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Final Report

Balance Health

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Abstract

This document describes my experiences while developing the Balance Health project. It will discuss the technologies used and why they were chosen, what was achieved, the challenges encountered, future work that can be added to the project as well as acknowledgements to those that helped me throughput the process.

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Introduction

This document will discuss the technical and non-technical aspects of the project, and illustrate the UI design used for the project. The document will also describe what the aims of the project were and what was achieved.

The document will first describe the project itself and the technologies used throughout in creation of the project. Each technology will be discussed and how it was used for the project as well illustrating the challenges encountered when using them.

It will then go on to discuss any difficulties or issues encountered while creating the applications for the project, the obstacles faced and how they were overcome. It will describe how the original specification and design for the project were adhered to and what changes were made while undertaking the project.

Finally, the document will give a final project review and discuss my personal learning outcomes from the project. This will describe how well I felt the project went, what I would change and what could have been done better. Any future developments to the project will also be discussed.

Project Description

The Balance Health projects aim was to create an application that will allow for the remote monitoring of a patents balance performance by medical personnel. To achieve this the project consisted of a mobile application, a Movesense sensor device, a web application, and a cloud database.

The Balance Health mobile application was developed for Android devices using Android Studio and the Java programming language. Android was chosen, as the documentation provided by the Movesense platform was aimed mainly towards developing for Android devices. As this is an area that was new to myself, it was decided to develop for Android where if any issues were encountered, I could review the documentation to try resolve the issue.

The web application was created using Python and the Flask web development framework. This was chosen as I have previous experience creating a web application using the Flask framework as well as I wanted to be able to access many of the libraries provided by Phyton for creating visualisations of the sensor data generated in graph format.

For the cloud database, I chose to use the Firebase platform developed by Google. The Firebase platform provides Backend as a Service (BaaS) which provides quick and easy setup with Android. Firebase also offers many other services, including Firestore Database, Realtime database, Firebase Authentication and Firebase storage.

The project itself was created to allow medical personnel to remotely monitor an elderly patient's balance performance while executing a series of balance activities. The activities chosen follow the 4-Stage Balance Test, which is "a tool to assess a client's mobility and risk of falls, based on his or her ability to hold four progressively more challenging positions" (Pysiopedia, 2021). The activities consist of four standing positions that get progressively harder to maintain

- Stand with your feet side-by-side.
- Place the instep of one foot so it is touching the big toe of the other foot.
- Tandem stance Place one foot in front of the other, heel touching toes.
- Stand on one foot.

The 4-Stage Balance Test follows the Balance Error Scoring System (BESS) developed by researchers and clinicians at the University of North Carolina's Sports Medicine Research Laboratory. "The Balance Error Scoring System provides a portable, cost-effective, and objective method of assessing static postural stability" (Altrium Health, 2021).

The patient will be in consultation with the medical personnel, who will inform the patient of the application and the activities to be carried out. They will be provided with the Movesense sensor device. The patient will install the mobile application to their mobile device and create an account using their email address which will also be shared with the medical personnel. Once the patient has created an account, they will be able to log on to the application, connect to the sensor device and begin carrying out the activities set.

The medical personnel in the meantime will have an account created on the web application. They can add patients to their patient list containing the patients details and medical condition. When the patient begins carrying out the activities the results are uploaded to the database. Once this happens the medical personnel can begin retrieving the patient's activity results from the database and begin to monitor and analyse how the patient is performing.

This will allow the medical personnel to remotely monitor the patient's performance while carrying out the 4-Stage Balance test and they will be able to view if there is any improvement or deterioration in the patient's performance while executing the activities. Should the patients' results be deteriorating the medical personnel can then recommend further balance exercises or even a walking support to the patient to prevent any falls.

Android Studio/ Movesense device

The mobile application was developed using the Java programming language for Android devices using Android Studio. Android studio is the official IDE for the Android operating system and is "the primary IDE for native Android application development" (Wikipedia, 2021). It provides the functions and services that will allow to create the mobile application.

The Movesense platform provides a set of developer tools, APIs and support that allows developers to create applications for sensing any type of motion. The platform provides the Whiteboard communication library for handling communication between the mobile device and sensor over Bluetooth Low Energy (BLE) (Figure 1).

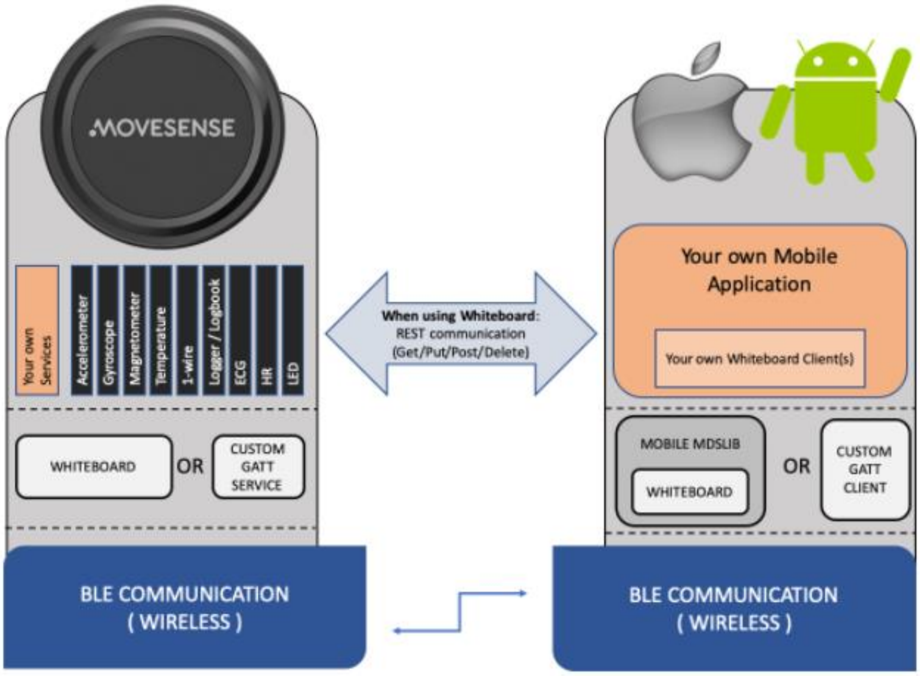


Figure 1 Movesense System - https://www.movesense.com/docs/mobile/mobile_sw_overview/

To then communicate with the sensor device, the Movesense platform provides the Movesense Device Service (MDS) library. The MDS library contains the components and interfaces needed to communicate with the sensor device over the Whiteboard communication framework. The MDS library allows the developer to create a Mds object which contains methods for connecting to and communicating with the sensor. Sensor data can be gathered from the sensor using the API request calls provided.

To connect to the device, the mobile application will also require a library that will provide the functionality to search for and connect with the device over BLE. This can be done using RxAndriodBle. RxAndriodBle is a powerful library that provides the functionality for scanning for nearby Bluetooth enabled and connecting to the device. Once connected to the sensor device, the mobile application can subscribe to and request data from the sensor using the MDS library.

Challenges – Android Studio / Movesense device

My overall experience with Android was relatively successful. While developing for Android was a new experience for me, I have previous experience using Java. Initial challenges faced included getting used to the Android environment and creating activities for each screen. Android has a large community of users and provides good documentation that is helpful when any issues were encountered.

Other challenges then encountered involved connecting with and communicating with the Movesense sensor device. As this was a new area for me initial difficulties arose in connecting with the Movesense device and gathering data from the sensors.

To help achieve this the Movesense platform provides documentation that was extremely helpful in providing any information needed to overcome many of the issues encountered. Movesense also provide the Mds library which allowed me to easily communicate with the sensor device and to subscribe and retrieve data from the sensors on the device.

To connect with the device, I also had to familiarize myself with Bluetooth and setting up connecting with the device over Bluetooth. For this, Android provided the libraries for connecting with a device over Bluetooth and documentation that made this task more easily achievable.

Successes – Android Studio / Movesense device

Once I had successfully connected with the Movesense device and was able to subscribe to the device and gather data from the sensor, I could begin creating the general layout of the mobile application and creating user registration and login procedures. For storing the user data, I decided to use Google Firebase. As a product of Googles, connecting with and setting up a Firebase database from Android was extremely easy. Google provide extensive documentation and support for creating a database for Android applications.

Firebase provides Authentication procedures that allowed for easy registration and login procedures for users to securely login and store the user's data. Firebase Firestore then provides a "flexible, scalable NoSQL cloud database to store and sync data for client- and server-side development" (Firebase, 2021). This allowed me to easily store the gathered data from the Movesense device along other required information.

Retrospective – Android Studio / Movesense device

In retrospect, I believe that choosing Android was the best choice when incorporating gathering data from the Movesense device. This was due to the documentation and support provided by the Movesense platform that allowed to connect and communicate with the device. Also using Firebase was the correct choice for Android ass it greatly simplified the installation and database creation process.

Flask Web Application

The web application will be developed using Python and the Flask web framework. Flask is a “lightweight Python web framework that provides useful tools and features that make creating web applications in Python easier” (DigitalOcean, 2021). Flask is a flexible and extensible framework containing an in-built server which allows developers to create web applications quickly and easily.

Flask in-built web server can handle incoming HTTP web requests and provide a response to the client. Flask uses the Jinja template engine to dynamically build HTML web pages using Python concepts. Jinja “is a Python template engine used to create HTML, XML or other markup formats that are returned to the user via an HTTP response” (Full Stack Python, 2021). Jinja templates contains variables that act as placeholders which can then store dynamic data rendered to the template from the python code. Jinja allows the developer to apply python programming logic in the templates.

Flask was chosen as I had previous experience creating a Flask application and so that I could easily access the Python libraries available for processing and visualizing the data gathered from the Movesense device. As displaying the data gathered in a way that would provide benefit to the medical personnel would demonstrate the patients balance progress or deterioration, this was an important aspect of the project.

Challenges – Flask Web Application

Challenges faced with creating the web application using Flask included setting up the Firebase authentication on the web app. Firebase provides methods for adding to and retrieving data from the Firestore database but to set up the authentication for the webapp a third-party library Pyrebase3 had to be used. After initial difficulties with installing and using the Pyrebase3 library I was able to set up users to register and login using the Firebase authentication procedures from the web application.

Further challenges then involved retrieving the gathered data from the sensor from the database and displaying the data in graph format and visualisations that provided benefit to medical personnel reading the data. While Python provides excellent libraries such as Pandas, Matplotlib and Plotly-Express for reading, manipulating, and visualising the data, I found it a challenge to display in graph format exactly what I would have liked the graphs to have shown.

Successes – Flask Web Application

After initial issues authenticating users through Flask and Python, I was able to use the Pyrebase3 library to successfully authenticate and validate users using Firebase’s authentication procedure. This allowed for medical personnel to set up an account and add patients so that could monitor and analyse the patients balance performance.

While I was not able to successfully display the data gathered exactly how I would have wished, I was able to use many of the Python libraries to get the data from the Firestore database to a Pandas data frame and analyse the data and manipulate into graph format so that it gave information to the medical staff.

Retrospective – Flask Web Application

In retrospect, while I felt using Python for gathering the data from the database and formatting the data to be displayed in graph was the right decision to make, I do not think that the Flask framework worked well with gathering data from a NoSQL database such as Firebase.

If I was to do the project again, I would look further into other options either for storing the data or using a framework that worked better with a NoSQL database.

Firebase

The cloud backend used for the project was Firebase. Firebase is a Backend-as-a-service (BaaS) platform developed by Google. It provides the platform from which mobile and web application developers can link their applications to a backend cloud storage platform where data can be pulled directly form the cloud with no server involvement.

Firebase allowed me to set up a project on the Firebase platform and register my Android and web applications on the project. Once the applications were registered, Firebase provides Firebase SDKs that allows access to Firebase products. Firebase products include, Cloud Firestore and Realtime database, Analytics, Performance monitoring, and Remote Config.

For this project it was decided to use the Cloud Firestore database. “Cloud Firestore is a flexible, scalable database for mobile, web, and server development from Firebase and Google Cloud” (Firebase, 2021). Firestore is a NoSQL cloud database which can be accessed directly from a mobile or web application using native SDKs. Firestore provides a flexible, scalable, and efficient method for storing and accessing the data including in-built security using Firebase Authentication.

Firestore allowed me to store data in documents that contain key value mappings. Documents can store many different datatypes including strings, numbers, Booleans, maps, arrays, or timestamps. Documents are then stored in collections which act as containers for the documents. Documents can also store subcollections within to store further data and each of the collections, documents, and subcollections can be then queried individually for more efficient and flexible requests.

Firestore’s functionality allowed for the applications to easily access the database and perform read and write operations for registered user’s for both the mobile application and the web application.

Challenges – Firebase

While working with Firebase was overall generally a success, I did run into some issues. Firestore stores data in a tree type structure consisting of collections, sub-collections, and documents. To store related data, I had to store sub-collections within collections so that data gathered could be related to a specific patient or medical staff. This often led to the collection expanding quite large and could lead to difficulties when trying to access certain items of data within a collection.

To overcome this often several variations of how to store the data were tried out, in order to see in what way the data could be stored most effectively so that the required information could then be easily accessed and retrieved when necessary.

Further issues also arose when attempting to apply Firebase's authentication procedure to the Flask web application. To achieve this, required the help of a third-party library which did not contain the same documentation and support as when working with Firebase using an Android application.

Successes – Firebase

I found setting up installing Firestore for the Android mobile application to be very intuitive and simple procedure to follow. The documentation and support provided made this process relatively easy to carry out.

Firestore's NoSQL database allowed me to store a range of datatypes and provided a flexible and scalable platform for storing the data. I found this to very helpful as I tested with the types of data that I would add to the database, such as lists of accelerometer data, that I would need to store to evaluate the patients balance performance.

Firebase also provide excellent authentication and security procedures for their databases removing much of the workload for the developer as well as providing many other services such as storage or analytics.

Retrospective – Firebase

I found using Firebase to extremely beneficial. Firebase provides a multitude of services and functions that are provided to the developer which take much of the stress of setting the application up on a database away from the developer allowing them to work on creating the application.

Considering the type of data to stored, I think that a NoSQL database was the correct choice as it allowed me to easily store lists of accelerometer data within documents. This data could then be easily retrieved with a simple get call which would have been more difficult to carry out using a SQL type database.

The only issue that really was with the implementing Firebase on the Flask application and that I felt Flask was more designed to work better with a SQL database rather than a NoSQL database.

Application Screens -Mobile

Splash screen

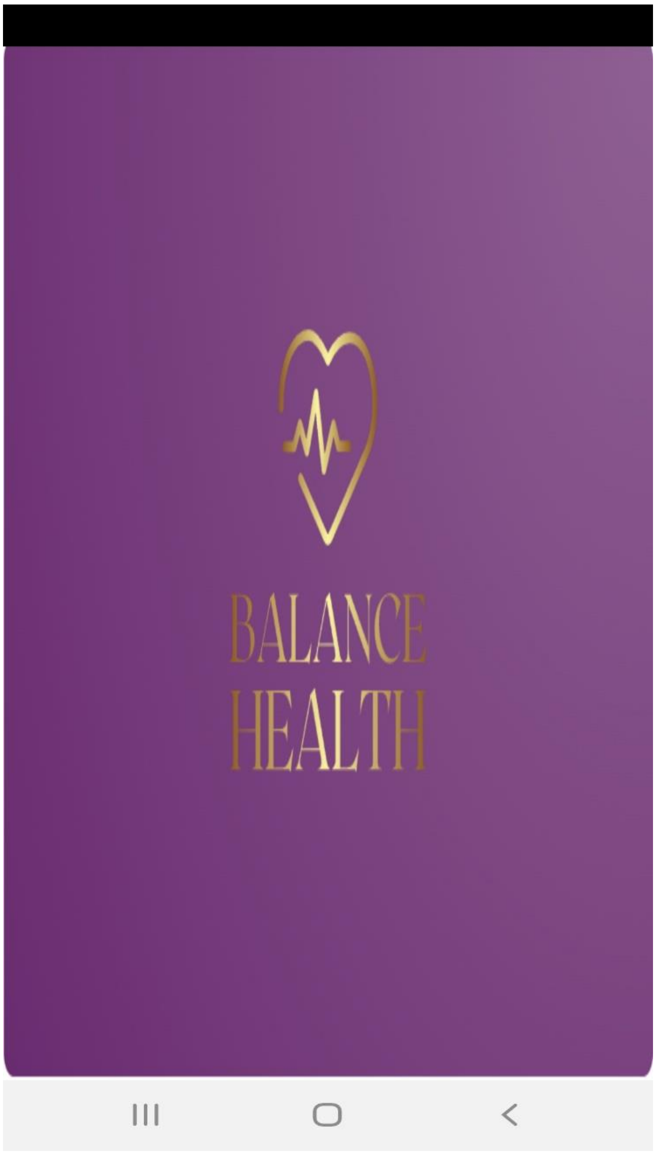


Figure 2 Splash Screen

The splash screen is the initial screen shown when the application is opened. It displays the project logo and brings the user to the login page.

Login Screen

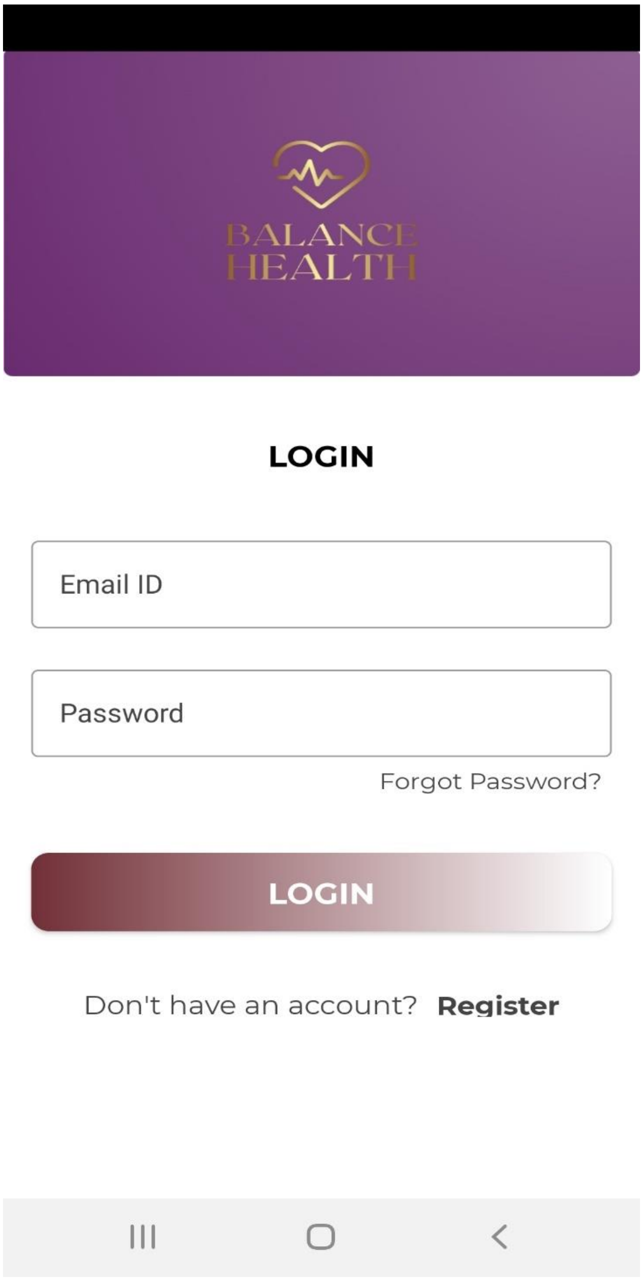


Figure 3 Login Screen

The purpose of the login screen is to allow registered users to log on to the application. To login the user must enter their email address and password.

Once the user has entered their login details, the entered data is validated using Firebase Authentication. If successful, the user is passed to the main screen. If unsuccessful an error message is displayed informing the user that the credentials entered cannot be authenticated and to try again.

The screen also provides options to the user to select forgot password option if they have forgot their password or register if they have not already created an account.

Register Screen

[redacted]

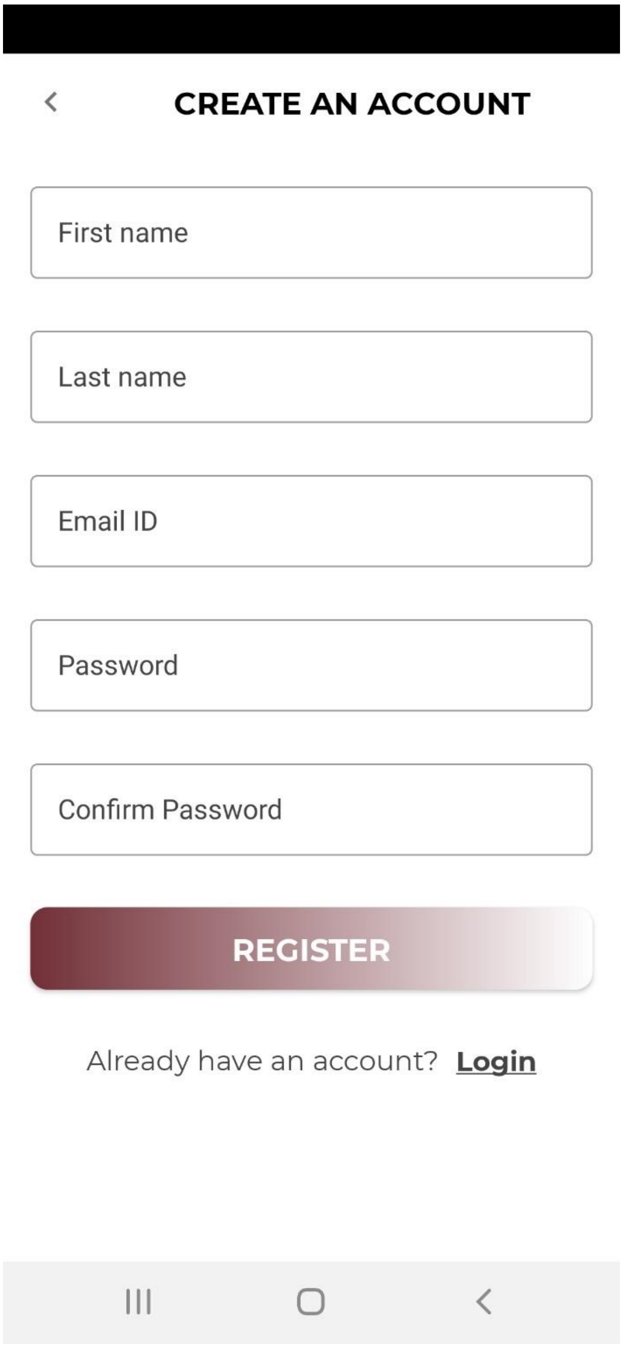


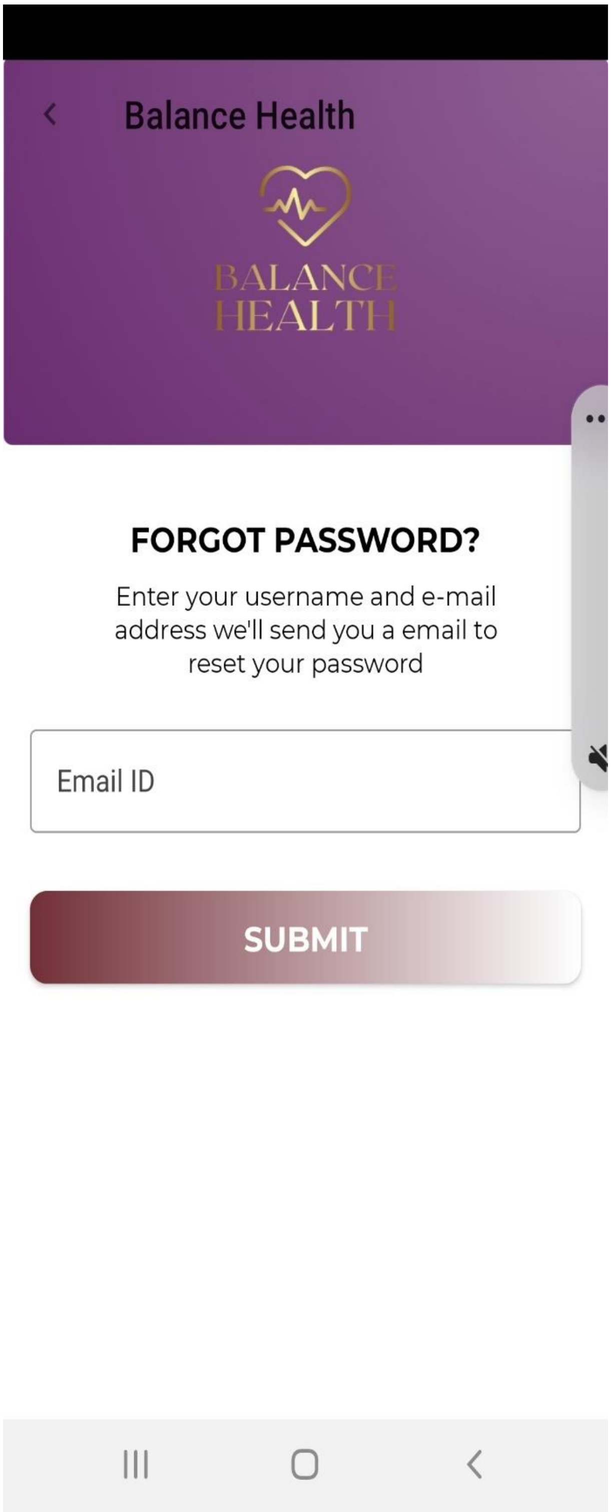
Figure 4 Register Screen

The register screen allows a user to register an account with the application using Firebase Authentication. To register an account the user must their first name, last name, email address, password and must confirm the entered password.

Once the user has entered their details, the details are validated and a user account is successfully created. If the details entered cannot be validated or the email entered already has an existing account, an error message is displayed informing the user that the details entered could not be validated.

The screen also provides a link to return to the login page.

Forgot Password Screen


Balance Health

FORGOT PASSWORD?

Enter your username and e-mail address we'll send you a email to reset your password

Email ID

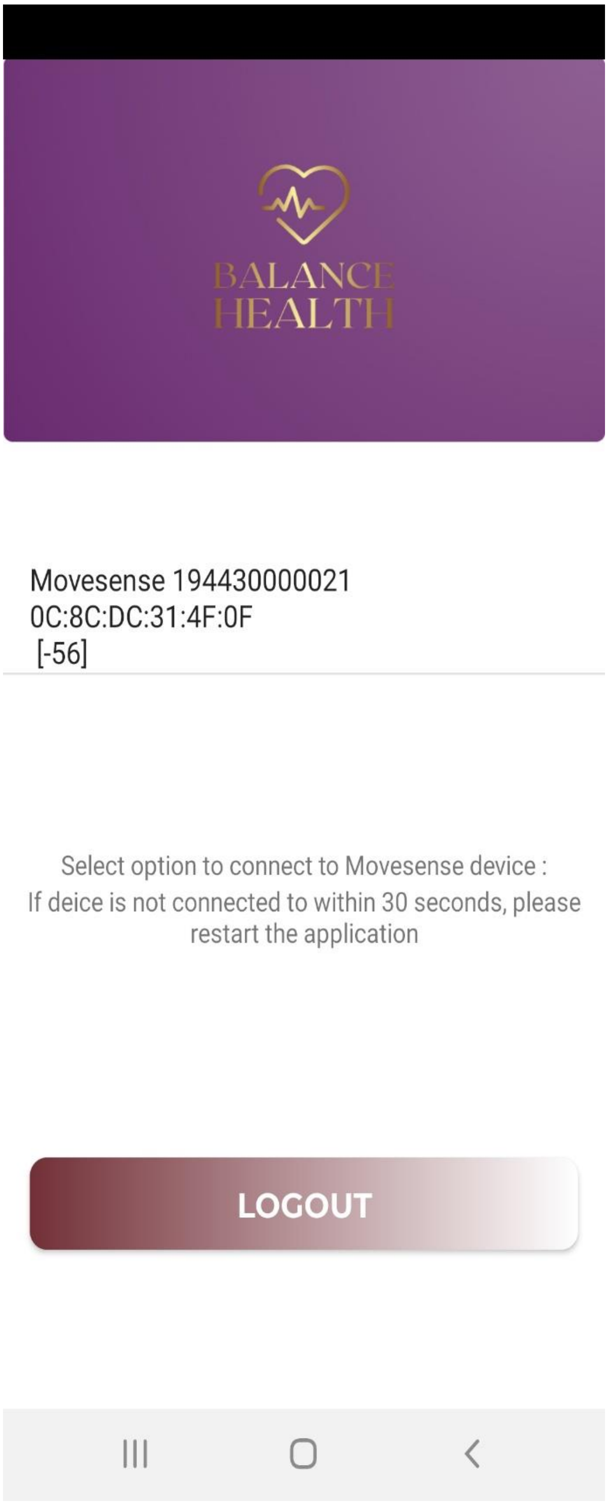
Figure 5 Forgot Password Screen

The purpose of the forgot password screen is the allow the user to rest their password in the situation should they have forgotten their password.

The forgot password screen allows the user to enter their password from which their password can be reset. Once the user selects submit, the user will be issued with an email allowing them to reset their password using an inbuilt method call to Firebase.

The user authentication details will be updated after the user follows the steps outlined in the email sent.

Main Screen



Movesense 194430000021
0C:8C:DC:31:4F:0F
[-56]

Select option to connect to Movesense device :
If deice is not connected to within 30 seconds, please restart the application

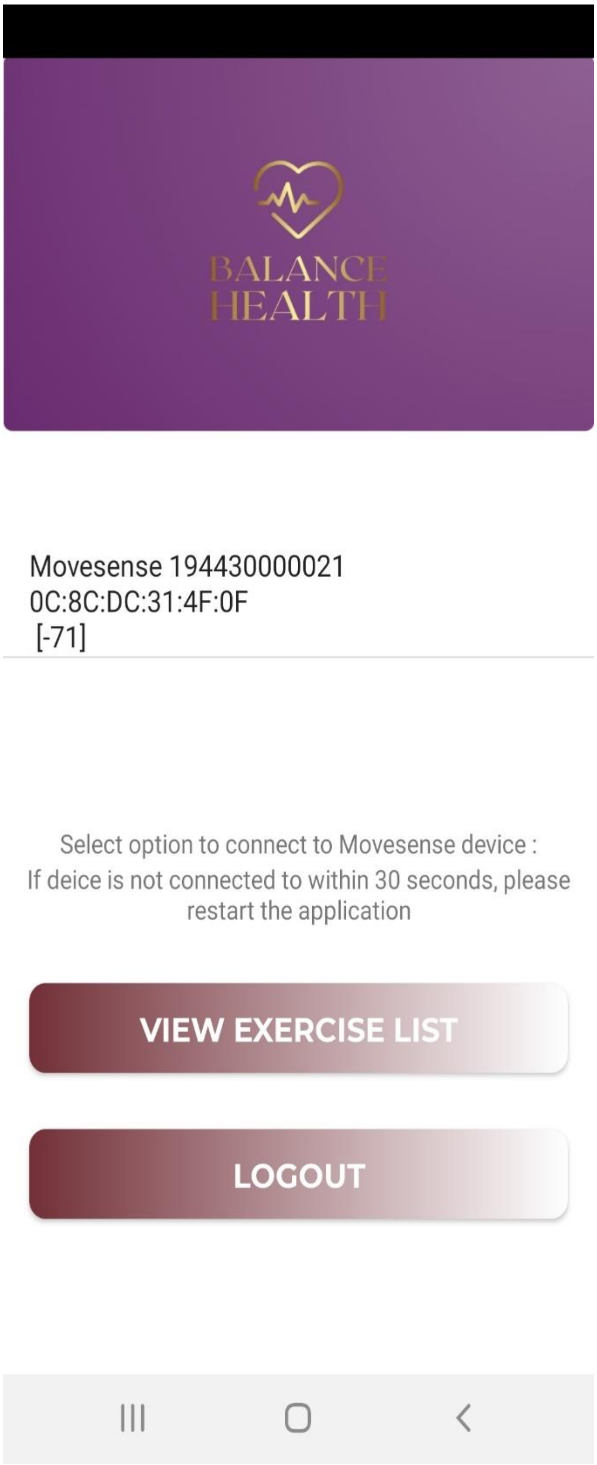
Figure 6 Main Screen

Once the user details have been successfully validated the user will be passed to the applications main screen.

Here the application will search for and display any Movesense devices found using Bluetooth Low energy. To connect to a device the user must select the device displayed on the screen.

The main screen also provides an option for the user to log out of the application.

Main Screen (connected)



BALANCE HEALTH

Movesense 194430000021
0C:8C:DC:31:4F:0F
[-71]

Select option to connect to Movesense device :
If deice is not connected to within 30 seconds, please restart the application

Figure 7 Main Screen connected

Once the user has selected a device to connect with from the options displayed and the device has been successfully connected to. The application displays a button that will bring the user to the remaining screens of the application.

Activity Options Screen

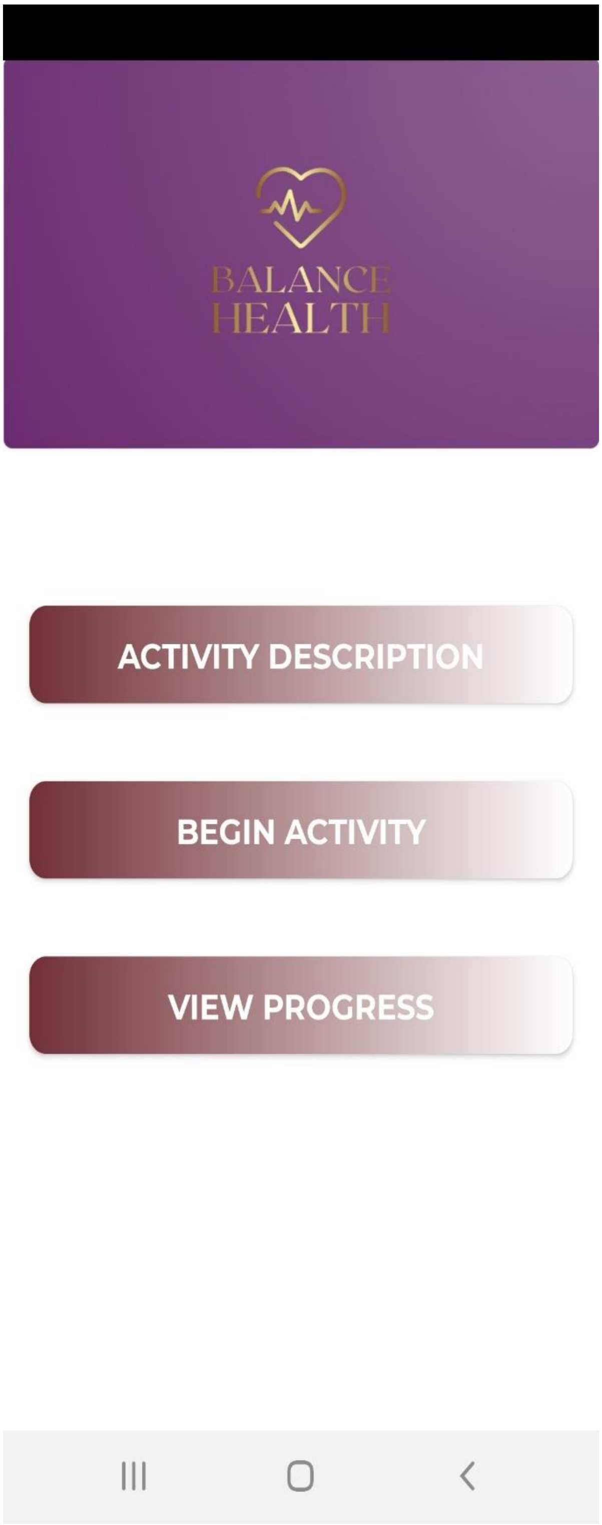
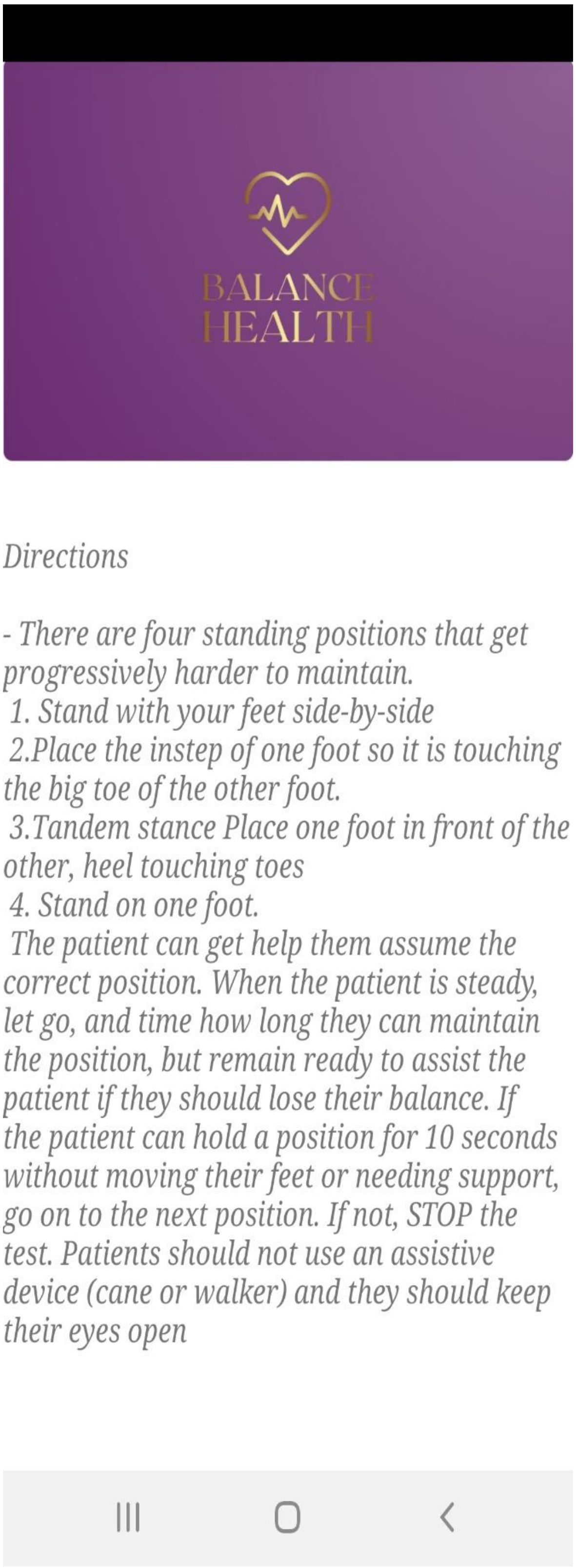


Figure 8 Activity Options Screen

On selecting the view exercise list button, the user is brought to the activity options screen. Here the user is given three options, to view the description of the activities to be undertaken, to begin carrying out the activities or to view their progress from previous activities.

Activity Description Screen



Directions

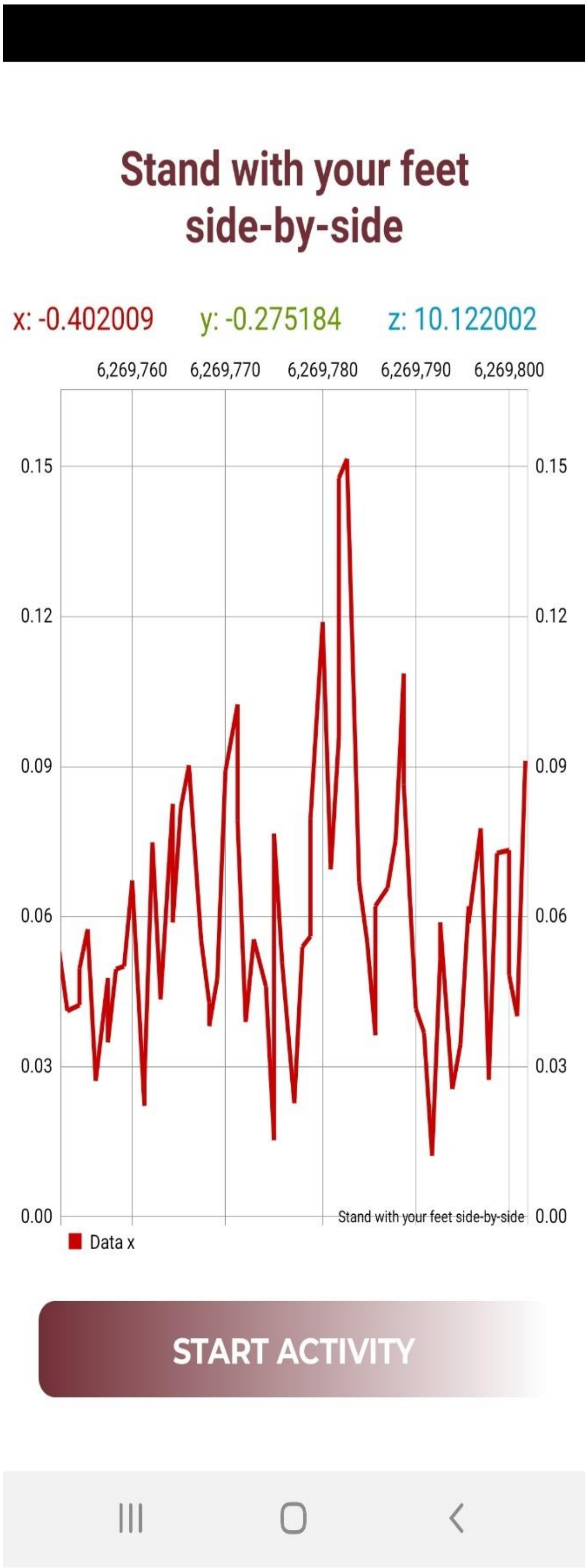
- There are four standing positions that get progressively harder to maintain.
1. Stand with your feet side-by-side
2.Place the instep of one foot so it is touching the big toe of the other foot.
3.Tandem stance Place one foot in front of the other, heel touching toes
4. Stand on one foot.

The patient can get help them assume the correct position. When the patient is steady, let go, and time how long they can maintain the position, but remain ready to assist the patient if they should lose their balance. If the patient can hold a position for 10 seconds without moving their feet or needing support, go on to the next position. If not, STOP the test. Patients should not use an assistive device (cane or walker) and they should keep their eyes open

Figure 9 Activity Description Screen

This screen displays a description of the activities to be carried out by the user. It describes each of the activities to be undertaken, how long the activities will take as well as any information that is useful to the user.

Begin Activity Screen



Stand with your feet side-by-side

x: -0.402009 y: -0.275184 z: 10.122002

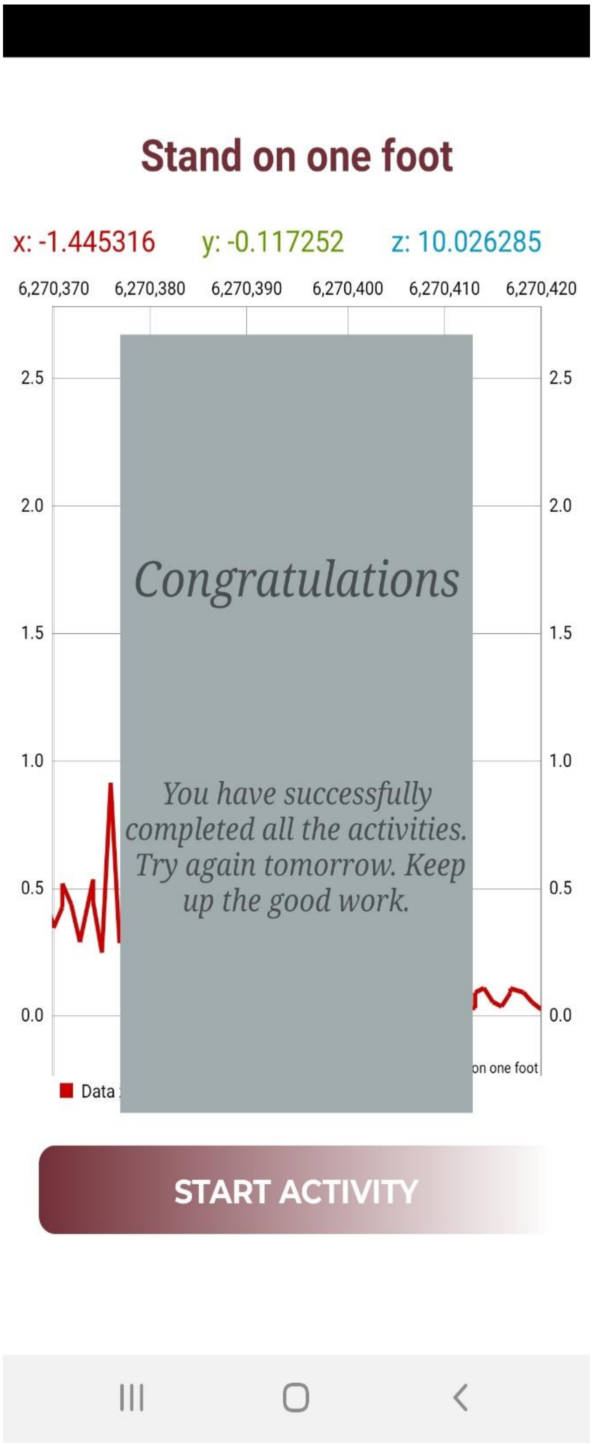
Figure 10 Begin Activity

The begin activity screen will allow the user to undertake each of the balance activities set out for the user. In this case the 4 Stage Balance test. The user will begin an activity by selecting the start activity button. A countdown will begin, informing the user of when to begin the activity and when the activity has finished by sounding a beeper.

Once an activity has been completed the user will be displayed a message stating if they were successful or not. If successful, the user can carry on to the next activity and so on until each activity has been completed or the user fails an activity.

The data gathered form the Movesense device will be displayed to a graph on the screen for the duration of the activity.

Begin Activity (completed)


[redacted]

Stand on one foot

x: -1.445316 y: -0.117252 z: 10.026285

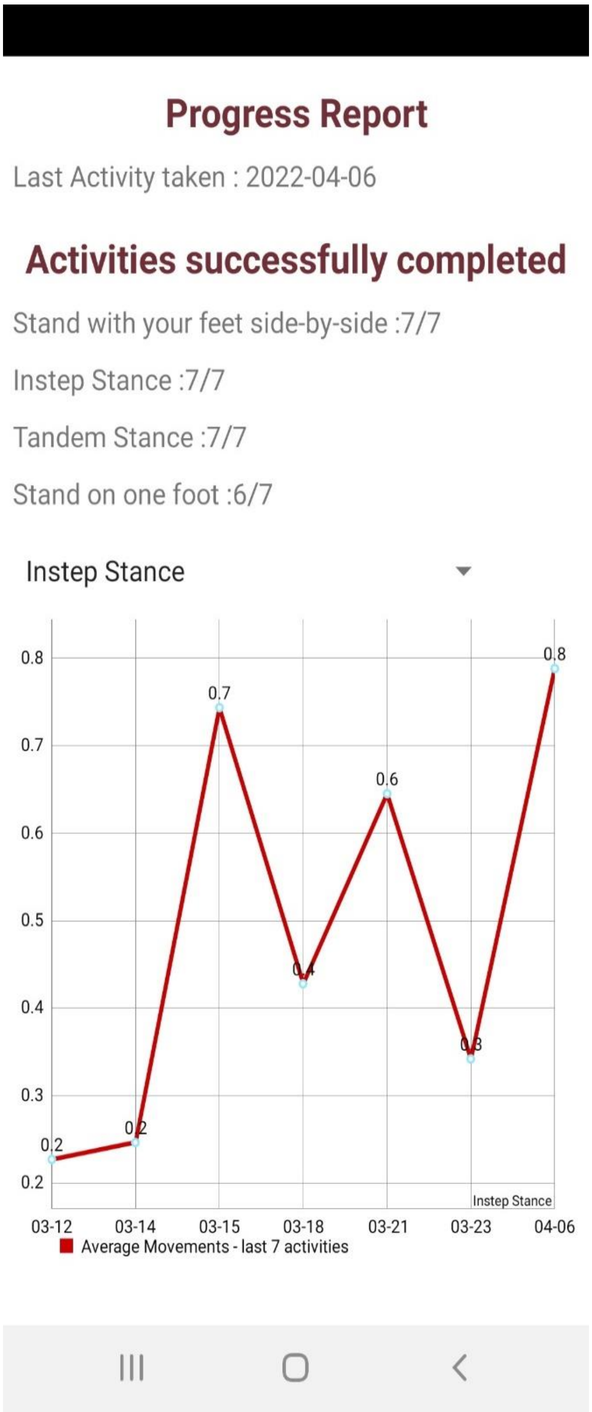
Congratulations

You have successfully completed all the activities. Try again tomorrow. Keep up the good work.

Figure 11 Begin Activity completed

On successful completion of an activity the user is displayed a message stating that the activity has been successfully completed and to move on the next activity to select the start button again.

Progress Report Screen



[redacted]

Progress Report

Last Activity taken : 2022-04-06

Activities successfully completed

Stand with your feet side-by-side :7/7

Instep Stance :7/7

Tandem Stance :7/7

Stand on one foot :6/7

Instep Stance ▼

Figure 12 Progress Report Screen

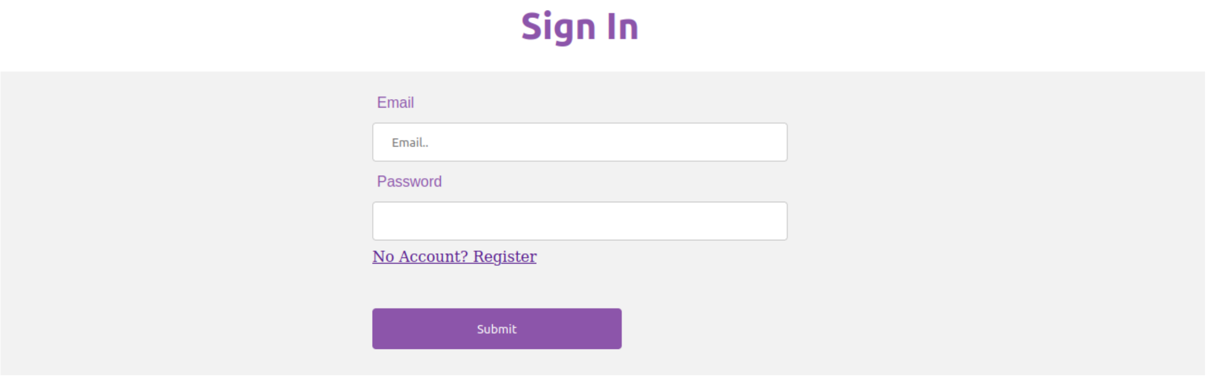
The progress report screen then allows the user to view their progress while carrying out the activities.

It displays to the user the data of the last activity undertaken as well as how successful they have been while carrying out each of the activities from the 4 Stage Balance test.

It also displays a graph showing the users progress for each activity showing the average movement of the user while carrying out each activity for the previous week's performances.

Application Screens -Web

Login Screen



Sign In

Email

Email..

Password

No Account? Register

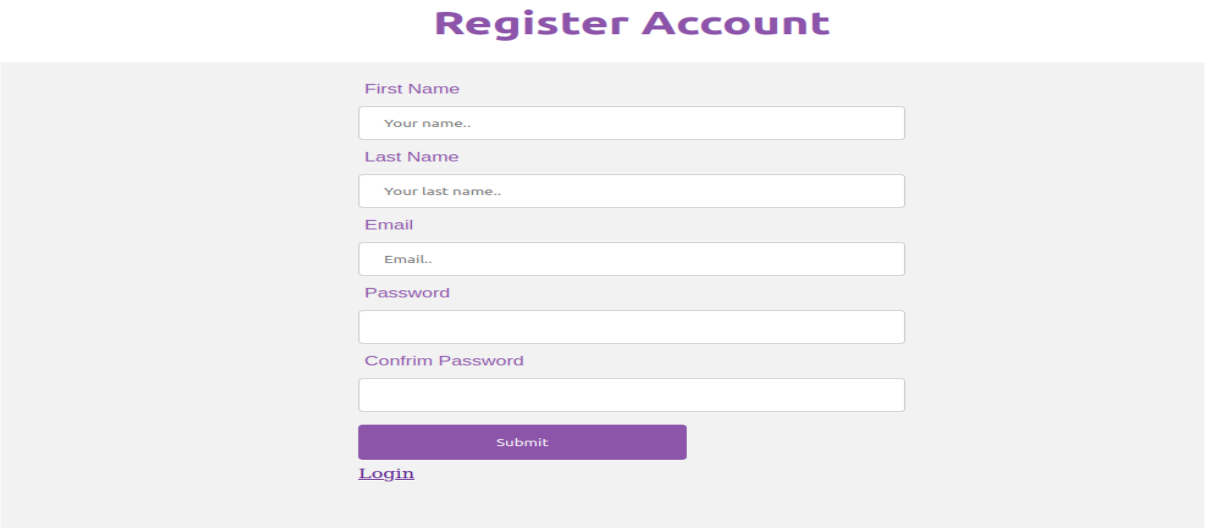
Figure 13 Login Screen (Web application)

This screen allows registered medical personal to log on successfully to the Balance Health web application using Firebase’s authentication procedure.

The user enters their email and password. Once the details have been validated on Firebase, the user is successfully logged into the application and passed to the applications welcome page.

The login screen also provides an option for the user to register an account if the user does not have an existing account.

Register Screen



Register Account

First Name

Your name..

Last Name

Your last name..

Email

Email..

Password

Confrim Password

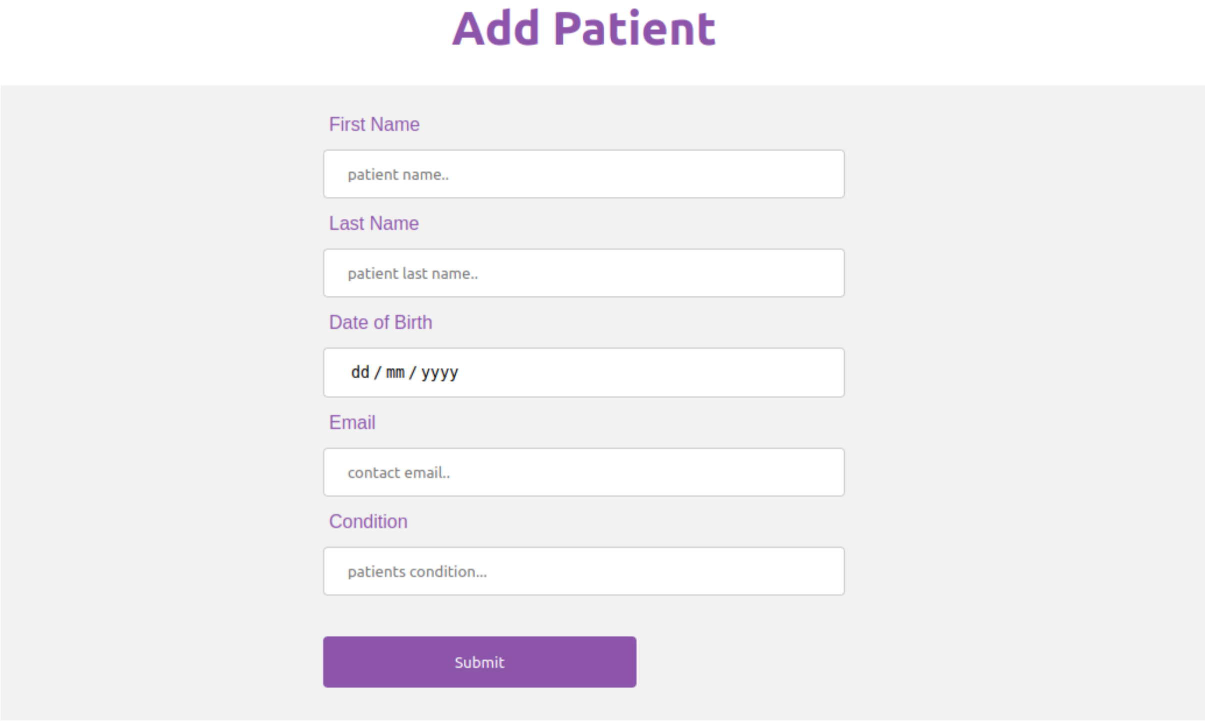
Figure 14 Register Screen (Web Application)

The register screen allows the user to register an account with the web application using Firebase Authentication. The user enters their first name, last name, email address and password and confirms the entered password.

The user’s details are validated and if successful, a user account is created. If they entered details cannot be validated, an error is displayed informing the user that the entered details could not be validated.

The screen provides an option to the return to the login page.

Add Patient Screen



Add Patient

First Name

patient name..

Last Name

patient last name..

Date of Birth

dd / mm / yyyy

Email

contact email..

Condition

patients condition...

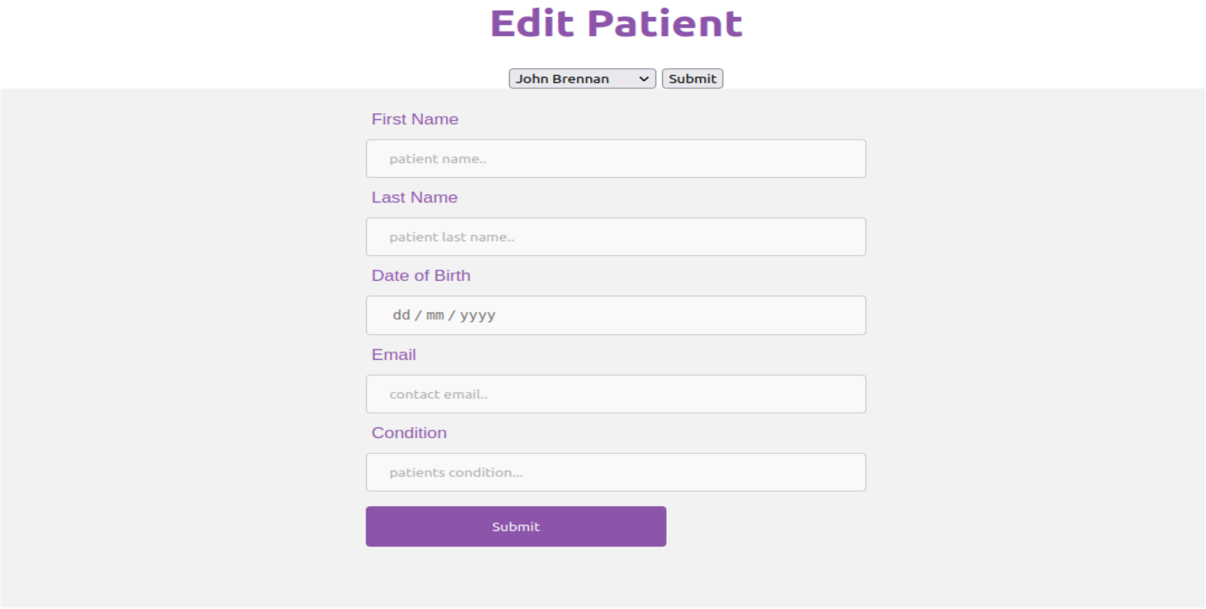
Submit

Figure 15 Add Patient Screen

Once a user has successfully logged in, they can then create patients for who they wish to monitor. The create patient screen allows the user to add the patient details including, the patients first name, last name, date of birth, email address and the condition that they wish to monitor.

On submitting the patient’s data, the patient’s details are successfully stored to the Firestore database. The patient’s details can then be used to access the patients balance data stored form the mobile application.

Edit Patient Screen



Edit Patient

John Brennan

First Name

patient name..

Last Name

patient last name..

Date of Birth

dd / mm / yyyy

Email

contact email..

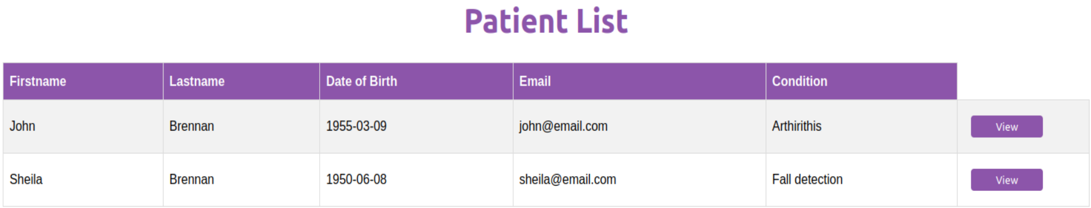
Condition

patients condition...

Figure 16 Edit Patient Screen

The edit patient screen then allows the user to update the details of a patient. The user can select a patient from a dropdown list provided and edit the patients details as required. The edited details are then stored to the database.

View Patients Screen



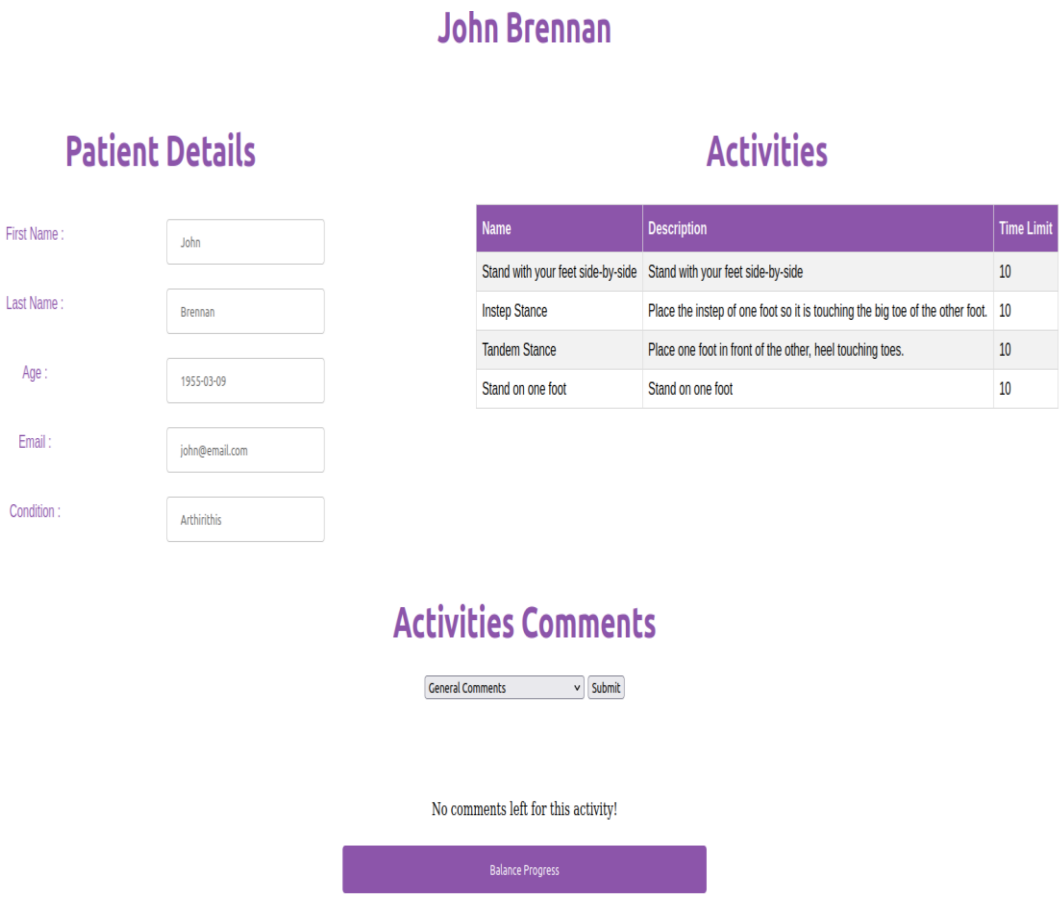
Patient List

Firstname	Lastname	Date of Birth	Email	Condition	
John	Brennan	1955-03-09	john@email.com	Arthirithis	View
Sheila	Brennan	1950-06-08	sheila@email.com	Fall detection	View

Figure 17 Patient List Screen

The view patients screen will retrieve all patients created by the current logged in user and displays each patient details in a table. Each patient row will also contain a button that will allow the user to view the selected patents details.

Patient Details Screen



John Brennan

Patient Details

First Name :	John
Last Name :	Brennan
Age :	1955-03-09
Email :	john@email.com
Condition :	Arthirithis

Activities

Name	Description	Time Limit
Stand with your feet side-by-side	Stand with your feet side-by-side	10
Instep Stance	Place the instep of one foot so it is touching the big toe of the other foot.	10
Tandem Stance	Place one foot in front of the other, heel touching toes.	10
Stand on one foot	Stand on one foot	10

Activities Comments

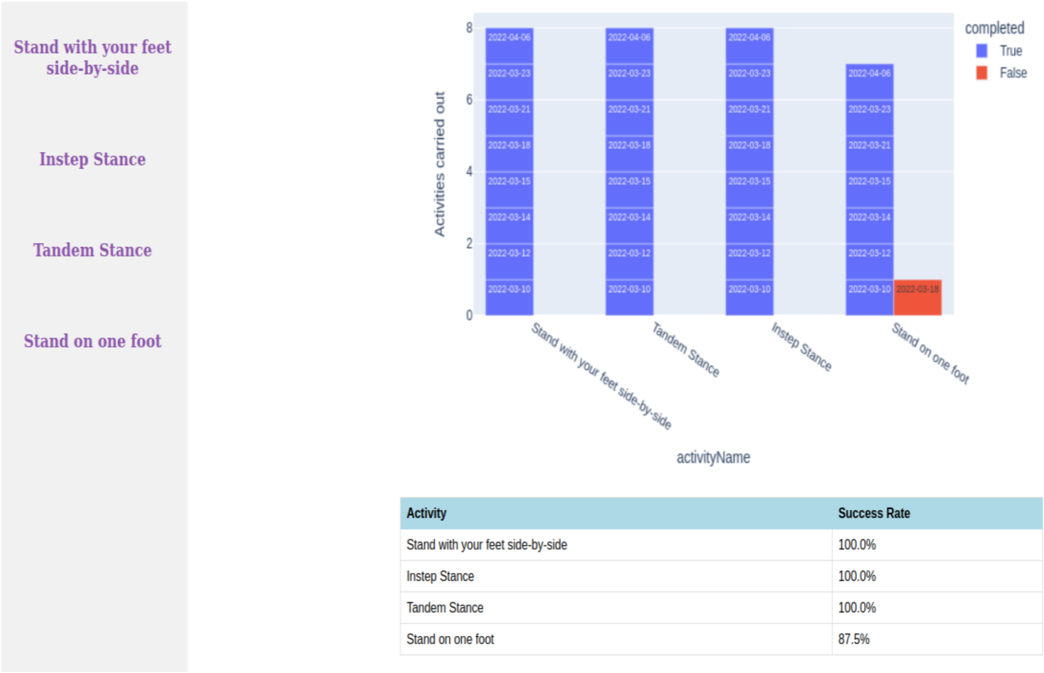
No comments left for this activity!

Figure 18 Patient Details Screen

The patient details screen will then display the selected patient's personal details, the activities assigned to that patient as well as any comments left by the medical personal for each of the activities carried out.

The user will be able to select form a dropdown each of the activities carried out by the patient to view any comments left by the user. A button is also provided on the screen that will bring the user to a screen displaying the patients performance while carrying out the activities.

View Activity Progress Screen



Activity	Success Rate
Stand with your feet side-by-side	100.0%
Instep Stance	100.0%
Tandem Stance	100.0%
Stand on one foot	87.5%

Figure 19 View Activity Progress Screen

The view activity progress displays the selected patient's overall performance while carrying out the activities. The displays provided include graphs and tables demonstrating when the patient last performed the activities, the patient's success rate while performing the activities as well as data relating to the patient's previous performances that may be of use to the medical personnel.

The screen also provides the option to the user of selecting a specific activity to view the patient's performance while performing each activity individually. The screen also allows the user to leave a comment relating to the patient's overall performance while carrying out the activities.

View Selected Activity Screen

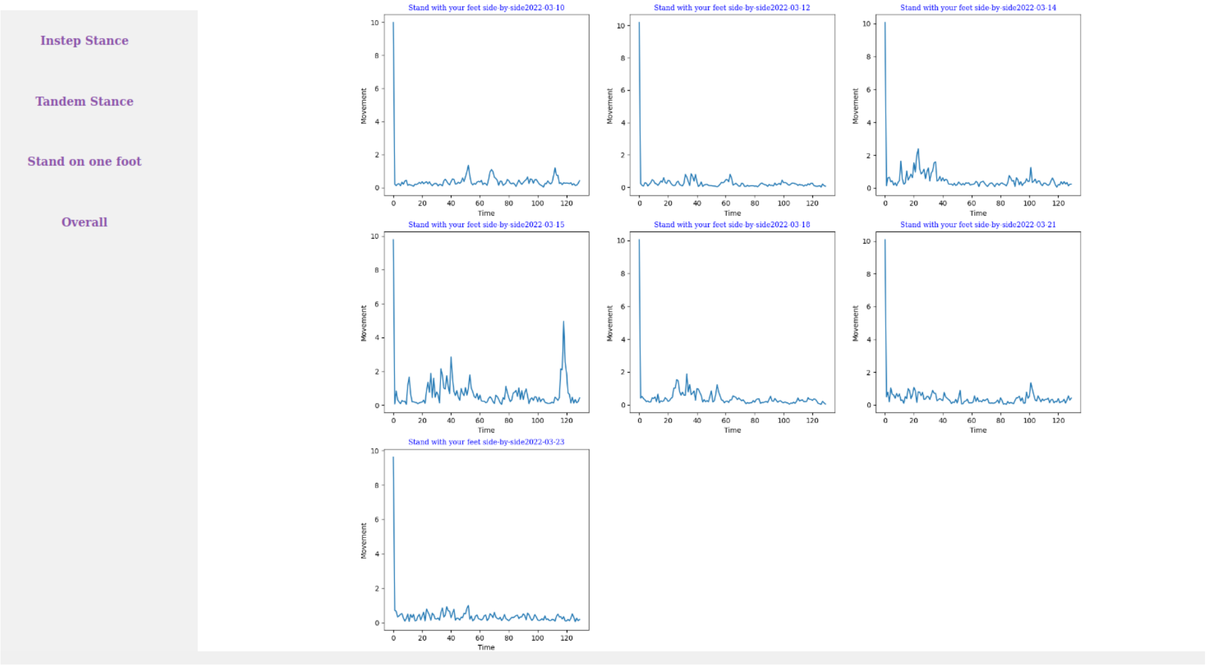

Instep Stance
Tandem Stance
Stand on one foot
Overall
Stand with your feet side-by-side2022-03-10
Stand with your feet side-by-side2022-03-12
Stand with your feet side-by-side2022-03-14
Stand with your feet side-by-side2022-03-15
Stand with your feet side-by-side2022-03-18
Stand with your feet side-by-side2022-03-21
Stand with your feet side-by-side2022-03-23
Movement
Time
0
2
4
6
8
10
0
20
40
60
80
100
120

Figure 20 View Selected Activity Screen

The view selected activity screen then provides details on each individual activity displayed in graph form to help describe to medical personnel how the patient is performing for each individual activity.

The graphs can indicate how the patient is performing or if there us an improvement or deterioration in the patient's performance. The user is also provided with an option to leave a comment for each of the individual activities for the patient.

Project Review

Achieved

From the initial idea for the project, the main concept of the project did not vary too much but certain elements and implementations had to be altered or removed as various issues and obstacles were encountered.

To begin the project aims was to gather sensor data from the Movesense device that would be used to track and monitor the wearers data. Initially, the project was to be aimed at the general population and would create an application that would allow the user to monitor and track their own personal data on a mobile application while wearing the sensor device. The data gathered would be used to display information regarding the user’s acceleration, and rate and other sensor data.

After additional research, it was decided to target the application to gather data on the user’s balance statistics specifically. Further consultation with members from the medical science department recommended the 4 Stage Balance Test to use as a recognised and tested metric for measuring a patient’s balance performance. The test is designed to be used by elderly individuals and can be used as a preventive measure for fall detection or other possible neurological conditions.

The core functionality of the project was achieved, and each use case illustrated in the Functional Specification was achieved to some degree. For the mobile application, a user can successfully register and create an account on the application entering their email and password. A user account is created securely using Firebase Authentication and the new user can log into the application.

Once logged into the application, the application searches for any nearby Movesense devices using Bluetooth Low Energy (BLE). Any nearby Movesense devices found over displayed on the screen. The user can select the device and the application will successfully connect with the sensor device using BLE.

Once connected the user can access the balance activities to be undertaken. Her the user can view information relating to the activities, can begin carrying out the activities or can view their previous performances.

Once the user begins the activities, the application successfully subscribes to the accelerometer sensor and gathers data for the duration of the activity. Once an activity has been completed the data gathers is successfully stored to the Firestore database. The user can the also retrieve their previous balance data performances from the database to view their progression.

For the web application, a user can successfully register their details and create an account on the application. The user’s details are encrypted and secured using Firebase Authentication. Once the user account has been successfully created, the user can log in to the application.

Once logged onto the application the user can perform CRUD operations for patients and balance activities. Once a patient has begun carrying out the activities on the mobile application, the user can begin retrieving the data form the database and monitor and analyse the patient’s performance.

Not Achieved

From the success metrics outlined in the functional specification, the only thing not achieved was setting activities for a patient to carry out on the web application. This however was due to changes in the requirements of the project. Initially the projects aim was to allow medical personnel to set out various balance activities of their own choosing for a patient to carry out but after gathering feedback form stakeholders in the industry it was instead decided to follow the 4 Stage Balance Test.

This did not require the medical staff to set the activities as the test contained predetermined, recognised, and validated activities that could be used as a metric for measuring a patient's balance performance.

While most of the requirements set out for the project were achieved, there remains some unresolved issues such as validating and verifying the data gathered from the sensor and displaying the data gathered in contrast with the validated metrics. This could be done so that when medical personnel viewed the data it could be shown clearly how well the patients balance data was in comparison to the verified and validated data.

Further items regarding the project that were not achieved related into the display of the project. Due to timing issues and constraints much of the layout and appearance of the applications still requires work to be completed so that the application provides a greater user experience for the user.

How Would I Start from The Beginning Again?

If I was to start the project from the beginning again possessing the knowledge that I have gained form this experience, there are a few things I would have approached differently. As this was the first project of this size that I have undertaken, I feel that I rushed into much of the process without taking into the whole development process into consideration.

From the outset of the project, the plan was to track and monitor a user's data while wearing the Movesense sensor device with no clear decision made into how the application should be implemented. Due to this there was many minor changes and adjustments made to the project design and implementation throughout the initial phases of the project which took up a considerable amount of time.

A final decision on the exact functionalities of the project were only made after consultation with Dr Claire Lodge from the medical science department who recommended a validated balance procedure which has been verified by others in the medical profession as a metric to accurately monitor a user's balance performance.

Unfortunately, I only gathered this feedback in February of this year which impacted on the time left to achieve much of the functionalities of the project. If I were to repeat the project again, I would not have raced into beginning the project as I had done and focused more on creating the research, design and functional specification documents ensuring I had a concreate plan to follow for the project.

I would have also involved stakeholders such as those that worked in the medical industry or people from the medical science department much earlier in the project to get more relevant information and insight into how to best develop the project and how the intended user would get most benefit from the applications.

Other changes I would have made involve the organization and structure of the applications and creating and sticking to a timeline throughout the process. By better implementing these processes throughout the project I feel would have greatly helped in the longer-term application of the project rather than leaving things to last minute which often was the case.

Future Development

While much of the functionalities of the project have been completed, after consulting with and receiving feedback from the medical science department, steps previously not thought of by myself into how to verify and validate the Movesense sensor to be recognised and approved to gather a patient's balance data were outlined.

To achieve this a balance assessment test procedure would need to be carried out on several individuals to investigate the reliability and validity of the Movesense device while gathering balance data. This would require user testing of the sensor deice and accurate recording of the participants data so that a range of measurements could be gathered to distinguish what would be deemed as a patient losing their balance.

Considering the time limitations and my lack of experience in this area this functionality was seen to be beyond the scope of this project but could be applied if the project was to be developed further or to be of a production level.

The range of values gathered form the tests gathered out could then also be used as a metric to display to the medical personnel as to whether a patient is successfully carrying out the activities while remaining within the estimated range of successfully completing an activity of their results fall outside the range and the patient needs further monitoring.

Adherence to original design

Here I will discuss how well I adhered to the to the specification and design documents originally created for the project and describe the changes that were applied during the project.

Initially the project was to consist of a phone application only which could be accessed by the users to monitor and track their own performance while carrying out some basic exercise activities. As further research was carried out into the application and similar applications currently available, it was decided to change the approach as to target the project towards specific patients and include a web application from which medical personnel could monitor and track a patient's performance while the patient carried out activities on the mobile app.

Once it had been decided to create a web application for the medical personnel it was also decided to aim the project at a more specific activity rather than using various activities. For this balance was chosen, the reasons for which are outlined in the research document. Again, initially the project was to be aimed at various activities the medical personnel would set out for the patient to perform.

However, after consultation with Dr Claire Lodge from the medical science department, it was determined to use a verified and validated balance performance test (The 4 Stage Balance Test) which could be better used to assess a patient's balance performance using a peer reviewed activity set.

While the main objectives of the project remained largely the same, these adjustments and changes to the project added more time constraints to the project. In future projects I would focus more on decided upon a set idea from the beginning of the project, involving the necessary stakeholders at a much earlier stage to build a clear picture of what the projects functionalities were and what exactly it aimed to achieve.

Process Methodology and Milestones

Throughout the development of the project, I tried to apply an agile approach so that the project could evolve and grow as more aspects and functionality were added. I tried to apply this approach to the project's development, research, and documentation, though I found it hard to maintain as the year went on and timing constraints and other course projects had to be completed.

For the most part I attempted to adhere to a set procedure for each week when possible. The general timeline was:

- Monday Evenings – Carry out research
- Thursdays – meetings with my mentor
- Fridays – Saturdays – implement functionalities and test application
- Sundays – Documentation

Figure 21 illustrates the timeline of the project, showing documentation and presentation deadlines as well as demonstrating the major milestones of the project.

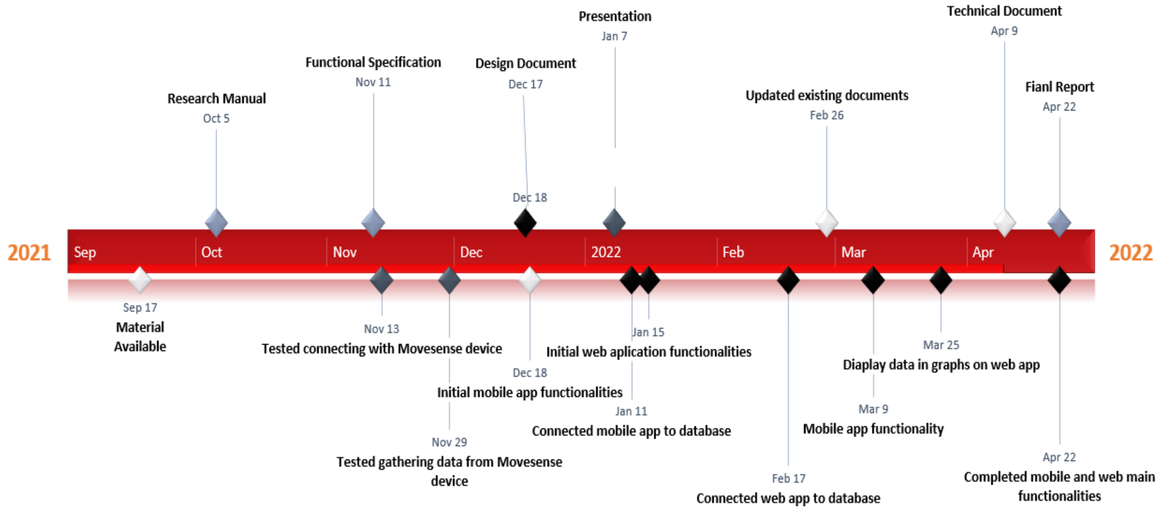


Figure 21 Project Timeline

Testing

The Balance Health application is targeted at medical personnel and their patients. The web application will be used by the medical personnel, while the mobile application will be used by the patient. The 4 Stage Balance Test was generally developed for elderly patients to provide some insight into the patient's balance statistics and possible risk of falls.

As COVID-19 remained prevalent throughout the year, it seemed inappropriate to carry out testing using elderly patients who stood at a greater risk of infection from the disease. Also, I felt to involve medical staff who already had been overworked due to the pandemic would be inappropriate during these times. Due to the limitations caused by the COVID-19, a full and accurate testing for the project was not possible.

Considering these restrictions, the testing carried out was limited. To test out the mobile application, I enlisted the help of my parents to use the application ever few days to monitor and analyse their balance performance while performing the activities. They agreed to allow their data to be used for the testing purposes. My parents are younger than the intended participants of the 4 Stage Balance test so results gathered may not be accurate compared to the target users but their interactions with the application would still be useful.

While interacting with the device, I performed an observational user testing technique to recorded how well they interacted with the application and any issues they encountered. This technique allowed me to find any issues such as updating user messages or errors that I may have missed. This helped me to develop the mobile application to resolve any issues that a new user may encounter while using the application. Examples of the results found are shown below.

Date:	14/03/2022
Participant:	John Brennan

Observations:

- Register and login – no issues
- Connecting with Movesense device – message unclear as to how to connect with Movesense device and proceed in the application
- Unsure how to move from one activity to the next

Changes:

- Updated display message for users indicating how to connect with the Movesense device and the steps to follow afterwards
- Updated the application to move from one activity to the next automatically upon successful completion of each activity.

Date: 15/03/2022

Participant: Sheila Brennan

Observations:

- Register and login – no issues
- Instruction for carrying out activities unclear
- Unsure how to move from one activity to the next

Changes:

- Updated activity description screen to describe more accurately the activities to be undertaken
- As above

For testing the functionality and user interface of the web application, through the help of my mentor, I was put in contact with Dr Claire Lodge of the medical science department. It was Claire who recommended the 4 Stage Balance test as a validated report which could be used to accurately determine a patient’s balance performance.

In further meetings, Claire also outlined the testing procedure that was needed to be undertaken to test the validity and reliability of the sensor device measurements when performing the activities. Once this testing had been carried out a range of measurements could then be used as barometer to test against while patients performed the activities which would be used to illustrate to a medical person if there was improvements or deterioration in the patient’s balance in contrast to the verified measurement range. The results could then be displayed in a graph that medical personnel could easily look at and view exactly how a patient’s balance was and where there were any issues if any to be found.

Unfortunately, this meeting only happened late in the year and there was not the time to perform such testing. I also this kind of testing would require someone with greater experience in this area to carry the testing out successfully and to gather results which could be accurately and clinically used to measure a patient’s performance. I believe this was beyond the scope of this project but would be performed if the application was to be developed upon further.

Learning Outcomes

The many learning outcomes achieved from carrying out this project have been extremely eye opening and beneficial. The experience gained over the course of developing this project and given me a valuable learning experience and knowledge that I can take me in the future.

As this was the first for myself to attempt a project of this size and difficulty, there was many new obstacles and technologies that I had not previously faced. The project consisted of a mobile application, a web application, a cloud database and a external sensor device. While I had some experience working with Java and had previously created an application using Flask and Python, developing a mobile application and web application of this size was a new experience for me.

Connecting with and communicating with an external sensor device and Firebase's cloud database were also new experiences for me. Though I ran into many issues and had to find ways to work around many issues I encountered I feel that this experience will be of huge benefit to me in the future.

The challenges encountered, the mistakes made and the knowledge I have gained from carrying out this project have taught me valuable lessons which I will bring with me into any future development projects that I will undertake or be apart of. It has helped give me a greater understanding of the hardware and software used and how different technologies can be integrated and combined to achieve a finished product.

The process has helped to gain a greater understanding the software technologies used, the software development agile process, how to apply software engineering techniques to solve development problems, how to document the process, carry out testing and providing a great introduction to the whole software development life cycle.

Acknowledgments

I would like to acknowledge the assistance provided to me by my project supervisor Joseph Kehoe for his continued support and mentorship throughout the process. Joseph helped guide me throughout the entire process, providing with valuable insights and support. His help is greatly appreciated.

I would also like to acknowledge Claire Loge for her guidance and assistance in providing with feedback and information into research the provides a recognised Balance test procedure that has been clinically evaluated and validated.

Finally, I would also like to thank all those who provided me with valuable information and technical support for queries and concerns I had and for the support provided.

Conclusion

This document concludes the Balance Health final year project. The report has described my experience gained throughout the process regarding all aspects of the project, what was achieved, not achieved, how I would approach things differently, future development of the project, adherence to the original concept, the learning outcome gained as well as the issues that I encountered.

The document outlines the learning and experience that I have acquired while developing the project which can I bring with me in the future.

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