Research proposal for the doctor of philosophy in computer science

**Developing server side database and web application for dealing with Community-dwelling Stroke Survivors**

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**Introduction**

A stroke is the well common reason for death and disability. It is the second cause of mortality internationally and in the near future, it will be the first cause of death across the universe. Among the most significant risk factors for stroke are age precedent, hypertension, diabetes, former stroke or transient ischemic attack. Hypertension and diabetes are the most significant and repeated adjustable risk factors of stroke. According to some researches ,it is the primary cause for long-range mature disability and the fifth leading reason of death in the United States of America, with ~795000 stroke cases every year.

Stroke patients are monitored frequently, sometimes every hour by the medical staff in order to better understand their physical state, progress and vital signs. Monitoring stroke patients is considered a difficult and time-consuming task and has a number of challenges because of the awareness and frequent monitoring and recording of patient’s data. Hence, to overcome these challenges, some studies have proposed and adopted arificial intelligence algorithms for monitoring and measuring patients’ activities through connected devices such sensors and monitors.

One of the projects that employs AI algorithms and currently being under development is the one by The University of Aberystwyth called a virtual exercise practitioner product (VEP), to deliver clinically validated. So, by joining the team who works on this project, the goal of this research, is to design and develop a server-side database to collect data sent from the mobile application, store it, visualize it to make a better use of it. Besides, developing a web application to handle the data, so we will focus on developing an intelligent data management system (server) to support a mobile app that will deliver clinically validated exercise programs for people suffering from stroke.

**VEP’s description and functionalities**

**Description**

VEP is a mobile application developed by professional android developers and considered the main front end for the whole project, also it is the interface that users interact with directly (through pressing buttons to enter data or retrieving information), or indirectly (through the sensors attached to patients which automatically send data using the app). VEP contains a temporary database that is used to stroe patient’s data collected from the sensor attached to the patient or from the user immediately, before it is tranfered and copied to the main database on the server for further processing.

**Functionalities**

* *Assess gait and balance: one important sign to the stroke patients’ health status is gait, a way a patient’s walks indicates whether he’s making a progress, being in stable condition, or having a problem.*
* *Subscribe patients new training programs to improve gait and balance: A stroke patient should always be up to the date with an appropriate training program level that suits his health condition as a part of medical therapy.*
* *Monitor patients progress: many actions and decisions can be taken based on monitoring patients progress which can tell more about his improvements, progress and also vital signs.*
* *Provide feedback to patients and clinicians: Having a number of records about patient’s gait, vital signs, progress…etc, this means having the ability for example to evaluate patients’ health or progress, send feedbacks to patients or their families, help physicians be in touch with latest update regarding the patient’s health status.*

**Server’s Features and Architecture**

The selection of server plays an important role in the success of the project, due to a the capabilities it has like data storage, information retrieval, data backup, data visualization, secruity and many more. Our desired functions and specifications in a server can be summerized in the following points:

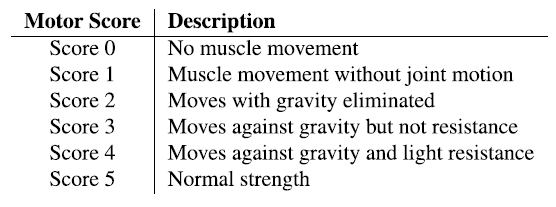
* Interacting with heterogeneous data: our server should have the capability to deal with different and heterogeneous data that read by sensors and sent through mobile app directly to the server and saved into a database. Some examples of the data like hypertension, diabetes, irregular heart beats or any other vital sign that may cause a threat to the patient’s life. Our server must be able to deal with this kind of data, store it, retrieve it, visualize it, evaluate the medical status of the patient, and most importantly; take quick necessary actions based on the received data if something unusual occurred.
* Data view and representation: in this project, there will be different types of users who have the ability to access the data stored on a server. There will be the medical staff like doctors, nurses, the patient who interacts with the application and supplies the server with data, the patient’s relatives like a partner or a son or anyone close to the patient and worries about him, and finally the system or the web server developers. So, there will be different data views for each type of users, for example some sensitive information about the patient himself can be kept unseen from the friends or relatives, also some medical information or reports are available only for medical staff and not meaningful for the patient to view.
* Data Security: all patients’ data are store in a centralized database on the server, and the data will be encryptedly stored to quarantee the maximum level of security and privacy. Most importantly in dealing with the patients’ data, is that we will be stricted to the UK General Data Protection Regulation(GDPR) rules and instructions.
* Dealing with traffic: the server must respond to as many requests as possible. There will be many users from different places accessing the servre and retrieving data from the database, and the need for a quick and fast response is strongly recommended.
* Intelligent Server: with the increment of size of the database being used, the should be a mechanism that can be used for long term monitoring for patients over a long period of time. Every time the server receives new data, it must analyze, update, evaluate and predict the patient’s status again for the safety of the patient. It must be well programmed and ready to interact with data sent or received all based on algorithmic steps.
* Database Scaling: with an expected increasing in numbers of users, size of data in database or a problem with connection to the server, the need for database scaling is considered to be an urgent need in the future. We can either scale the datbase vertically by increasing the the power of a single server or cluster for example more CPUs, memory and storage space. Besides, scaling the database horizontly by making copies of the database on multiple servers to improve performance using techniques like Replication or Partiotioning or even both together, is also a very good option.
* Data archiving: automatically when patient is known to be dead, all of his data shall be removed from the current database under usage, and put into another database designed speciaifally to store archived data for different usage plans like scientific researches .. etc, this will help in reducing the amount of data stored in the main database and assign another database for archived data.
* Indexing and query optimization: they are both important features to have especially in big projects, because they improve the efficiency of read operations by reducing the amount of data that query operations need to process. For instance, If the application queries a collection on a specific field or set of fields, then an index on the queried field or a [composite index](https://www.mongodb.com/docs/manual/core/index-compound/) on the set of fields can ban the query from searching the whole collection to find and return the results, and this saves much time and reflects and quicker response from the server.
* Responsiveness: the server is always online and users are frequently in touch with it for different purposes, like assessing gait and balance, monitoring patients’ progress, suggesting new training programs to patients based on their progress levels and supplying patients and clinicians with feedback. So, the need for quick and fast response to users’ queries, users’ data is a considered to be mandatory because it saves lives in some critical cases.

**Literature Review**

It is sometimes a crucial mission to understand a patient’s prognosis, recovery and identify critical times for taking medications, especially if the patient is admitted to intensive care unit ICU [1]. It is also pertinent for the discovering of early start of Intensive Care Unit Acquired Weakness (ICU-AW), that can persevere for up to 2 years after patient discharge [2]. Measuring motor function is often made through integrated measurement tests, for instance; the Oxford Grading system for hourly neuro assessments [3] , done by a nurse or a medical staff on the patient, whose strength is evaluated and scored 0 to 5 on each limb.

Artificial intelligence has shown great results in characterizing motor activities extracted from accelerometers, through implementing machine learning algorithms [4] [5].

Table 1. Oxford motor grading scale



While researches applying machine learning and big data methods for evaluation in the ICU have been discovered before, they have been concentrated towards determining agitation and sedation manner, and delirium state, but not motor impairment [6] [7].

According to [8], the movement information received from the accelerometers can be used to make useful feature which can be employed in new monitoring methods or approaches, especially when it is used for long term monitoring of severe motor impairment patients.

**Methodology**

To address our research questions, we are going to perform a mixture of qualitative and quantitative study. To obtain better results, the study will take place in cooperation in future with the National Health Service NHS in Wales. Interviews shall be arranged with team members like mobile application developers, doctors and sometimes patients to discuss and investigate closely the effectiveness and results of monitoring stroke patients, and the actions need to be taken based on those results. In this study, there are no expensive tools or materials required to accomplish its goal rather no barriers or pitfalls because the results will be beneficial for researchers, NHS, patients’ famillies and the patients themselves.

After searching on the internet and studying for which software and technologies could be most suitable and effective for better results, we found out that using a Nosql databases are the best option for saving heterogeneous data. More specifically, MongoDB is one of the best choices for designing a database for such kind of data because of the flexibility and variety of options it has and also ability to expand in both vertically or horizontally or both like mentioned earlier in server features. We have decided to use the multi-cloud application platform called Atlas webserver which considered one of the most advanced cloud database services on the market today. We also found out that it was recommended to get as big RAM size as possible and SSD hard disks for better processing and a quick data manipulation.

When patient attaches the device or sensor to his body and starts to use the application provided on his cellphone, he will create an individual account and data collected from the sensor begins to be transmitted directly to be stored onto the server’s database. So, the journey of monitoring the patient’s vital signs begins, and rules taken from physicians are employed into server side to predict or make an evaluation about patient’s health status whether it is normal or it requires urgent medical aid.

A time duration of maximum three years is expected for accomplish the required research goal and its objectives.

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