Lab 2 - SeizSmart Specification Outline

Lab 2-SeizSmart Product Specification

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1 Introduction

Epilepsy is the fourth most common neurological disease in the world. The cases of epilepsy in the US are predicted to increase as they have done in the past five years (Epilepsy Foundation, 2019), Figure 1 describes worldwide statistics of epilepsy. Fifty million people suffer from epilepsy worldwide, as a result they are 3-6 times at risk of death compared to an individual not suffering from epilepsy. SeizSmart will only be able to detect the most common type of generalized seizures. SeizSmart will not be able to detect Absence seizures because the patient just stares out into space for this type of seizure.

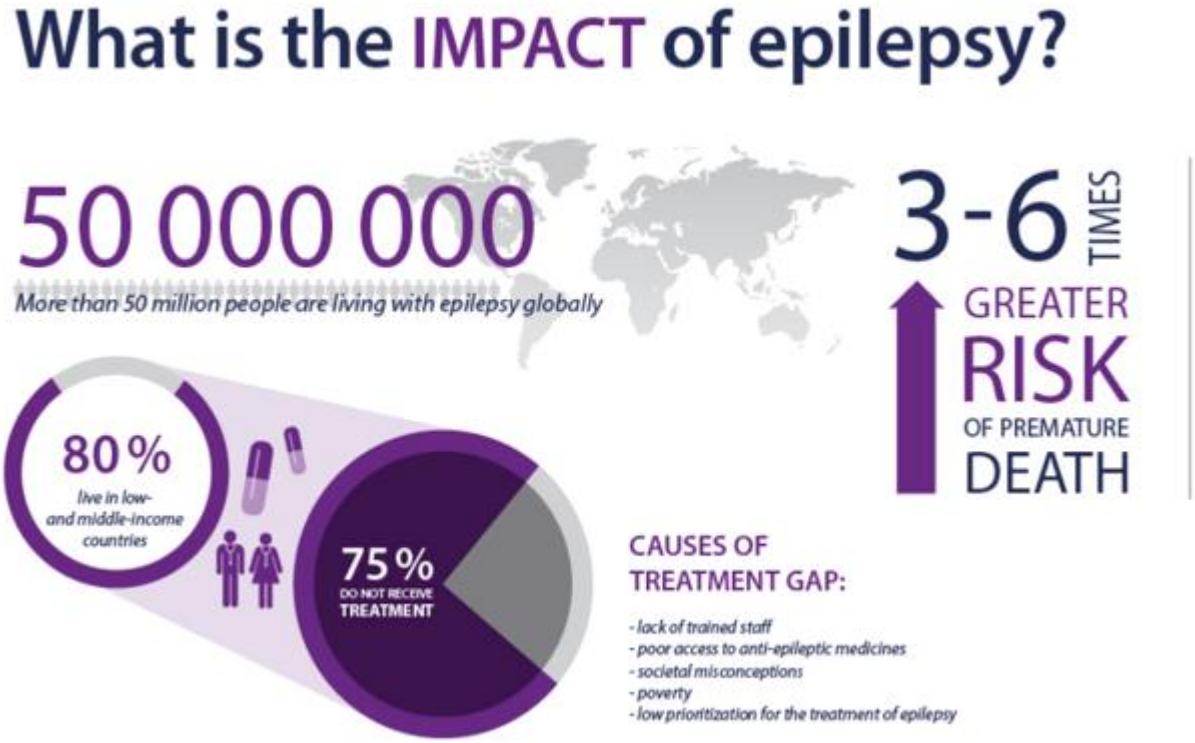

Figure 1. Background of Epilepsy

SeizSmart is not the only application that intends to help individuals with generalized seizures. Some of the competitors include Empatica Embrace 2, SmartMonitor, SeizAlarm. The difference between the competitors and SeizSmart is that these competitors do not monitor both

the patient's heart rate and repetitive body movement when it comes to the detection of potential seizures. They mostly utilize one or the other they do not combine both. Figure 3 is the current process flow of SeizSmart competitors. SeizSmart will provide peace of mind to the users and their family members or care takers by sending alerts to selected emergency contacts once a seizure is detected. SeizSmart will be a free application for users with access to a smartphone and a smartwatch.

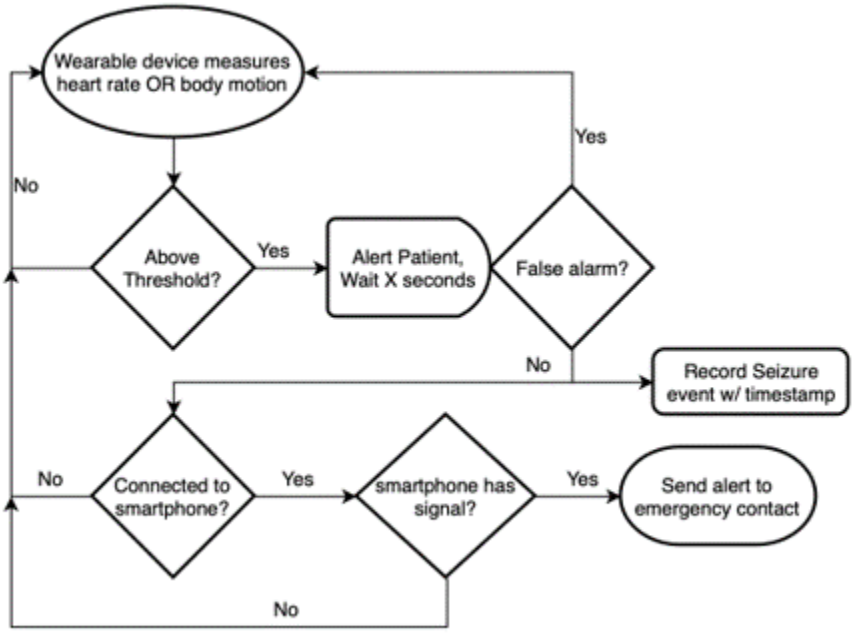

Figure 2. Current Process flow with detection of seizures

When dealing with a neurological condition such as epilepsy accuracy should be one of the most important areas to investigate. False alarms and false positives could lead to the application not being used. To combat this issue SeizSmart will be using multiple vectors to detect any potential seizures. If an elevated heart rate is detected with no significant increase in limb movement this will not be reported as a seizure. One issue that could stem from such a system is that the user might want to use this application whilst they are partaking in physical activity such

as sport. For such a scenario the user could inform the application that they are about to partake in such an activity and the threshold values can be adjusted by the user.

1.1 Purpose

SeizSmart will be an application running simultaneously on a smartphone and smartwatch. SeizSmart will be used to detect potential seizures in users suffering from generalized seizures. SeizSmart will consist of three components (1) the smartwatch component, (2) the smartphone component, and (3) the server component. The smartwatch application will assume to always be on the patient this will be used in detecting potential seizures, it will monitor both heart rate and body motion. The application on the smartphone will be used for reporting, viewing and adjusting of threshold values. The server will be using biometric data from the smartwatch for the training of the neural network. End users of SeizSmart will be individuals with generalized seizures. The customers could be caregivers of people suffering from generalized seizures.

1.2 Scope

SeizSmart is a very large project and cannot be completed in the span of one semester. As a result, some functionality will have to be simulated for the scale of this class. Table 1 summaries which features will be simulated and the ones that will be implemented. The SeizSmart prototype should be able to function fully with the use of simulated data as the team does not have access to an epilepsy patient. SeizSmart consists of three algorithms (1) the detection algorithm, (2) the recording algorithm and (3) the reporting algorithm. These algorithms should be operational, a simulated seizure event should be detectable by the prototype.

The first goal that this prototype will try to achieve is to simulate real world data. For this prototype to be functional, simulation of real-world data will be necessary as the team will not have access to an epilepsy patient, so they will have to simulate data. This might be done by collecting data during a period of exercise to collect high heart rate data and repetitive limb motion or by using random number generation. The collected data will then be fed into the neural network to train. Based on the previous data the prototype should be able to detect a potential seizure as the subject's normal biometrics would have been fed into the neural network to train so the simulated data should be detected as a potential seizure.

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Functional elements	Real World Product	Prototype
Detect generalized seizures in real time	Fully functional	Implemented through simulation of seizure event
Record generalized seizures in real time	Fully functional	Implemented through simulation of seizure event
Track generalized seizures in real time	Fully functional	Implemented through simulation of seizure event
Monitor repetitive shaking motion	Fully functional	Fully functional
Continuously monitor user's heart rate	Fully functional	Fully functional
Alert emergency contact when does not respond	Fully functional	Fully functional
Collect data about the environment at the onset of a seizure being detected	Fully functional	Fully functional
Use machine learning to detect generalized seizures	Fully functional	Implemented through simulation of seizure event
Fully functional without dependence on a smartphone or external device	Fully functional	Fully Completed

Table 1. Prototype Features

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1.3 Definitions, Acronyms, and Abbreviations

Absence Seizure: A generalized onset seizure that lasts only a few seconds, causing the patient to suffer lapses in awareness. Formerly known as a petit mal seizure.

Atonic Seizure: Also known as drop attacks. In this kind of seizure, some or all of the patient's muscles suddenly become limp.

Complex Partial Seizure: A brief seizure that starts in one side of the brain, also referred to as a focal (onset) impaired awareness seizure. During this kind of seizure, the patient loses awareness of their surroundings.

Clonic Seizure: A seizure characterized by sustained, rhythmic jerking of the patient's body.

Emergency Contact: Anyone who cares for a patient; usually family members.

Epilepsy: A neurological disorder characterized by multiple unpredictable seizures.

Myoclonic seizure: A seizure characterized by brief jerking or twitching of muscles.

Patient: An individual who experiences generalized seizures. May also be referred to as the end-user.

Seizure: A disturbance in the brain caused by a sudden surge in neuroelectric activity.

Seizure Profile: Personalized for each patient, describes information regarding the individual's typical seizure, such as physical indicators, or their average threshold for specific biometrics during a seizure. The seizure profile is used to provide more accurate seizure detection. Technically; a matrix of weights computed from training data used to classify new inputs as seizure or non-seizure related.

Simple Partial Seizure: A brief seizure that starts in one side of the brain, also referred to as a focal onset aware seizure. During this kind of seizure, the patient does not lose awareness of their surroundings.

Tonic Seizure: A seizure in which the patient's body, arms, or legs suddenly stiffen.

Tonic-Clonic Seizure: What most people think of when they hear the word "Seizure." It combines the characteristics of tonic and clonic seizures.

Detection Algorithm: This algorithm will use ten seconds of accelerometer, gyroscope and heart rates values. These values will then be compared to the threshold for the neural network, based on this a seizure might or might not be detected.

Recording Algorithm: The purpose of this algorithm is to record all the data that will be necessary to be used for training by the neural network.

Reporting Algorithm: The purpose of this algorithm will be to inform emergency contact and any bystander that a seizure has been detected.

MySQL: An open-source relational database management system.

SQLite: C-language library that implements a small, fast, self-contained, high-reliability, full-featured, SQL database engine.

Rest API: An application interface that uses HTTP requests to GET, PUT, POST and DELETE data.

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1.5 Overview

This product specification provides a high-level look at the goals or objectives that the prototype aims to achieve. An overlook into the architecture (software, hardware and external interfaces that is required) and structure of SeizSmart will also be provided. The requirements will be discussed in section 3 which will be in a separate document.

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2 General Description

SeizSmart will be an application running on a smartphone, smartwatch and a server. Users will have access to the smartwatch and the smartphone application. The smartphone will be utilized by the patient to view their seizure data and to implement any changes. The smartwatch will be worn by the patient, this will be recording seizure data and it will detect any potential seizure. On the server side there will be a database which will contain patient seizure data and emergency contacts, there will also be a neural network which will be trained using patient seizure data.

2.1 Prototype Architecture Description

SeizSmart require multiple components to be operational (1) the smartwatch application, (2) the smartphone application and (3) the server-side component. Figure 3 is the MFCD which details all the components required for SeizSmart.

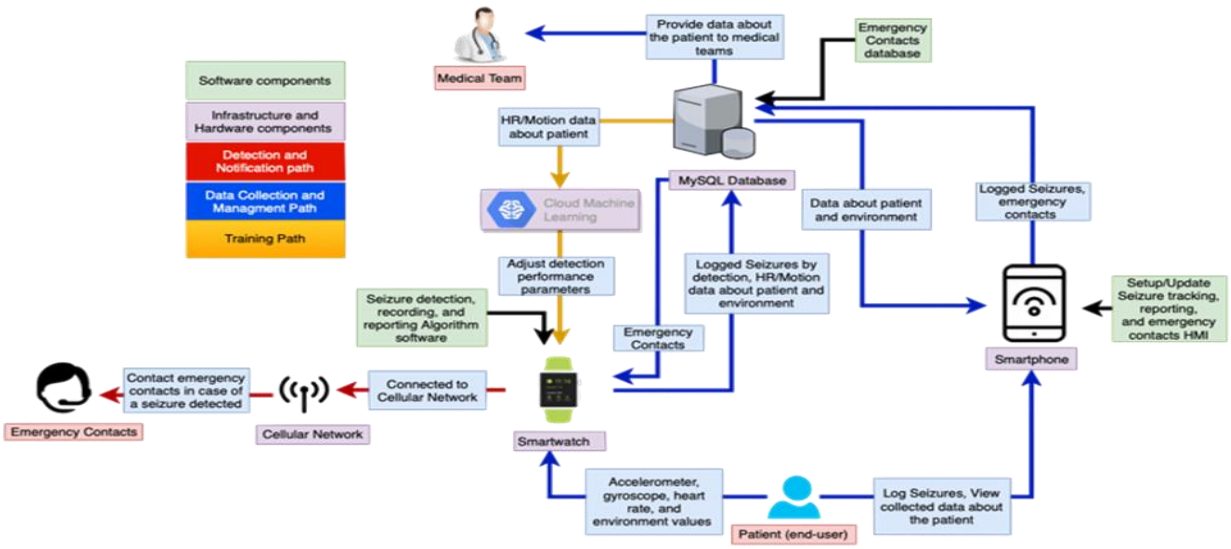

Figure 3. Multi Functional Component Diagram

The mobile application will be vital when it comes to the initialization of patient profile, reporting or updating of seizure tracking, setting and updating of emergency contacts. Patients can also use the application to view their seizure data which will be pulled from the server database. The smartphone will require an internet connection to GET or POST to the server. The mobile application will be running on an Android smartphone.

The smartwatch application will be the most important one because it is the application that gets patient biometrics, to get this data the application will be using the gyroscope, accelerometer and optical sensors on the smartwatch. This data will then be stored on the local SQLite database on the smartwatch, but will be eventually sent to the MySQL database on the server, this will require a connection to the internet. In the case that a smartwatch detects a seizure an alert will be sent to the emergency contacts which requires that the watch be connected to the internet.

SeizSmart also has a server-side component. This server will contain a MySQL database which will hold all patient's data. This data will be sent to the smartphone as requested. The biometric data will also be sent to the neural network for training of the threshold values. After training, the new threshold values will be sent to the smartwatch for detection purposes.

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2.2 Prototype Functional Description

The major functional component of SeizSmart include three different algorithms that will be responsible for SeizSmart to be functional, (1) the detection algorithm, (2) the recording algorithm and (3) the reporting algorithm.

The detection algorithm will use ten seconds of accelerometer, gyroscope and heart rates values. These values will then be compared to the threshold for the neural network, based on this a seizure might or might not be detected.

The purpose of the recording algorithm is to record all the data that will be necessary to be used for training by the neural network. A SQLite database which will contain patient biometrics will be used locally on the smartwatch and MySQL will be used server side, which will contain all the data from the smartwatch.

The purpose of the reporting algorithm will be to inform emergency contact and any bystander that a seizure has been detected. This will check that the watch has a connection before it can contact any stored emergency contact.

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2.3 External Interfaces

The main external interface that will be used by this project will be the network connection as the smartwatch, smartphone and the server will all be connected to each other.

2.3.1 Hardware Interfaces

The hardware interfaces for this project will be:

- Android Smartwatch: The watch application will be an android application. The smartwatch with also needs to be able to connect to the internet.
- Android Smartphone: This application will be an android application that should be able to connect to the internet.
- Smartwatch sensors: These sensors that will be used for this project are the accelerometer, gyroscopes and optical sensor (for heart rate).

2.3.2 Software Interfaces

The software interfaces for this project will be:

- Rest API: The team will be using Rest APIs to send and receive data to the server from the smartwatch or smartphone.
- Local SQLite Database: This database will contain all the biometric data from the smartwatch sensors.
- External MySQL database: This database will contain all the user's data and seizure data from the watch.

2.3.3 User Interfaces

The user interfaces for this project will be:

- Touchscreen: for both the smartwatch and smartphone the users will be interacting with the respective applications using their screens.

2.3.4 Communications Protocols and Interfaces

The communication protocols and interfaces for this project will be:

- IEE 802.11: WIFI will be used on the smartwatch to notify emergency contacts
- REST API: To send and receive data to server. These are list of endpoints:
    - /biometrics?s=SESSION_TOKEN: POST uploads JSON payload of biometric logs.
    - /notify?s=SESSION_TOKEN: POST posts list of people (either username or phone number) to be notified of seizure.
    - /trained-algo?s=SESSION_TOKEN: GET returns a JSON payload of trained weights for use in detection.