DUBLIN CITY UNIVERSITY
School of Computing

Functional Specification for Hand Mobility Monitoring and Analysis

Computer Applications Final Year Project

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Introduction

Overview

Over the past few years' software that helps monitor health and exercise have become very popular, with many mobile applications and websites' been developed and used to track daily exercise and food intake. However many if not all these applications are designed as a logging system of what a user says they have done without any means to check or get accurate measurements of activity, with the exception of pedometers on mobile devices and smart watches. With the popularity of these types of applications there have been developments in applying them to the medical field of physiotherapy. Companies such as Physiotools[1] ltd and Salaso[2,3] enable healthcare professionals to monitor their patient's progress through logging applications that report what the patient says they have done as well as how they are feeling.

The project proposes to develop a web application that enables the monitoring and analysis of a user's hand mobility through the use of a leap motion controller. The application will have two groups of end users, these will be care providers made up of doctors, physiotherapists or nurses, and patients who are undergoing examination, or rehabilitation of hand mobility. The system will provide a way for care providers to monitor their patients' progress through the use of information given in both table format and more graphical representation of charts. This information will be detailed to a level that cannot be done through conventional means without a great deal of difficulty collecting information straight from the patient. This information is gathered when the user is using the leap motion and logged into a portal for exercising or examining their hand mobility.

Through the portal patient end users will be able to access a number of exercises they can do from their location, either at home or at a care provider's location. The exercises will go through a set of movements that are aimed at improving their mobility and the system will track their hand movements to carry out these tasks, to analysis their range of movement, and to insure they are carrying out a set of movements correctly.

The project aims to create a new application that allows a care provider to retrieve measurements of movements from a patient without having to do a set of manual examinations on a patient. Instead they will have access to information that their patient will generate themselves while carrying out their own set of exercises. The project also aims to free time up for both patient and care provider. As the patient will be able to carry out the exercises themselves and create the information about their progress regardless of location they can shorten the time needed to go see a physiotherapist or doctor for examinations.

Both end users will have two different functions available to them. For care providers they will be able to login to a care provider portal that allows them to see how one of their patients is progressing. This will be done through the function of report making. This function will allow the care provider to select what information they want to see from a patient data that was created when they performed a set of exercises on the system. For patients they will be able to login and select an exercise to complete, through their own portal, during which measurements will be made and recorded for their care provider. As this data is sensitive

medical data the project will have to conform to data security laws for medical information as laid out by the EU as well as ethics about how the data is handled.

Glossary

Leap Motion Controller: The leap motion controller is a device that uses two IR camera and three infrared LEDS that tracks hand movements with in its scope of view.

Throughout the document the word exercises will be used to encapsulate the following:

- Thumb flexion/extension
- Separation of fingers and closing of separation.
- Hand/finger tendon glide
- Wrist extension and flexion

General Description

System Functions

The system will contain a variety of functions for both care provider end users and patient end users.

Below describes what functionality each end user group will have access to within the their respective portals in the web application.

Care Providers

1. Account Management: The care provider user will have the ability to add patients to the system and provide information about the patient such as name, age, gender, conditions etc. This process will register the patient and add them to the care providers list of patients. The care provider can also remove a patient from their list or transfer them to other care providers on the same system.

2. Report Creation: The system will take a request of a patient's data to be placed in ether a graph or table. The output to be shown is selected from a list of possible choices based on the data that has been generated which could range from, range of angle of closer of a joint on a finger, to the time spent a day using the system by the patient.

3. Export of Report: The system will allow the creation of PDF's of reports created by the care providers. The exported PDF's will contain all information that is within the report view, which may contain graphs or tables with patient data from exercises placed in them with comments made by the care provider below them if they are necessary for comment. Along with this basic identification information such as name, hospital identification number, date of birth, etc. for filing and documentation purposes.

Patients

1. Exercise Guide: The system will allow for the tracking of a patients hand movements and guide them through different exercises that will be used to gather information about the patients' mobility. Each guide will focus on one movement of the hand.

2. Report Progression: The system will allow the patient to record any extra information about their progress in recovery. This may include how they are feeling that day, any problems preforming the exercises or improvements they have noticed in daily activities.

3. Exercise Selection: The system will allow the patient to select what exercise they wish to complete.

User Characteristics and Objectives

There are two user communities, care providers and patients. Both of these user communities have different expected expertise with the proposed type of system and the applications domain.

Care Providers

The care provider user community would be made up of primarily two groups of professions doctors and physiotherapists with nurses a secondary profession to this community if they specialise in a particular medical area. These two groups of professions would be skilled in working with systems that deal with keeping track of patient information as more medical reports have become digitally accessible. The two professions would be knowledgeable about what information they are looking for when using the application in terms of what measurements they wanted to see from their patient. However due to the system been proposed been new to many in both professions, formal training on the system would be necessary I know how to obtain the patient data they are looking for as well as managing their patient list.

There would also be the objective to change what the patient is doing day to day in terms of the length of time spent on an exercise by controlling the number of sets to do in a day and the level of difficulty of the exercise by controlling the number of repetitions to be done in each set. As well as setting which exercise to complete from a list of available options they have to choose from. This objective comes from been able to see what exercises become too hard or easy for a patient through the use of viewing a patients data been collected through the exercises instead of word of mouth from a patient during a check-up.

To complete these objectives a number of system requirements are necessary.

- The system must be usable to all, for both care providers and patients.
- Information about patients must be kept confidential but be accessible to care providers who are allowed to see the patients data.
- There must be a high level of data integrity and reliability of the system.
- Patients' data must be viewable in a sensible manner.
- They must be able to store patient's' information for a period of time, even after removal of patient from care. This is to follow rules and regulations of holding patients data digitally. To achieve this, the system must provide a process of coping and exporting data from its operational database, so that an external copy can be created for storage.

Patients

The other user community, patients, have different characteristics to care providers. This group of users would have little knowledge of the web application itself. As the system would be new and focused on a select group of users first time patients would have no previous knowledge of an application like the propose one. As well as this the hand tracking of the users hand movements will be completely new to them with them having very little to no experience with the leap motion controller. For these reason formal training when the patient is added to the system would be needed.

The user community of patients will have the objective of carrying out a set of exercises. These exercises will be different to each patient and very on aspects according to their individual needs decided by their care provider. Apart from this they will have objectives of login into the system and reviewing their account, time spent exercising and a history of what they have done and when they have done it.

For these objectives to be carried out the following requirements are necessary.

- The system must track user's completion of exercises.
- The system must have a variety of exercises to choose from.
- The system must have the ability to have different users with username and passwords.
- The application must be secure as sensitive patient information is stored in the system.
- The interface must be usable by all patients suffering from hand mobility issues. That is to say that the application must be usable by patients that need help from accessibility software such as voice controller navigation, for example windows voice recognition software, or solo keyboard navigation to be able to use a computer and enter in details such as their login details.

Operational Scenarios

Logging into the system

A patient or care provider enters the systems portal through the use of a URL and web browser. They enter their username and password, and then the system takes the users inputs and checks it with what is on the system. If both, username and password, match up the user is brought to their designated portal where they can access all information and options available to them.

Looking up Patient Information

A care provider enters a patient name or identification number into a search field. The system checks to see if there is a patient matching the terms within the system, and that the care provider has permission to view patient information. If the system finds that both cases are true it returns the patient's information to the care provider. The care provider may now see the requested patient's information. If the cases are not true the care provider is notified that the patient is not on the system or they do not have access rights to them.

Creation of Patient Reports

A care provider looks up patient information. When they obtain the information from the system they select a marker to see and an output for the information to be shown in. The system takes this request and requests the necessary information from a database and processes the information returned into the requested output for the care provider. Incompatible information and output types are reported to the care provider.

Carrying out Exercises

A patient selects an exercise to do out of a list of possible options. This can be done through mouse clicks, the leap motion or keyboard shortcuts. The system takes the selection and loads up the exercise. The patient moves their hand when indicated or when an event takes place on the screen. The exercise responses to a user’s hand movements and takes in data about their hand, using three dimensional vectors for joints and fingers and processes this for meaningful results. Once the user finishes the exercise the information is processed and resulting findings are placed in records.

Constraints

1. The system will handle extremely personal information about a patient's health and as such the system must adhere to EU data protection regulation and particularly to the treatment of health data.

2. The leap motion can consume a lot of power from the device to which it is connected. As such any service that uses the leap within the system must be designed to be resource light as to not add to the number of resources the system needs to consume to function.

3. The system must be fast at detecting any issues with hand tracking and correct the mistake either internally or externally as to not corrupt data integrity.

4. The system must be usable on a range of web browsers and functionally be the same for each of them.

5. The system must be able to provide more than one way of interaction for the user with web pages within the application. For example entering in login details by a patient to get into their portal. Navigating to the login details form should be doable through the use of a mouse or keyboard.

Functional Requirements

Priority levels are from 0 to 10, 0 been lowest priority and 10 been the highest priority.

Creation of reports and PDFs

Description: The system must be able to take in a request from a care provider with a patient's data to be shown and a type of output for it to be displayed with. The system then must provide the care provider with a space to make comments on the output and allow then the choice to download the graphical output and comments in a PDF containing the information on the patient that the care provider sees fit to place on the report.

Criticality: This requirement is of a level 7 priority as it is the main function of a care provider to use to see how a patient is progressing.

Technical Issues: This requirement has to take in different graphical reports and comments made at run time to be compiled together into one file. Comments to make the most scenes would have to be grouped with together with the graphical information that would also need to be named to say what it represents. This would be a lot of work for on care provider to do manually so it would have to be done automatically by the system.

Dependencies with other requirements: This function will depend on the system's hand tracking analysis and recording of results as to populate a patient's information. It will also Depend on the systems authorisation functionality to allow care providers to see patient’s information and to save it locally.

Hand Tracking Analysis

Description: The system will use the leap motion controller to keep a record of different position of finger and joints relative to the leaps position. To get meaningful data out of this record and to be able to place it up in a designed database an analysis of results in necessary.

Criticality: This requirement is of a level 10 priority as it is the main functions of the system.

Technical Issues: The leap motion already has an SDK that allows for the hand and its fingers and joints to be pinpointed from a relative point from the leap motion itself. However the leap can have a refresh rate of 200 fps or higher depending on the users computers specifications. The system must be able to handle working it a refresh rate that allows for an accurate reading of a user's movements but also be able to process all the information in a small time frame without consuming too many resources.

Dependencies with other requirements: This function depends on authorisation check as for hand analysis of a patient to occur the patient must first be logged into the system.

Authorisation check

Description: The system must check if a care provider is able to log into a portal page and be able to view information about a patient. This is to comply with data protection regulations in the EU. The authorisation check is to be done on both usernames and passwords when logging into the system and when in the system to check that a care provided has rights to see a patient's health care data.

Criticality: This requirement is of a level 8 priority it is to comply with data protection regulations and is critical to a system that deals with sensitive personal data.

Technical Issues: The system has to have a way to store sensitive information behind a security wall where only those with the right credentials can gain access. This must itself be secure as any flaws would make the structure insecure as a whole.

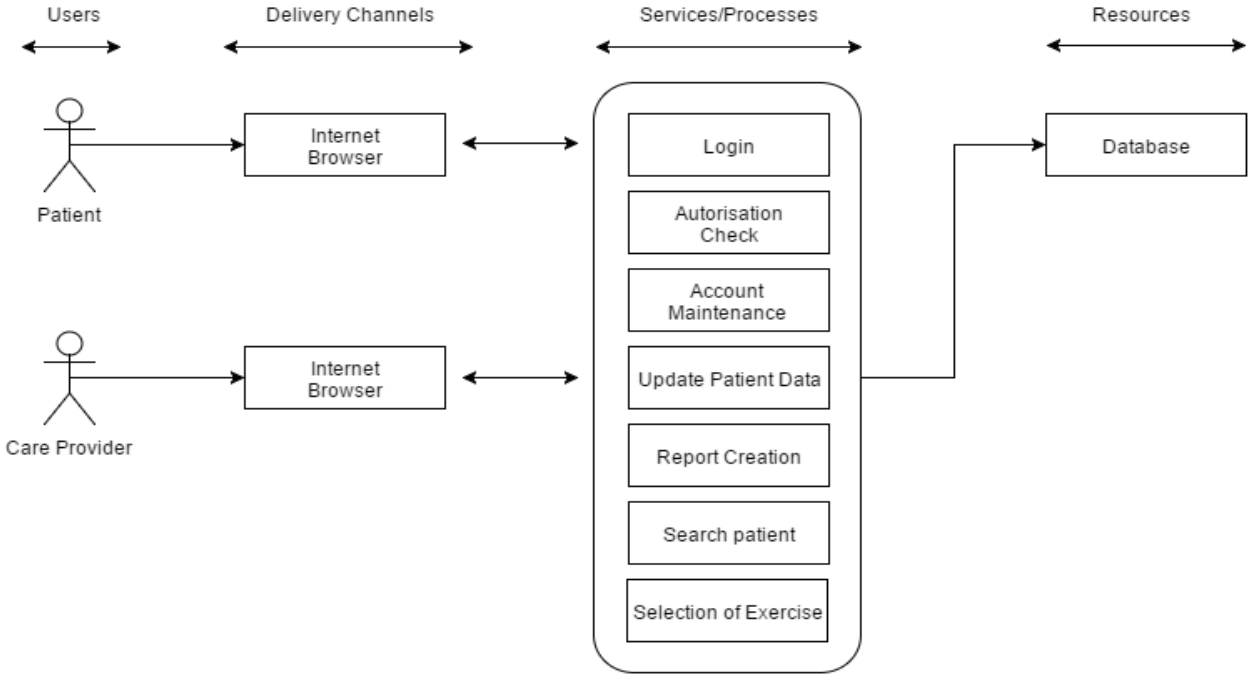
Dependencies with other requirements: No dependencies on other requirements.

System Architecture

The system architecture shall be split into two sections. The first section will be server side and the other client side.

The server side of the system will be a manager of the whole system. It will contain connections to the database system and will be the only side that has full readability of the database and will use authorization checks to see if a user can see information from the database.

Architecture Overview Diagram - Business View



Users & Delivery Channels

The system will allow users to access the application functions through the use of an internet browser. Due to the systems sensitive data and the purpose of the system PC based browsing of the system will be the main supported interaction.

It will also be the main area where the patient's browser processing of the leap hand tacking results will be sent from to the system.

Services/Processes

Each channel provides the two user groups with a different user interface that accesses and present different data and functionality. This is due to security of patient data and the functions that the two groups will carry out.

The functions available to the patients are:

- **Login** - Gain access to the system.
- **Update patient data** - Allows the patients browser to add information about the patient's exercise results from the leap motion.
- **Selection of Exercise** - Allows the patient to select what exercise to go through and to tack hand movements for.

The functions available to the care provider are:

- **Login** - Gain access to the system.
- **Report creation** - Allows for the creation of reports from a patient's data.
- **Account management** - Adding and removing a patient from the system.
- **Search patient** - Allows the care provider to search for a patient given a name, and identification number.

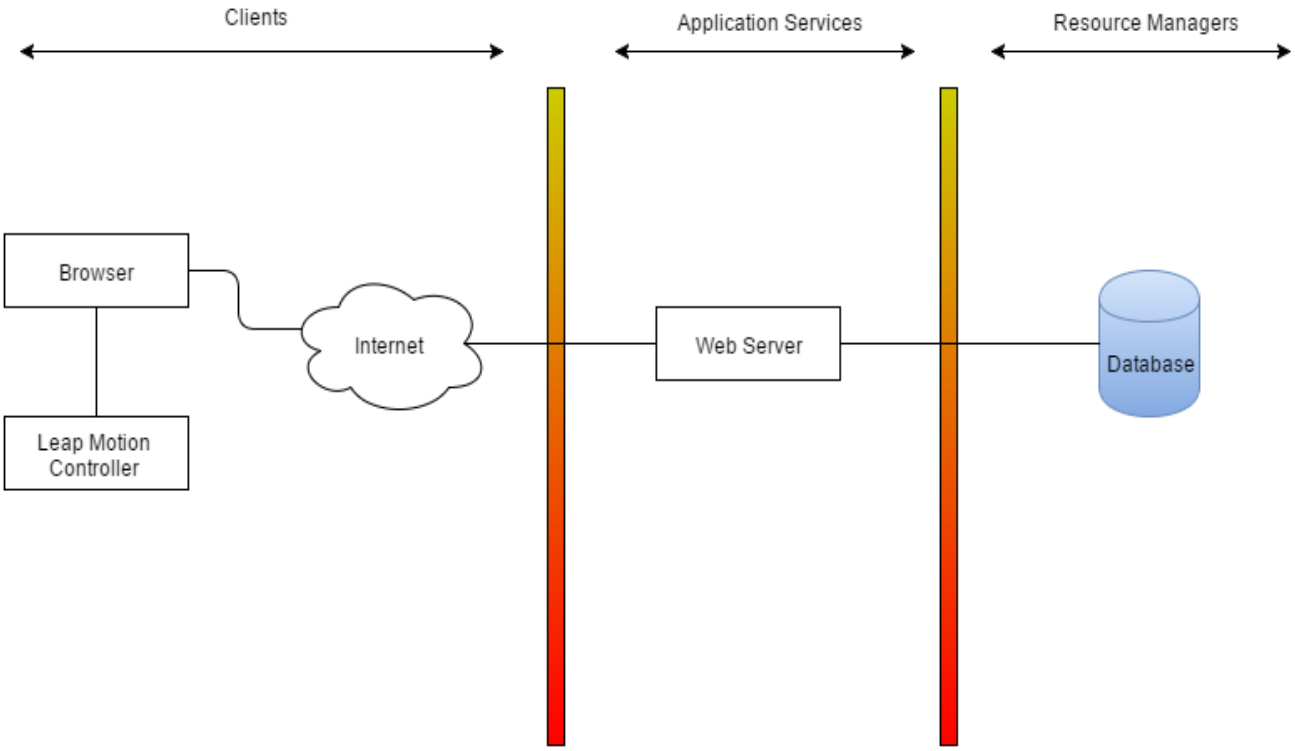
The authorisation functionality will allow for both users to login in and to see what data is available to them.

Resources

The database connected to the server, hosting all functionally, will contain all information on patient and care providers.

It will contain results of each patient's hand tracking results from exercises, and other personal data.

Architecture Overview Diagram - IT System View



The IT system view above shows the main connections from one part of the system to another. The leap motion will be connected to a patient's computer and the browser will allow for the tracking of the hand through the use of the leap. The patient's computer will then process all the information and push the final results to the database through the system. For care providers only browser interaction is needed to access patient information.

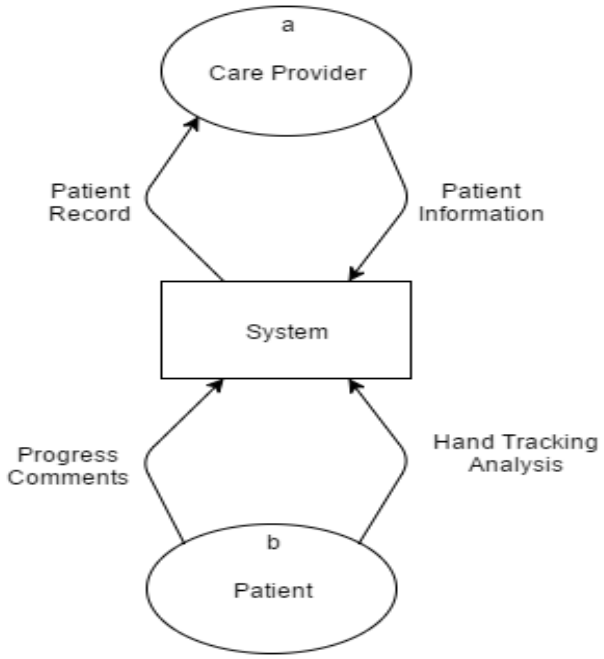
Client Side Architecture

The client side of the architecture for the system will consist of a web browser on a computer that supports the leap motion controller and the leap motion controller. For patient interaction with the system they will use both of these components to send information that is necessary for the system to perform its functions.

Within the client side the browser will process all information that the leap motion controller passes to the browser. This shall be done through the use of the leaps SDK and JavaScript. This processed information will then be passed to the systems server side, after it is encrypted, to be stored and accessed later.

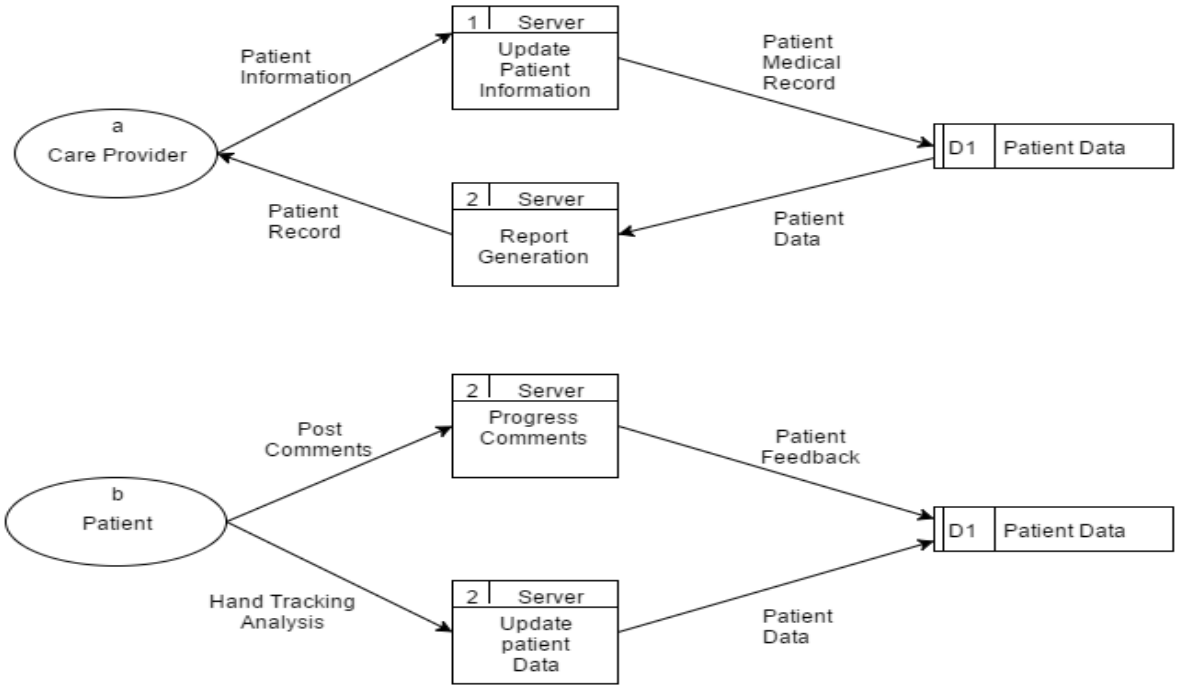
High-Level Design

Data Flow Diagram - Context Diagram



The context diagram of the system shows the external entities care provider and patient interacting with the system with their main transfer of information between them and the system. The interactions at this level are all done through the use of a HTTPS connection from the external entities to the system.

Data Flow Diagram - Level 1



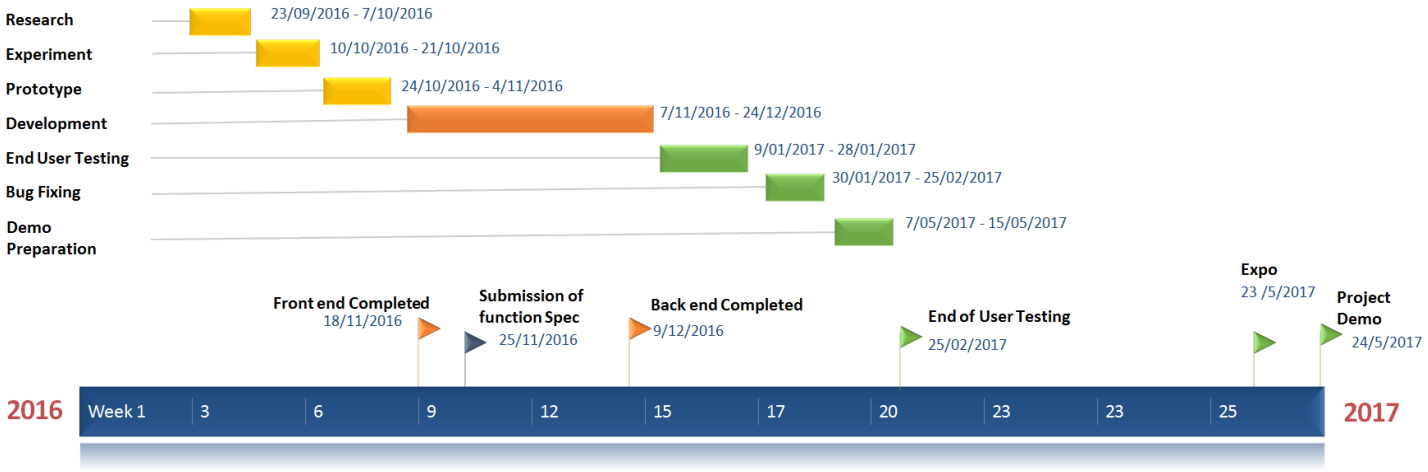
The level 1 DFD above shows a lower level DFD then the context diagram. Here is can be seen that the two entities both input different data to the system. The server is the main connection from user to data source. It is the main processor of all information.

The pervious diagram shows the relationship from user to data resources. A user such as a care provider can enter patient information to the system. The server which hosts the application then goes through the process of updating patient data resource. The patient entity also shows a similar situation when a patient performs an exercise and the results are placed into the system and when a patient posts a comment on their progression.

The system is also shown to give data back through from the data storage to a care provider. The care provider is provided with a patient record that is to be displayed to them through a browser. The system collects the data and processes the data and sends it on to the care provider in a format that is useful the both the user and there browser.

Preliminary Schedule

GANTT chart of schedule



The preliminary schedule is lay out as three to four week sprints. These sprints are to have goals for each one that will be decided on based on what stage of the project it is and what events have occurred with the project.

The preliminary schedule has 7 main stages all lasting for different lengths of time.

These stages and main tasks are:

1. Research – Looking into how to implement current architecture and features
2. Experimentation – Sampling API, SDKs and library's needed.
3. Prototype – Build small versions of localised features and user interfaces
4. Development – Develop system
5. End User Testing – Ensuring the system functions to a user's standard.
6. Bug Fixing – Resolving system bugs that appear during user testing
7. Demo preparation – Prepare for demo of project.

Each stage will intersect with each other near the start and end of the stages and each stage will depend on the one before it. For example research is need for experimentation of API and the setting up of System components such as a web server and database connections. This would go directly into development later on. Some stages may also need to revert back to a previous one if problems occur.

Appendix

1. http://www.physiotools.com/#
2. https://salaso.com/
3. https://play.google.com/store/apps/details?id=com.salaso.salaso&hl=en