CA400 - Functional Specification

Project Title : Mini Mental State Examination Application

Student Name	Matthew Nolan
Student Number	16425715
Student Name	Michael O'Hara
Student Number	16414554
Project Supervisor	Prof. Garreth Jones
Data Finished	22/11/2019

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1. Introduction

1.1 Overview

Our project is based on the Mini Mental State Exam (MMSE). The MMSE is a 30-point questionnaire which is used in clinical and research practices to measure cognitive impairment in patients,It is also used in medicine to screen for dementia. The main purpose of this exam is to estimate the severity and progression of cognitive impairment and to monitor the course of cognitive changes in a patient over time. This makes the test an effective method to document a patient's response to treatment.The examination includes questions that gauge the patient's sense of date and time, sense of location, short-term memory, basic mathematics, naming objects and complex cognitive functions like drawing.

The way in which the exam is currently administered is with pen and paper. Our idea to modernize the way in which the MMSE is conducted by creating an application which will allow the test to be carried out in a more efficient manner. The application we hope to produce will digitise the MMSE and allow for the option, in some cases, for the patient to be able to carry out the exam themselves. We plan on constructing a reliable and user-friendly application that will be able to efficiently predict and monitor levels of cognitive impairments in patients, making the application a suitable information management system for any institution which uses the MMSE.

Interpretation of MMSE Scores

Score	Degree of Impairment	Formal Psychometric Assessment	Day-to-Day Functioning
25-30	Questionably Significant	If clinical signs of cognitive impairment are present, formal assessment of cognitive may be valuable.	May have clinically significant but mild deficits. Likely to affect only most demanding activities of daily living.
20-25	Mild	Formal assessment may be helpful to better determine pattern and extent of deficits.	Significant effect. May require some supervision, support and assistance.
10-20	Moderate	Formal assessment may be helpful if there are specific clinical indications.	Clear impairment. May require 24-hour supervision.
0-10	Severe	Patient not likely to be testable.	Marked impairment. Likely to require 24-hour supervision and assistance with activities of daily living (ADL).

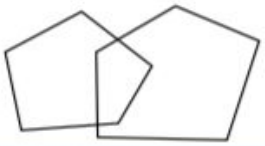
* This diagram shows the different ranges of scores and their interpretations for the MMSE. These ranges change depending on the education group of patients. I.e patients with an education grade of 7 or lower are expected to score a 22 or above to be considered competent.

SMART!

MINI MENTAL STATE EXAMINATION (MMSE)

Patient's name:

Hospital number:

ONE POINT FOR EACH ANSWER	DATE			
ORIENTATION				
Year Month Day Date Time	____/5	____/5	____/5	____/5
Country Town District Hospital Ward	____/5	____/5	____/5	____/5
REGISTRATION				
Examiner names 3 objects (eg apple, table, penny) Patient asked to repeat (1 point for each correct). THEN patient to learn the 3 names repeating until correct.	____/3	____/3	____/3	____/3
ATTENTION AND CALCULATION				
Subtract 7 from 100, then repeat from result. Continue 5 times: 100 93 86 79 65 Alternative: spell "WORLD" backwards - dlrow.	____/5	____/5	____/5	____/5
RECALL				
Ask for names of 3 objects learned earlier.	____/3	____/3	____/3	____/3
LANGUAGE				
Name a pencil and watch.	____/2	____/2	____/2	____/2
Repeat "No ifs, ands, or buts".	____/1	____/1	____/1	____/1
Give a 3 stage command. Score 1 for each stage. Eg. "Place index finger of right hand on your nose and then on your left ear".	____/3	____/3	____/3	____/3
Ask patient to read and obey a written command on a piece of paper stating "Close your eyes".	____/1	____/1	____/1	____/1
Ask the patient to write a sentence. Score if it is sensible and has a subject and a verb.	____/1	____/1	____/1	____/1
COPYING Ask the patient to copy a pair of intersecting pentagons: 	____/1	____/1	____/1	____/1
TOTAL	____/30	____/30	____/30	____/30

*The above diagram is an example of the Mini Mental Examination. Here you can see the types of questions the medical professional asks the patient. The columns on the right are the total number of answers the patient got correct. The final question is a test of the

patient's complex cognitive functions, by asking them to copy a diagram. One challenge of our application will be its ability to correctly score the accuracy of the drawing.

1.2 Business Context

Information management systems are essential in the ever-growing modern day healthcare system. These systems are designed to handle the acquisition of information from multiple sources and the distribution of the information in a concise and efficient manner.Our project is an example of one of these systems and we believe that it can be deployed in numerous hospital and medical practices in which the MMSE examination is carried out.

We believe that our application will greatly benefit any institution that uses the MMSE.Our application will allow for a more modern methodology to be adopted by the medical professionals in relation to the Mini Mental State Examination. Our application will change the way in which the examination is conducted. Digitizing the examination means that all results will also be digital, allowing for them to be stored in a database, reducing the need for paper and making information storing and retrieval much more efficient and simple.

The other main aspect of idea that we believe will revolutionise the way in which the exam is conducted is the ability of our application to allow patients to carry out the exam themselves on a device. Throughout the implementation of our application we will focus on its accessibility and flexibility in order to cater for patients of differing levels of cognitive impairments. Our reasoning behind this is; we believe that some patients may be capable of carrying out the examination themselves based off the judgement of the medical professional, this will allow the patients to have more sense of independence and streamline the process of carrying out the exam.

1.3 Glossary

- ***MMSE*** - Mini-Mental state examination.
- **Cognitive Impairment -** Cognitive impairment is when a person has trouble remembering, learning new things, concentrating, or making decisions that affect their everyday life. Cognitive impairment ranges from mild to severe.
- **Cognitive functions -** Cognitive processes describe how students acquire knowledge, store it in long-term memory, and retrieve it for later use.
- **Xamarin forms -** Cross Platform framework between .NET logic and the Android, IOS and Windows systems.

2. General Description

2.1 Product / System Functions

Describes the general functionality of the system / product.

The General functionality of our MMSE application is:

Conducting and Administering the test - The main functionality of our application is the ability to conduct and administer the MMSE on a chosen device.In its current state, the examination is carried out on pen and paper exclusively by a medical professional.The flexibility of our allows for the application to be used by the two different user groups, the medical professionals and the patients.Due to the scoring of the examination varying from little to no apparent cognitive impairment (scoring 25 or more) to Severe levels of cognitive impairment (scoring 9 or less), we believe that some patients are capable to carry out the examination themselves, once it has been administered by an overseeing medical professional.

Gathering and Presenting information - One of the main advantages of our application is its ability to efficiently and effectively gather and present information. Regarding gathering information, this will mainly be conducted when the test is being carried out. The patient's information will be taken and stored along with their examination results once they have completed the MMSE. The patients results will be stored alongside any previous results and will be linked to the patient for easier information retrieval. In relation to presenting the information, the medical professional will be able to view and analyse their patients previous results visually by using graphs. We hope to be able to add in the ability to predict the next score of the patient using their previous results.

Predicting Results/Recommending Diagnosis - As a result of the test being digitised, along with its results, we will now have a large pool of data. The data stored will be comprised of patient information, related diagnosis and previous test results. Using this data we plan on implementing a system which will be able to provide an accurate prediction on the future state of the patient's level of cognitive impairment. Prediction will only be available to the medical professional on the patient profile page.In regard to recommending a diagnosis, once a test has been taken a scored, our application will provide a recommended diagnosis based off the previous results and diagnosis and also based off the scoring of the MMSE. Any diagnosis made by our application will only be an interpretation of test results.

Security - As this application will handle a lot of sensitive data it is a priority to ensure that the information is being treated in a secure manner. The application will only allow access to members of staff with the correct clearance. We will implement two-factor authentication, to address any concerns with only using a password. This will ensure that the data will only available to chosen individuals. Each ward will have its own “ward code” which we will assign to the medical professionals and their patients, in order to segregate the data between wards. This in turn will make our system into a multi-tenancy system. Multi-tenancy systems ensure that data stays within its assigned “ward code”.We hope to include encryption to further ensure that the data is safe from vulnerabilities.

2.2 User Characteristics and Objectives

Our user community can be split into two categories, medical professionals and patients. Medical professionals are familiar with information management systems as they are used throughout the healthcare system, therefore they will have some technical experience. The patient user group will have varying levels of experience depending on multiple factors such as age, background and diagnosis. Due to the varying levels of experience within the patient user group, users in this group will not need any previous technical experience.

The User Interface of the application will be clean and user friendly as we don’t want to add any stress to the user. The colors we use will be neutral and not too aggressive as to upset the users. We will make sure the font is easy to read and use a big size as not to strain the eyes. We will clearly lay out instructions as to how to progress through the test using simple language.

The other side of the application will only be accessible by the medical professional and will be where they can see the previous results of test and also be able to see the graph of the progression of the impairment. We then aim to be able to predict how fast the progression will move in the future. We are still looking into ways to make sure the process is as accurate as possible.

2.3 Operational Scenarios

Predict the progression of the impairment:
The medical professional may want to try to predict the rate of progression of the cognitive impairment in their patients. This part of the application would use an algorithm to estimate the result the patient may get in the next test. This would help the medical professional make a diagnosis and then recommend treatment. Although before this can be done the application would need to have sufficient data on the patient. The application would also need to be trained to make accurate predictions using other test results. We also hope to implement a way for the medical professional to provide feedback on the predicts in order to see if they are correct.

Graphing Results:
Once enough test results have been collected, our application will be able to display the results visually using graphs. These graphs will be available for the medical professional when he/she wants to view previous results of their patients. The application will need to add the results to a graph and render the image of the graph for the medical professional in a timely manner.

Recommend Diagnosis:
After a test has been conducted and the results have been collected our system will be able to recommend a diagnosis. The recommended diagnosis will be based off previous diagnosis for other patients along with the patient's own information. The diagnosis can differ depending not only on the test score but also on the age and education level of the patient, for example if a person with an education level of grade 7 or lower scored 22 or more they are considered to be competent, whereas a college student would have to score 26 or higher to be considered competent.This is something that our application will take into account when making it’s suggested diagnosis. To measure the accuracy of the application, we will allow the medical professional to give feedback on the presented diagnosis.

Carrying out the MMSE:

The test can be set up to be run in 2 different modes. The first mode being that the medical professional sets up the test then hands the device to the patient. This would only be done for patients that the medical professional deems to have a high enough level of motor function to use the device and an ability to read an answer the questions themselves. This could allow patients who may have lost the ability to speak but have retained the use of their hands do the test independently.

The other method of testing is that medical sets the test up and then reads the questions to patient and records the answers given by the patient. This method would be done for patients who are unable to hold/use the device the test is being conducted on.

Having these 2 modes opens up the range of patients the test can performed on and may lead to faster diagnosis'.

Secure:

Medical professional must first login and verify their identity. This is so the data contained within the app is secure and not readily available to anyone. They would use their staff number or another form of identification to login to an account set up on the system. Then once the medical professional is set up they will also have to verify that the patient is in their care. This means only data on patients in their care is available. This is to protect the data from intruders due to its sensitive nature.

2.4 Constraints

Our main constraints will be:

- Making the application accessible, usable and flexible:

  We need to make sure the User Interface is usable and accessible to all users. This will involve making sure the colors are not contrasting. It will also involve making sure the font is clear and easy to read and the language used is simple and concise.

- Complying with GDPR:

  We need to make sure that any personal data that is collected and stored complies with the General Data Protection Regulation. GDPR lays out responsibilities to ensure the privacy and protection of personal data, provides data subjects with certain rights, and assigns powers to regulators to ask for demonstrations of accountability or even impose fines in cases where an organisation is not complying with GDPR requirements.

- Making sure testing is carried out in accordance with ethical policies:

  We need to make that any testing carried out must be done in accordance with all ethical policies. We also need to make sure that any patients the application may be used have been informed of what is happening and are capable of giving informed consent to the data being used for our testing.

- Accurately scoring and predicting results:

  We also need to make sure our method for prediction is as accurate as possible for it to be useful. We will use previous data in order to train the application. Once this has been done we make secondary test data to have our application predict the progression of our dummy test patient. This will be done on dummy data as, during the initial test phase we don't want to use patient data as the prediction may be initially inaccurate. We hope it can be used to aid in the diagnosis and treatment of patients. This means if its not accurate then it may lead to misdiagnosis.

3. Functional Requirements

3.1 Carry out the examination

- **Description:**

  This is the main functionality of our application. We will make it so the test is able to be carried out electronically either by a medical professional or by the patient themselves. The method of examination will be decided by the medical professional based off the level of motor skills and mental faculty retained by the patient.

- **Criticality**

  Since this is the main functionality of our project it will be the main focus of our work on the application. Once this has been completed we will then begin to add the other features mentioned in this section

- **Technical Issues**

  Making the User Interface clean and user friendly to be easy to use and to not upset or distress patients.

- **Dependencies with other requirements**

  This section doesn't depend on any of the other section

3.2 Process the results of the examination

- **Description:**

  This section will mainly be the backend of our application, it will take the answers and check them to see if they are correct and return the result to the medical professional

- **Criticality**

  This will be the other main function of our application and will have to be completed once the questionnaire. This is needed for the medical professional to be able to make a diagnosis.

- **Technical Issues**

  We have to make sure our grading is accurate and fast as incorrect results could lead to misdiagnosis.

- **Dependencies with other requirements**

  This section depends on the ability to complete the examination as we need the data provided to process

3.3 Store Results:

- **Description:**

  The storing of the results from previous tests for a patient to allow the medical professionals to refer back to them at a later date if needed.

- **Criticality**

  This is critical to the application as the previous results will be used in the prediction of progression of cognitive impairment .

- **Technical Issues**

  Like with the login system we need to make the stored results are secure and protected. We also need to insure that the results have been correctly linked to the patient

- **Dependencies with other requirements**

  Depends on the ability to carry out the test.

3.4 Graph Results:

- **Description:**

  Graphing of the results from previous tests will allow us to track the cognitive impairment in patients from test to test. This allows the medical professional to alter treatment if necessary.

- **Criticality:**

  This function is needed as it would provide a quick and easy visual representation of how the patient is scoring on the test.

- **Technical Issues:**

  We need to determine an efficient method of graphing the data on the backend in order for it not to take a long time to render the graph.

- **Dependencies with other requirements:**

This piece of functionality depends on the ability to store the previous results as we need the old results to fill out the data on the graph.

3.5 Predict the progression of the impairment

- **Description:**

  This will use the previous results to determine the rate of progression of cognitive impairment. This would allow the medical professional to make early calls when treating the patient.

- **Criticality:**

  This isn't a critical need for the project but we feel it would be a useful feature if implemented successfully

- **Technical Issues:**

  We need to make sure the algorithm we use to predict the progression is accurate as diagnosis may be made from our result.

- **Dependencies with other requirements:**

  This part will depend on the storing of previous results, as this will be the data we use to calculate the progression. It will also depend on the graphing of results as this will be where will display the predicted rate of progression.

3.6 Login System for Medical Professionals:

- **Description:**

  The Login System will allow medical professionals to login using their staff number of staff ID. This will allow them to view results of previous tests of the patients in their care or to administer the test to a new patient.

- **Criticality:**

  Essential for record keeping and for keeping patient records secure

- **Technical Issues:**

  Keeping passwords secure and data secure without making logging too cumbersome

- **Dependencies with other requirements:**

  This will depend on the security of the application.

3.7 Security within the application:

- **Description:**

  The application needs to be secure as it handles very sensitive patient information. It will only allow users who are authorised to access certain information

- **Criticality:**

  Essential for keeping sensitive information secure

- **Technical Issues:**

  Keeping logins secure, data secure while also making sure the “ward code” is implemented correctly

- **Dependencies with other requirements:**

  This does not depend on other requirements.

3.8 Recommending a diagnosis

- **Description:**

  This will use the previous results to recommend a diagnosis once a test has been conducted.
  Criticality:

  This isn’t a critical need for the project but we feel it would be a useful feature if implemented successfully

- **Technical Issues:**

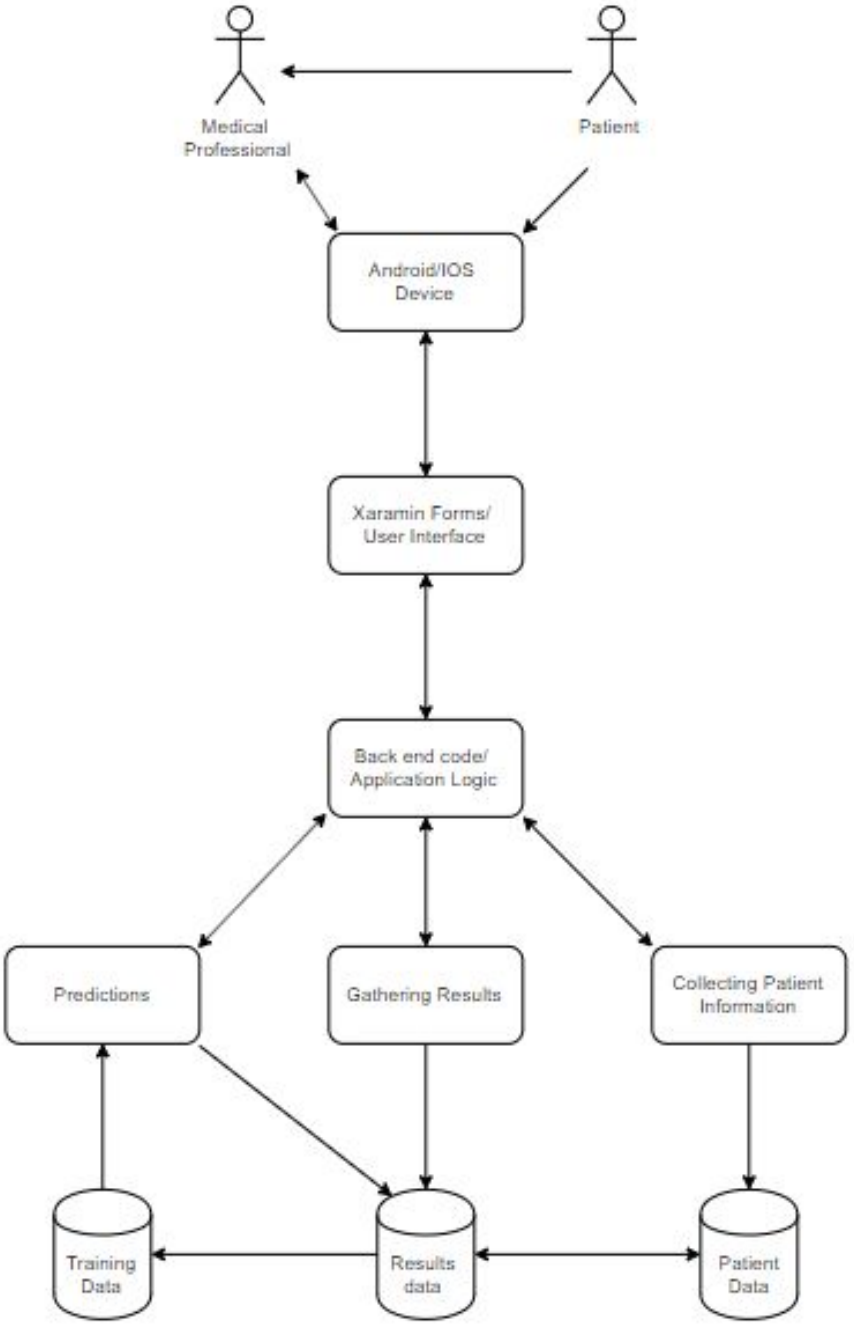
  We need to make sure the algorithm we use is accurate as we dont want to misdiagnose

- **Dependencies with other requirements:**

  This part will depend on the storing of previous results

4. System Architecture

4.1 System Architecture Diagram



4.2 System Architecture Brief Description

The user will interact with our application with either the web application or the iOS/Android version depending on the resources available. The medical professional will login using their staff ID. They will then select which function they would like to use out of the “Carry Out Exam” “Patient Lookup” or “Questions. Then based on their selection they will be brought to the desired screen.

If the selection was “Carry Out Exam” then they will be brought to the options for exam screen to select the desired settings for the exam.
The “Patient Lookup” will be where the medical professional can search for and view patient records to view or refer back to.
The “Questions” section will be where the medical professional can see a list of questions that the exams contains, this could be used if a question in the exam needs to be added, removed or updated.

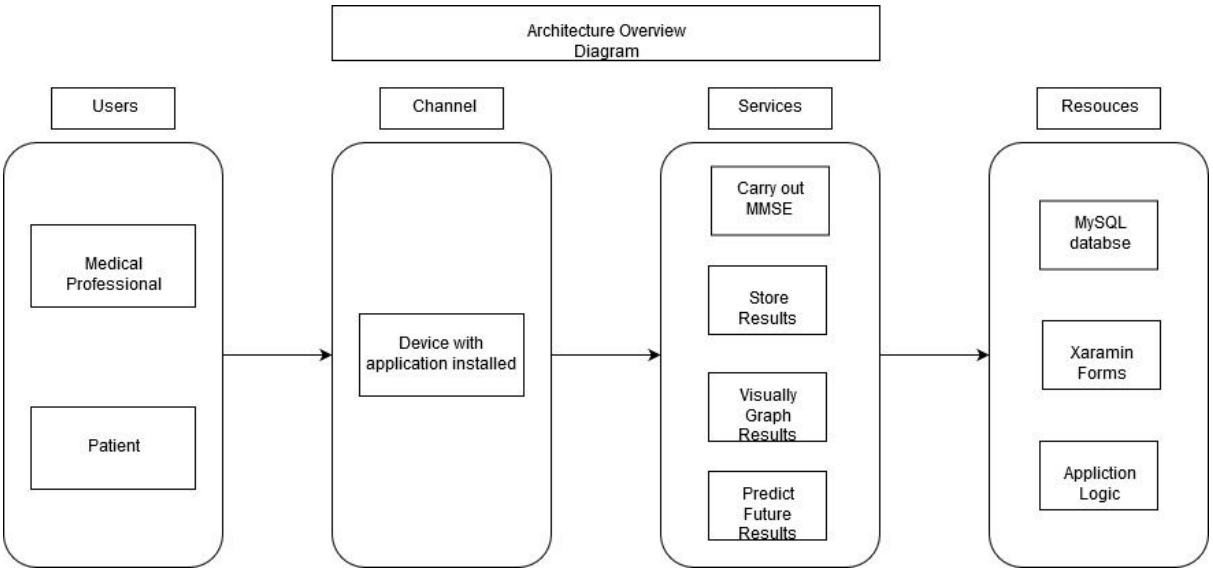
The results of exams will be stored in our database. This will allow us to view, store, update and delete records. We will use either mySQL or MongoDB for this.

For the result predictions and the recommended diagnosis we will use take some of the data from our database to use as training data. Any predictions or diagnosis made by our application will also be stored.

We will use the Xamarin Forms as an abstraction layer between our C# code and the Android and iOS platforms. This will allow us to deploy our applications to these platforms without having to write specific code for each platform

5. High-Level Design

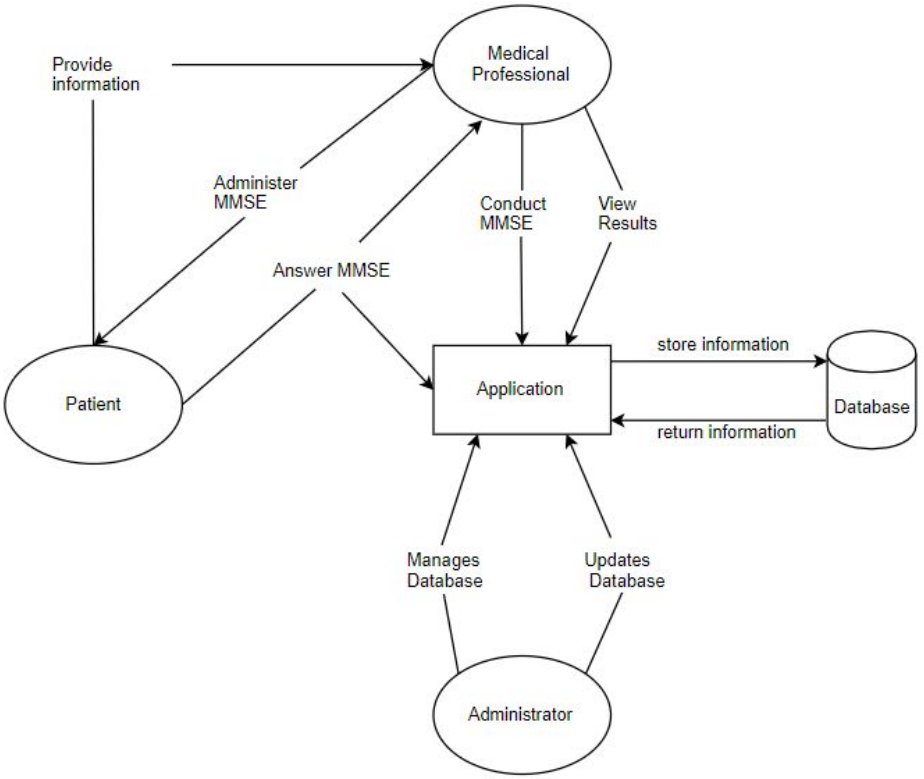
5.1 Architecture Overview Diagram



The purpose of the above diagram is to show a higher level view of our application. The main goal of this diagram is to explain the function of application to an audience with a varying range of understanding. It does this while also retaining a good amount of key details of the main areas of the project. We broke our diagram up into 4 sections which are as follows:

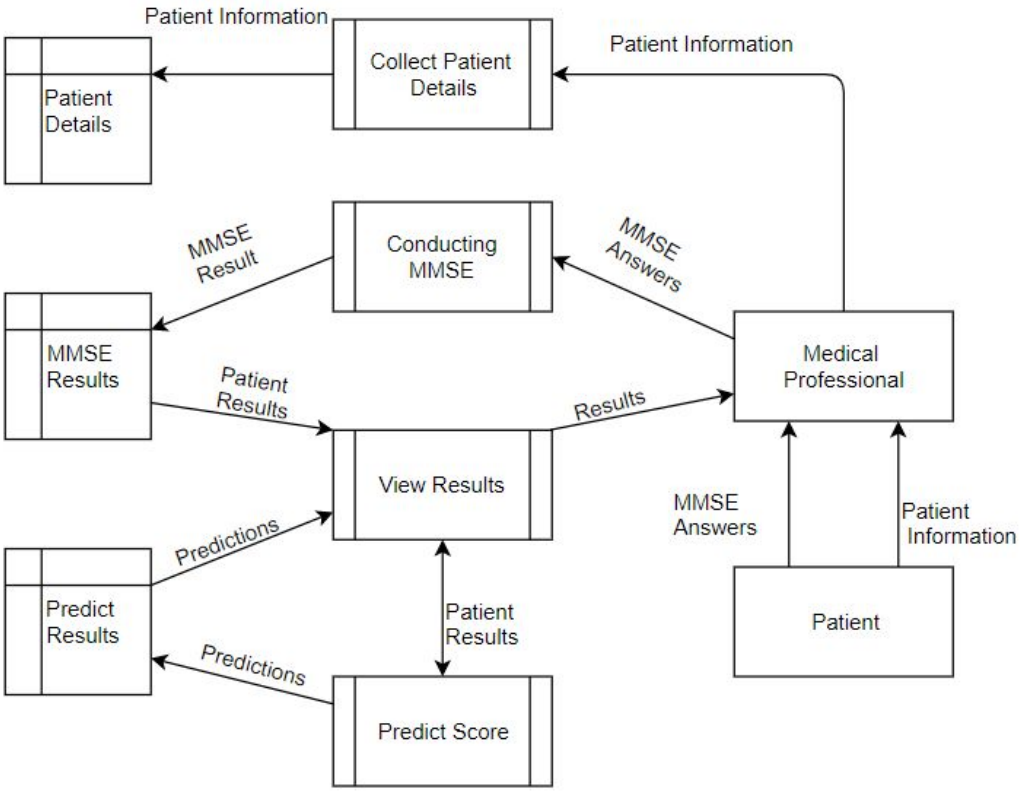
- **Users:**
  These are the people who will interact with our application
- **Channel:**
  This is how the user will interact with our system
- **Services:**
  These are the functions which our application will carry out as the users usit on a day to day basis
- **Resources:**
  These are some of the different technologies we plan on using to implement our application.

5.2 Context Diagram



A system context diagram shows the systems as a single high level process, which shows the relationships that the system has with other entities that brings the whole system together.Above we can see the users groups interacting with the system itself. We can see here that the medical professional has two options when carrying out the MMSE, Administer the exam to a patient or conduct the MMSE themselves by asking the questions verbally and filling in the patients responses, this is reflected with the patient entity where we can see that they can answer to the medical professional or to the application themselves.

5.3 Data Flow Diagram



The above image is the Data Flow Diagram for the system. It shows how the data is transferred and converted on its path from user device to speaker. It also shows the components of the system and how they interact with the data that passes through them before being passed to a different component of the system. The items on the left of the diagram are depictions of the datastores for each of the main processes of the application.

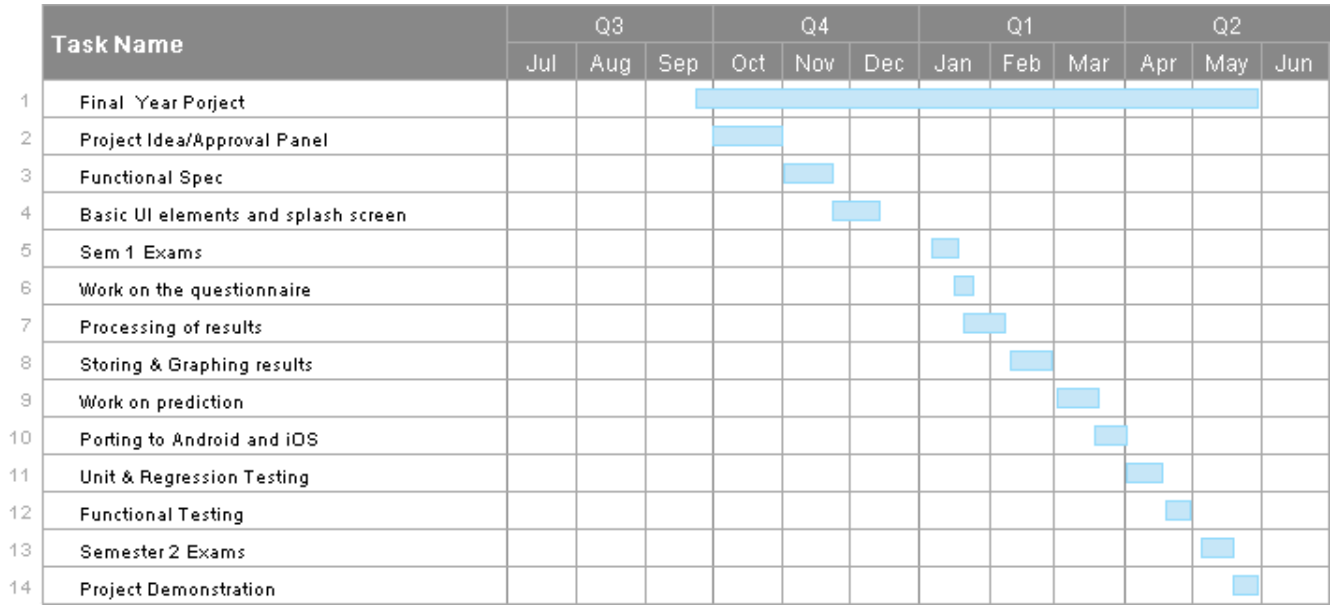
6. Preliminary Schedule

6.1 Task List

Task Name	Duration	Start	Finish
Final Year Porject	180d	23/09/19	29/05/20
Project Idea/Approval Panel	23d	01/10/19	31/10/19
Functional Spec	16d	01/11/19	22/11/19
Basic UI elements and splash screer	16d	23/11/19	13/12/19
Sem 1 Exams	10d	06/01/20	17/01/20
Work on the questionnaire	6d	16/01/20	23/01/20
Processing of results	14d	20/01/20	06/02/20
Storing & Graphing results	14d	10/02/20	27/02/20
Work on prediction	14d	02/03/20	19/03/20
Porting to Android and iOS	10d	19/03/20	01/04/20
Unit & Regression Testing	12d	02/04/20	17/04/20
Functional Testing	9d	19/04/20	29/04/20
Semester 2 Exams	10d	05/05/20	18/05/20
Project Demonstration	9d	19/05/20	29/05/20

Above is the list of tasks we have to do in order to complete the project, an estimated time to completion and start and finish dates. These tasks may spawn smaller tasks and could have the possibility of introducing bugs we did not forsee. These will be tackled in a timely manner as to not have us stray to far from the timeline we have set ourselves.

6.2 GANTT CHART



The preliminary schedule is pictured above in our GANTT chart. We have begun the design process of how we want our application to look. We have to put a good bit of thought into this as it needs to be easy to use and user friendly. We aim to have the UI decided upon, the questionnaire finished and the ability to process results done by the end of January/ early February. This will also provide us time to study for our exams in January. By the end of April we plan to have the storing, graphing and predicting of results and the login system completed. This will allow us to use the final few weeks to iron out bugs and make tweaks where necessary.

7. Appendices

- https://www.bgs.org.uk/sites/default/files/content/attachment/2018-07-05/mini-mental_state_exam.pdf
  Example Mini Mental State Exam
- https://www.ncbi.nlm.nih.gov/projects/gap/cgi-bin/GetPdf.cgi?id=phd001525.1
  This describes in detail each section of the MMSE.
- https://study.com/academy/lesson/what-is-cognitive-impairment-definition-causes-symptoms.html
  Study on dementia and cognitive impairment