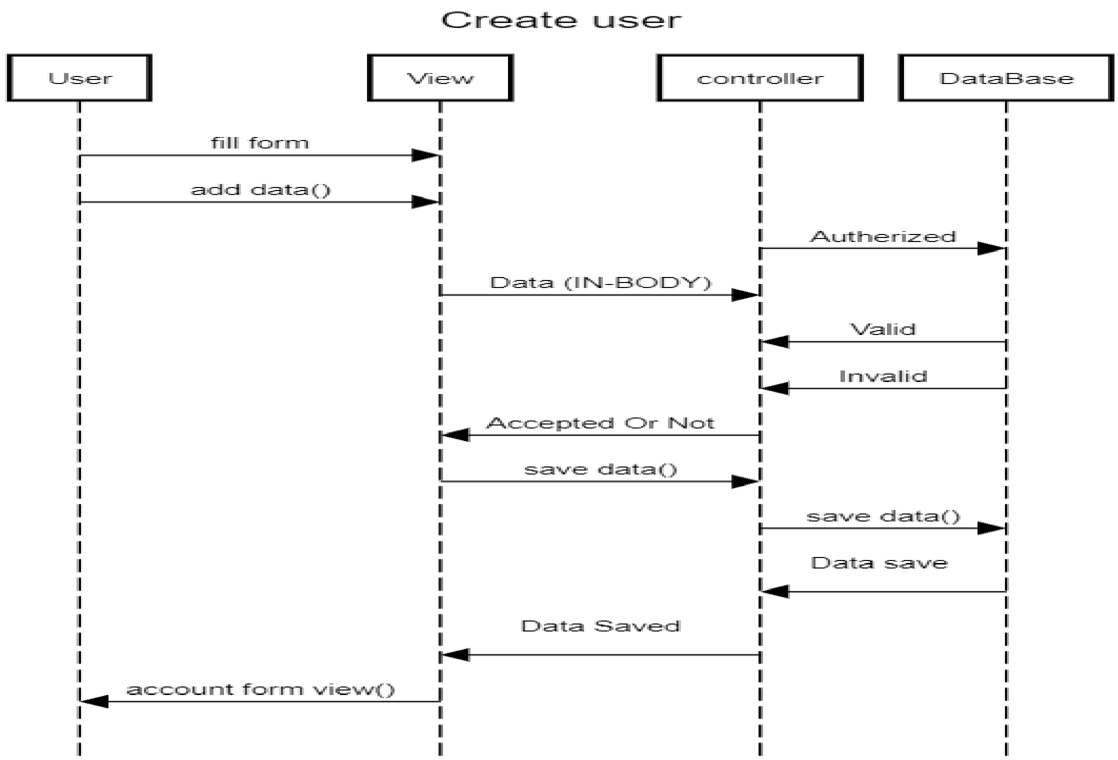
3.2.2 Activity diagram

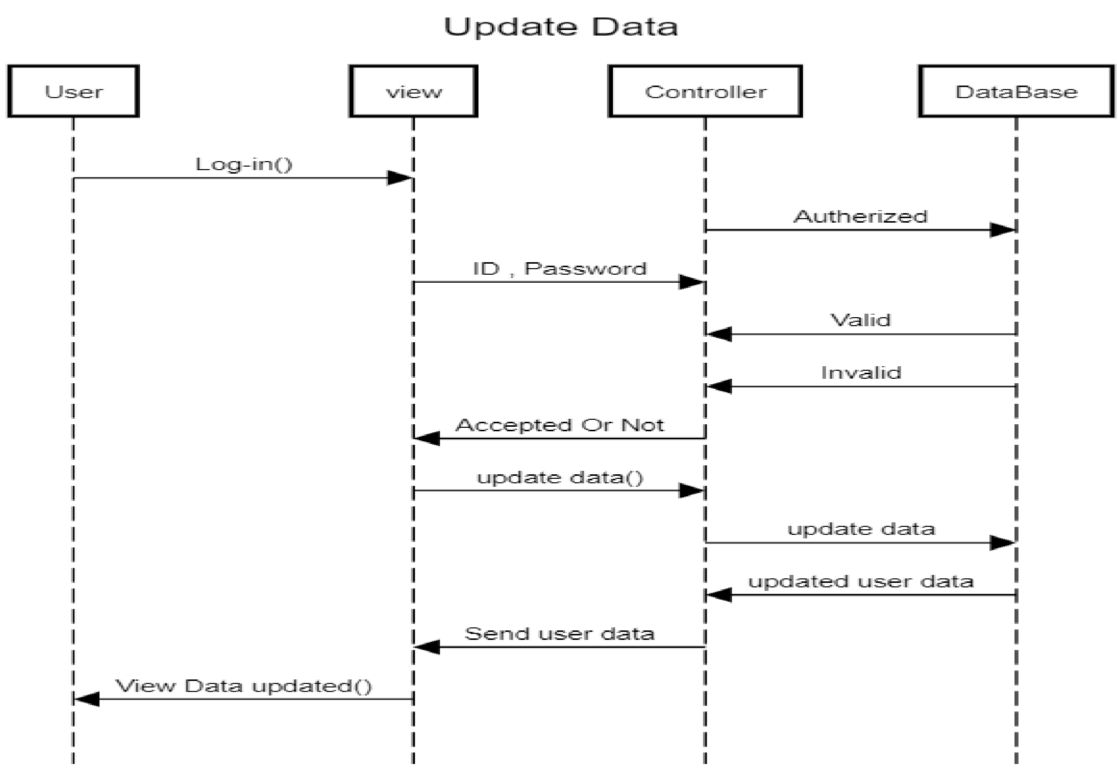


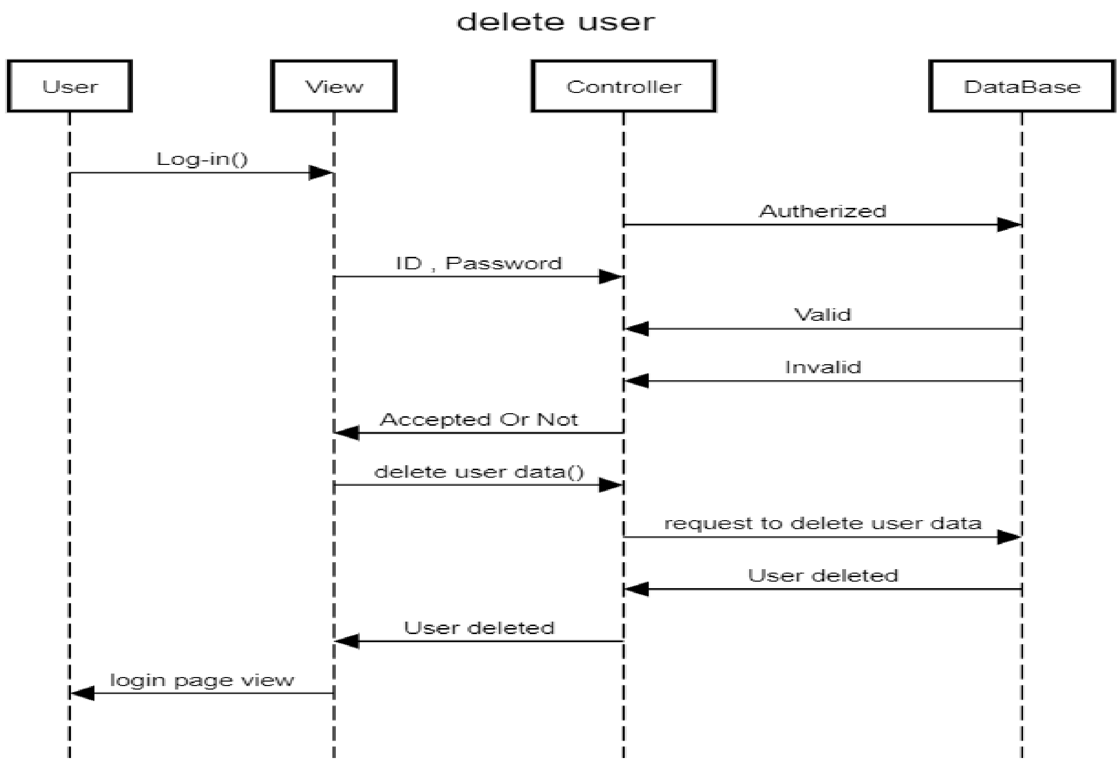
3.2.3 State diagram

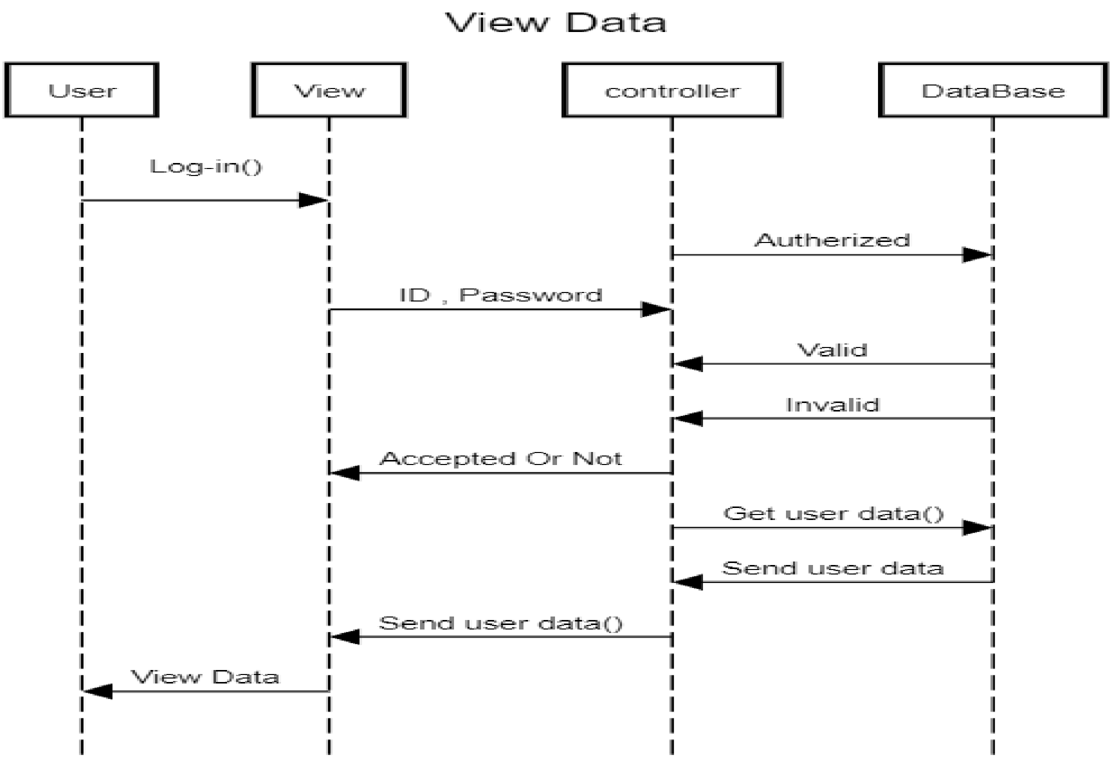


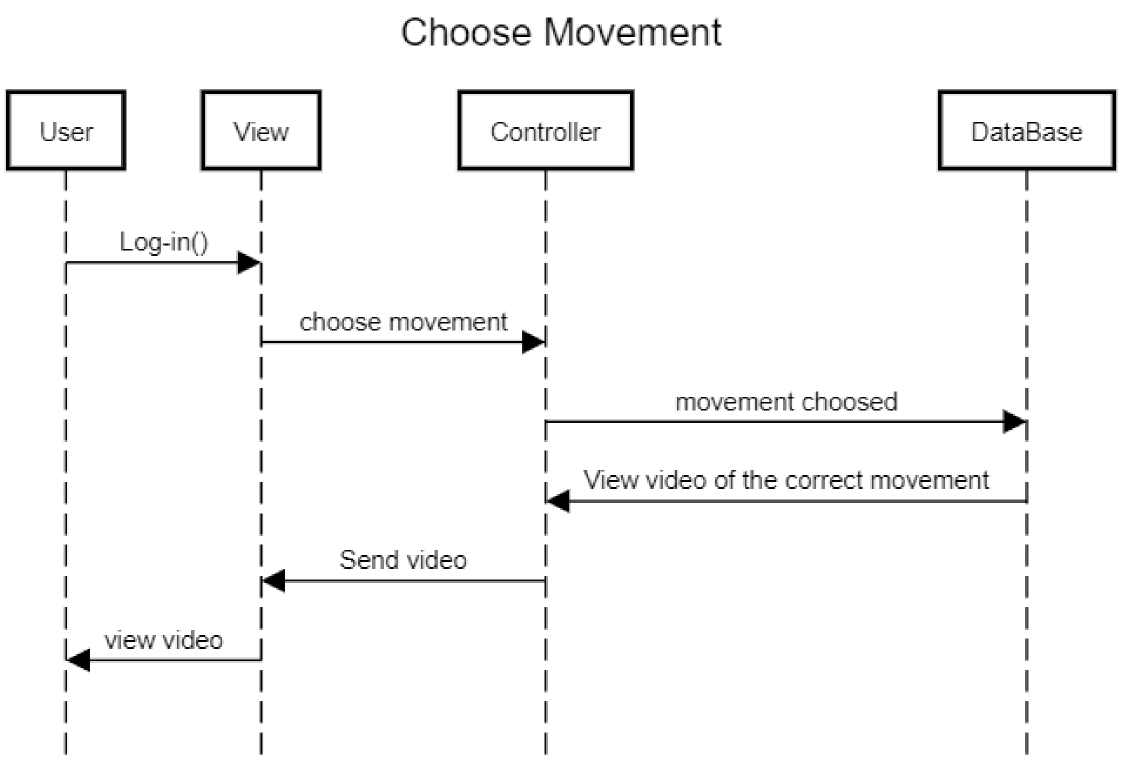
3.2.4 Sequence diagram

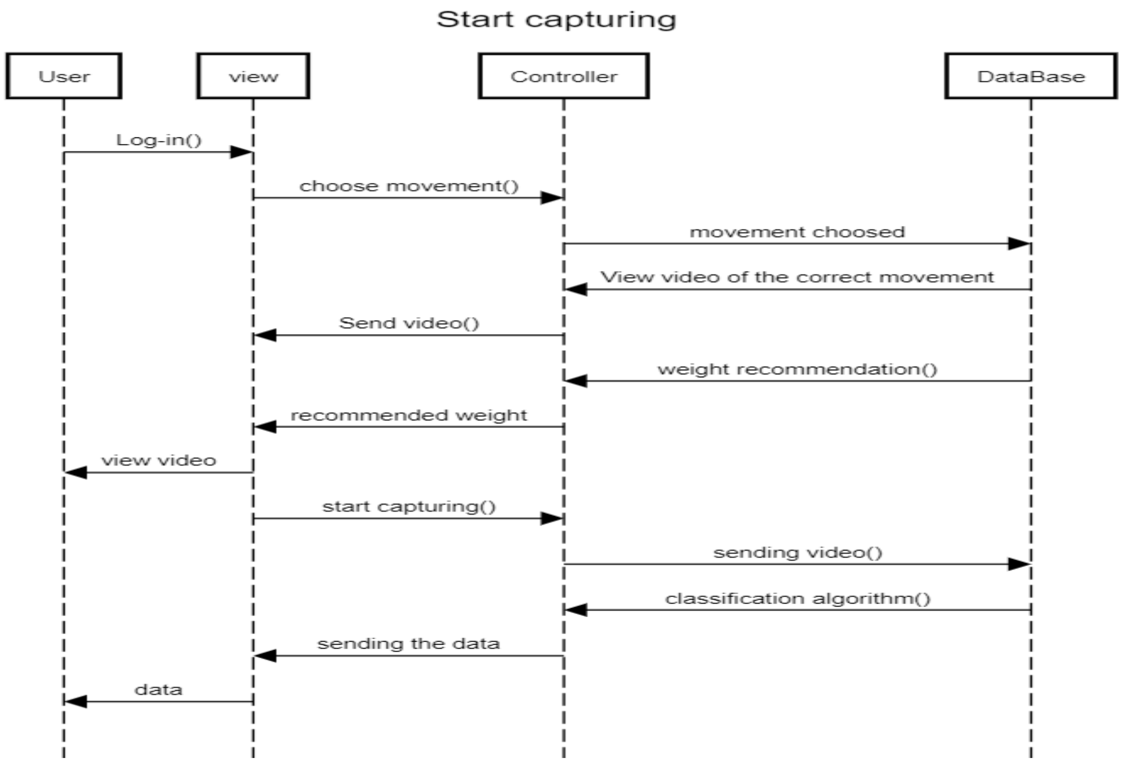



Update Data
User
view
Controller
DataBase
Log-in()
Autherized
ID , Password
Valid
Invalid
Accepted Or Not
update data()
update data
updated user data
Send user data
View Data updated()


delete user
User
View
Controller
DataBase
Log-in()
Autherized
ID , Password
Valid
Invalid
Accepted Or Not
delete user data()
request to delete user data
User deleted
User deleted
login page view


View Data
User
View
controller
DataBase
Log-in()
Autherized
ID , Password
Valid
Invalid
Accepted Or Not
Get user data()
Send user data
Send user data()
View Data


Choose Movement
User
View
Controller
DataBase
Log-in()
choose movement
movement choosed
View video of the correct movement
Send video
view video



3.3 Design Rationale

Our system is based on the model-view-controller design which splits our system to 3 base pages; the model is used to identify the data of our tables and has the functionality, the view is used to show the html and css code for Graphical user interface and the controller is used to manage the model functionalities and control CRUD of the objects. We tested 3 different algorithms for the system and were able to determine which one works best.

3.3.1 SVM

Linear SVM is given a set of train data which belong to a certain class to find an optimal separating line. It tries to maximize the distance between each class to avoid miss-classification. Then a test data are given to be classified to one of the classes formed before.

3.3.2 KNN

KNN is simple classifier useful for basic object recognition it predicts the label of a new instance by finding the K closest neighbors from the training data. Its main disadvantage is it can be slow if there are a large number of training examples.

3.3.3 DTW

DTW works by measuring similarity between two sequences, which may differ in speed like similarities in body motion for example. It can also be used on sets of points (x,y,z) in a method called wrapping path.

We have chosen DTW as our classifier because it was the most suitable one for the system that was able to differentiate between different types movements accurately and in the shortest amount of time using the joints extracted from the kinect camera.

4 Data Design

4.1 Data Dictionary

4.1.1 User

this entity contain the details of all user data it stores user name(Last name and First name) ,password, ID, age, height, weight and User type as a foreign key from section 4.2.2.

4.1.2 UserType

this entity contain the type of the user whether weight lefter or admin it stores ID and type

4.1.3 Movement

this entity list the movements available on the system such as dumbbell lateral raise and dumbbell shoulder press and and it stores ID and Movement Type

4.1.4 UserMovement

this entity show what the weight lefter trained so it link between the user from section 4.2.1 and section 4.2.3 so it stores ID ,User Id as a foreign key and movement id as a foreign key

4.1.5 Result

this entity contains the main result if it right or wrong and it stores Result ID and the Decision

4.1.6 MovementResult

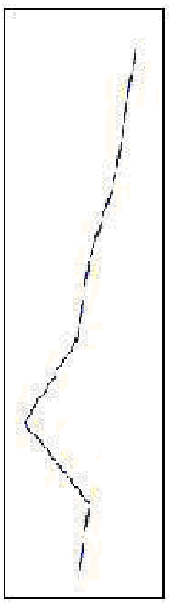
this entity link the result of the movement performed by weight lefter in section 4.2.5 by the User movement from section 4.2.4 and it store ID, UserMovementID as a foreign key amd ResultID as a foreign key.

5 Component Design

5.1 Data Capturing

The main data we need to extract is the features of the human body to identify its motion, so we used kinect v1 camera to capture some specific features. Those features are joints in the form of x,y,z points for left right hands, left right elbows, left right shoulders, center hip and spine. Joints are saved in a csv file as float numbers where each row is one frame captured and each column has a different type of joint.

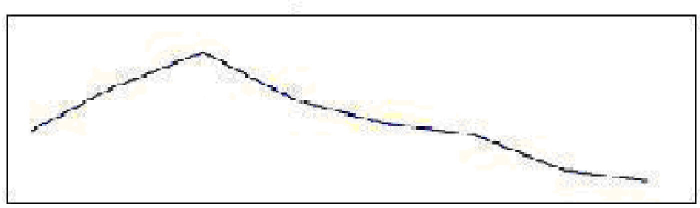
5.2 Classify



Test feature vector

								0.9	1.0
0.2	∞	1.5	1.9	2.4	1.8	1.2	1.0	0.9	1.1
0.3	∞	1.3	1.5	1.8	1.3	0.9	0.8	1.0	
0.4	∞	1.2	1.0	1.3	0.9	0.7	0.8	1.2	
0.6	∞	1.1	0.7	1.0	0.7	0.8	1.0	1.5	
0.7	∞	0.9	0.5	0.6	0.9	1.4	1.6	2.0	
1.1	∞	0.3	0.5	1.0	1.0	1.0	1.1	1.5	
0.6	∞	0.2	0.4	0.9	1.0	1.1	1.3	1.8	
0.7	0	∞	∞	∞	∞	∞	∞	∞	
	0.5	0.9	1.2	0.8	0.6	0.5	0.2	0.1	

Training feature vector



To classify the data extracted we used DTW because it was the most suitable one for the system that was able to differentiate between different types movements accurately and in the shortest amount of time using the joints extracted from the kinect camera. It compares the data with with the trained one and represents it on a graph to get the shortest alignment between points and classify them accordingly. In our system the classifier will work on a weightlifting workouts to classify them as right or wrong and for that we only used upper body joints as mentioned before.

6 Human Interface Design

6.1 Overview of User Interface

Users in this project will need to create an account first by inserting their data such as username, password, and weight etc. They will need to login to the system using their username and password so they can get to the home-page options to choose from. They can either view their profile to edit it or start a new workout. After that they will choose their preferred workout and their level of experience with it so they can get notified by the system their maximum weight they can lift to prevent any injuries. Last step is to confirm and start their workout and if they need help with it they can watch a video of the movement done correctly to imitate it easily. The result of the movement will appear right after its done and they can view how many times they have done it right or wrong.

6.2 Screen Images

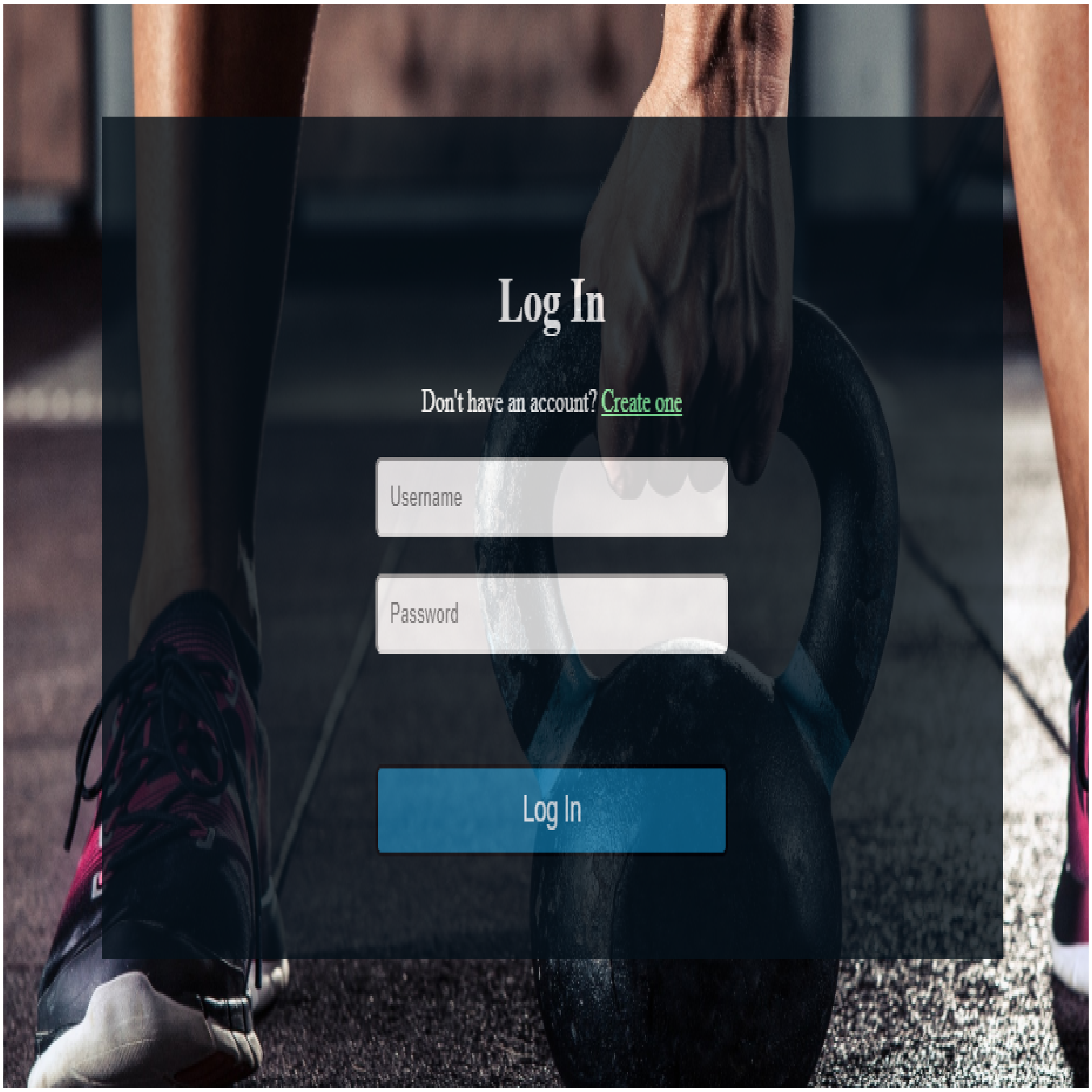


Figure :[1] login with user name and the password

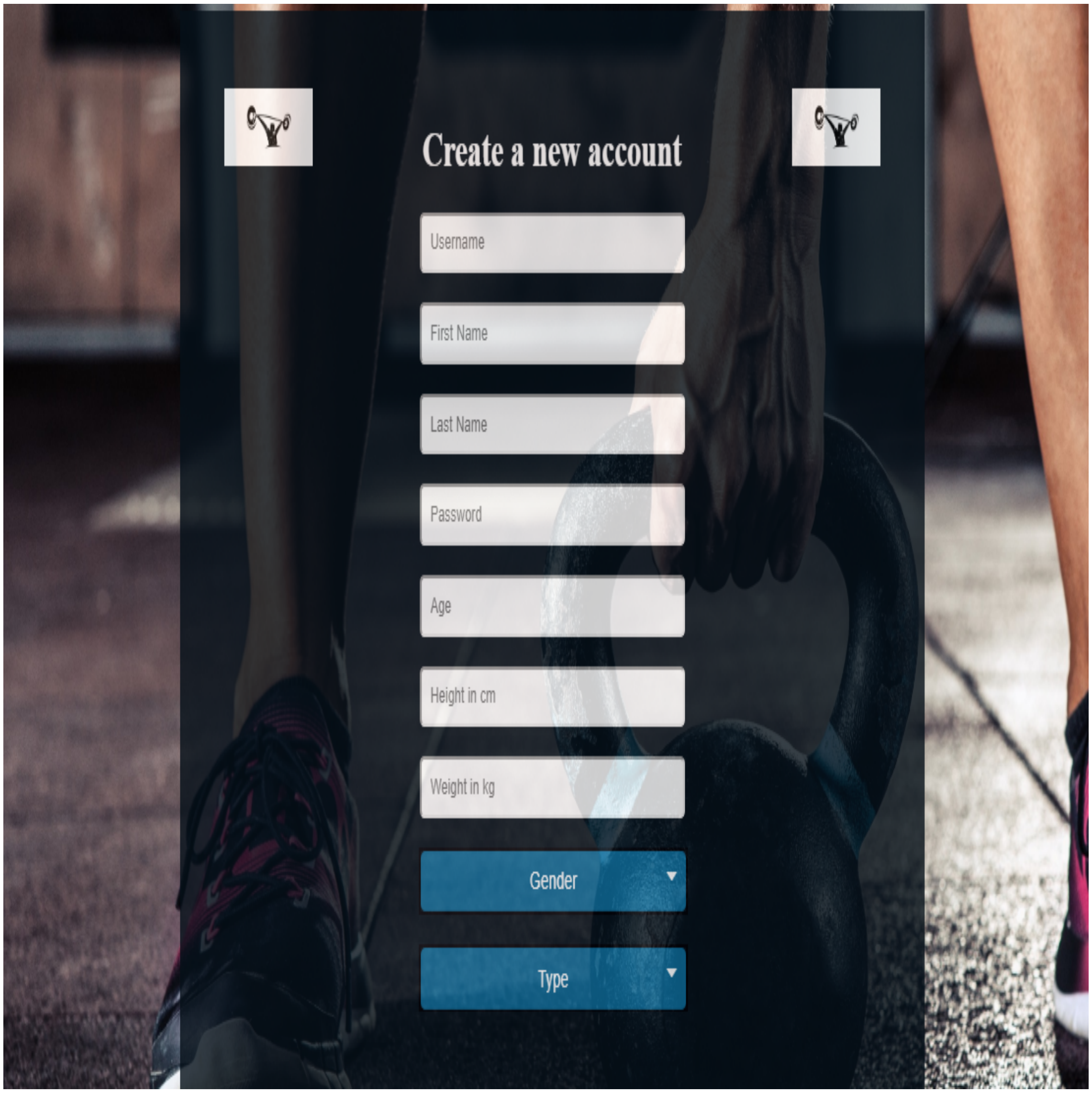


Figure :[2] Data to be inserted for a new account

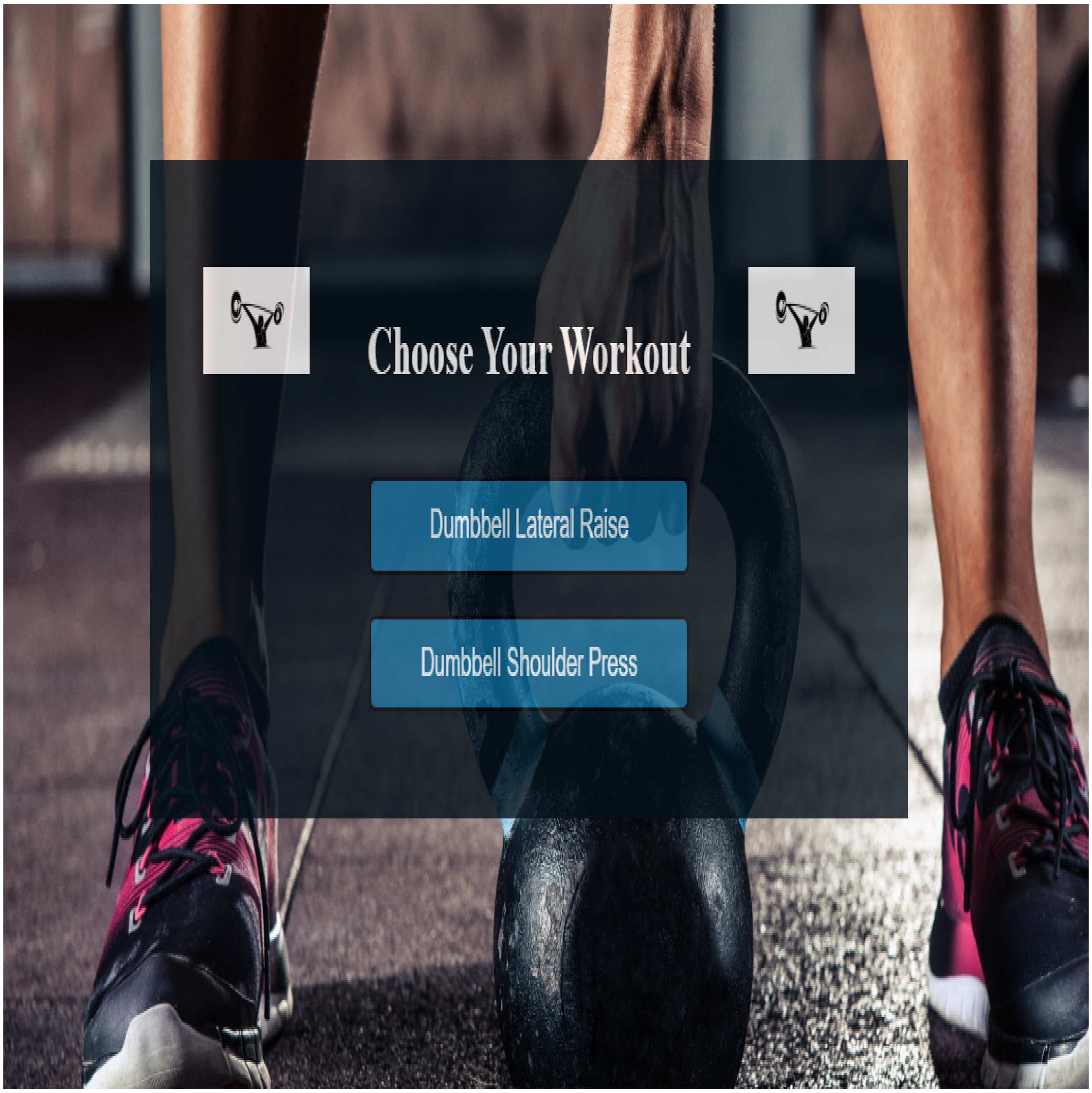


Figure :[3] User gets to choose the workout he prefers

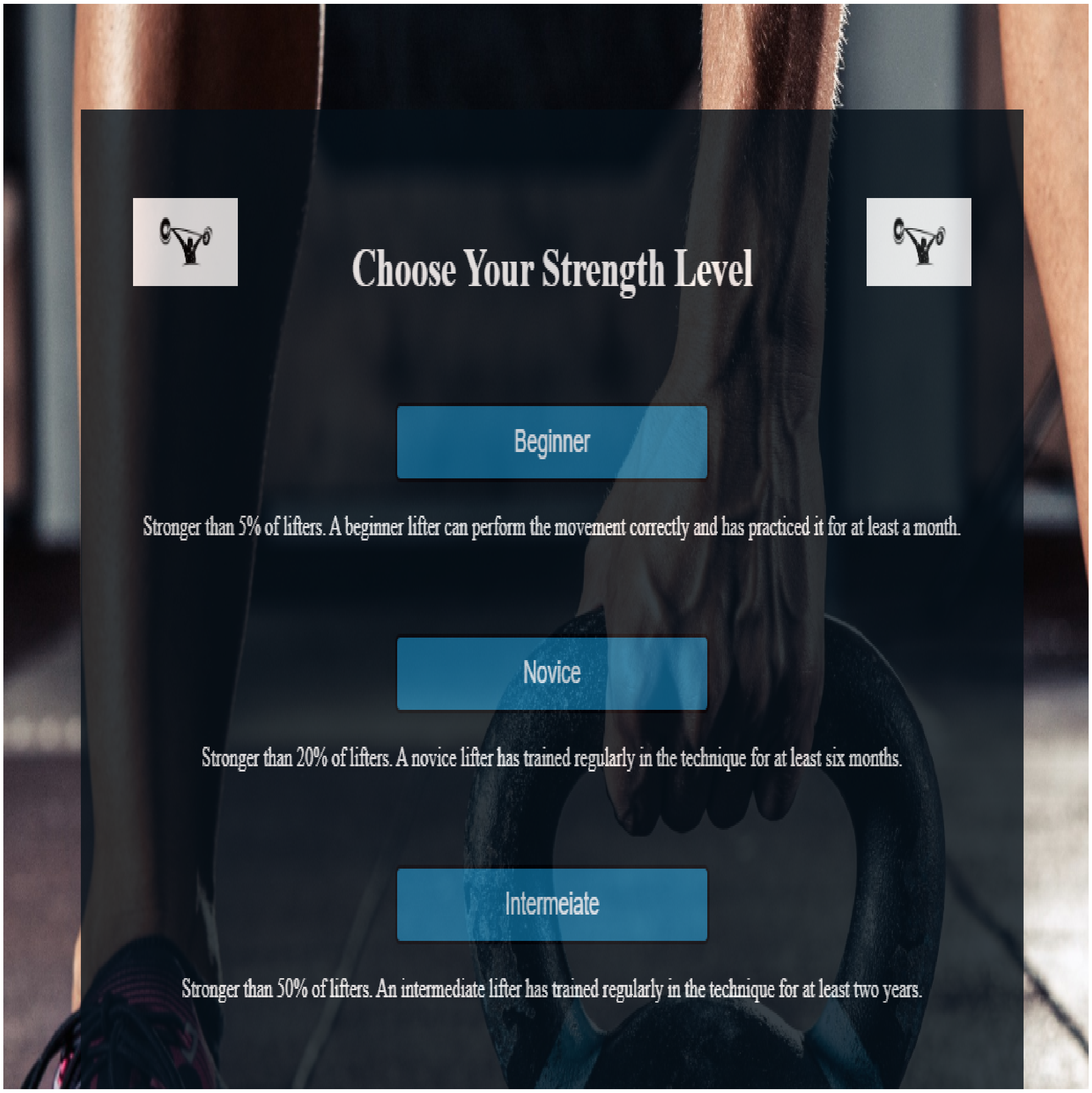


Figure :[3] User gets to choose his experience level with the workout

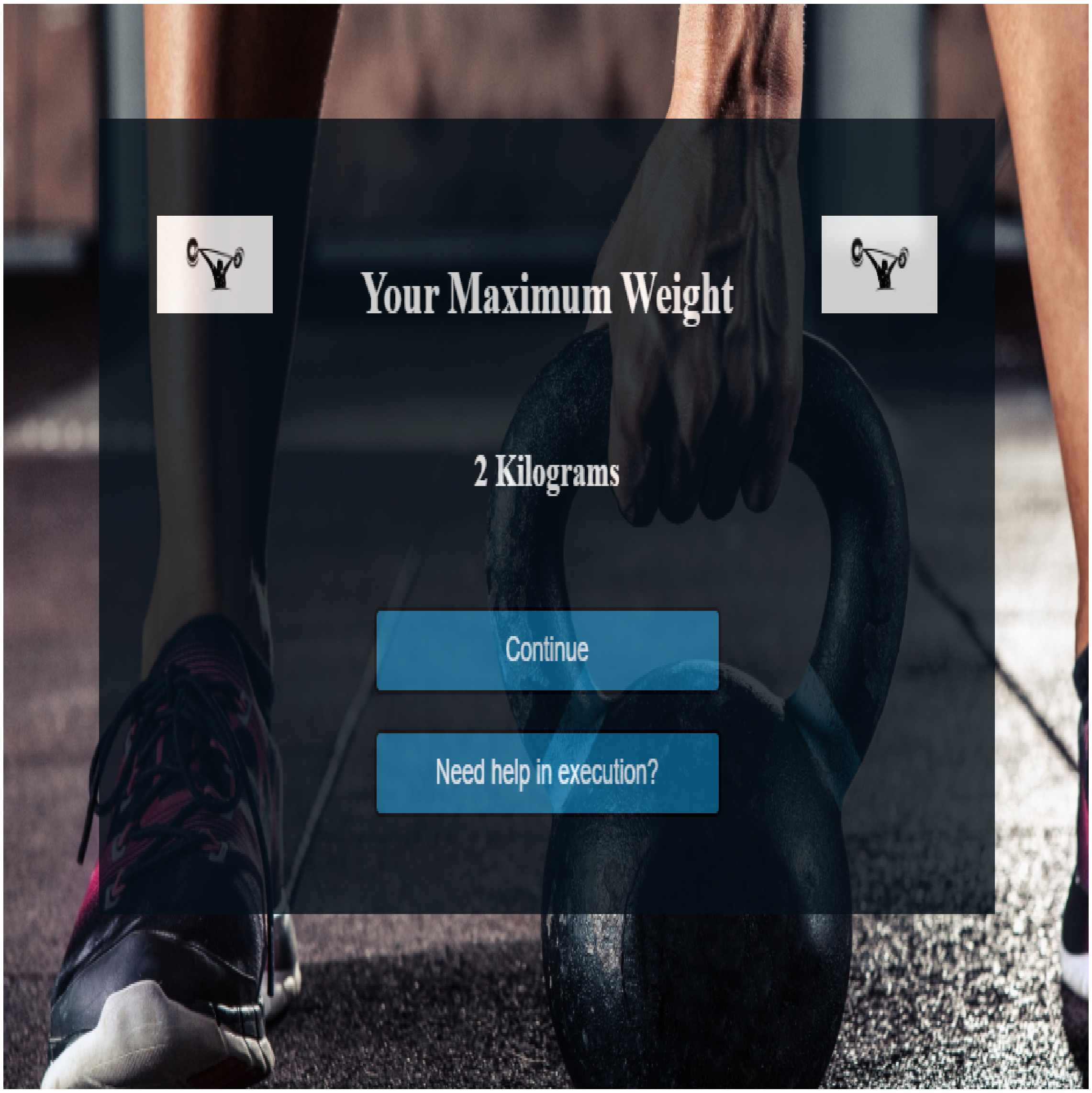


Figure :[3] Max Weight which will be calculated from the user in-body data

7 Requirements Matrix

Functions	Create User	Login	Update User	Delete User	Choose movement	Choose level	Maximum weight rec.	DTW classifier	view movement
Create User	X								
Login	X	X	X	X					
Update User	X	X	X						
Delete User	X	X		X					
Choose movement		X			X			X	
Choose level		X				X			
Maximum weight rec.	X	X	X		X	X	X		
DTW classifier		X			X			X	
View movement		X			X				X

References

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[2] Patty Wellborn *"UBC engineers advance the capability of wearable tech"*. The Journal of Sensors and Actuators A: Physical. 2018

[3] Wiehr, Kosmalla, Daiber Krüger *"FootStriker Proceedings of the 19th International Conference on Human-Computer Interaction with Mobile Devices and Services"*. ACM New York, NY, USA ©2017

[4] Liao, Y., A. Vakanski, M. Xian *"A Deep Learning Framework for Assessing Physical Rehabilitation Exercises"*. University of Idaho, USA, Jan 29th-30th, 2019

[5] Liao, Y., A. Vakanski, M. Xian *"A Deep Learning Framework for Assessing Physical Rehabilitation Exercises"*. University of Idaho, USA, Jan 29th-30th, 2019

[6] Varun Gulshan *"Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs"*. Jama, November 29, 2016.

[7] Strength level `https://strengthlevel.com/strength-standards/dumbbell-lateral-raise`