Lab 1 – SeizSmart Description

Alpha Din Gabisi

CS 411

Professor Thomas J. Kennedy

September 6, 2019

Version 1

Table of Contents

List of Figures

List of Tables

1. Introduction

SeizSmart will be an application running simultaneously on a smartphone and smartwatch, that will be used to detect potential seizures in users suffering from the most common type of generalized seizures.

Epilepsy is the fourth 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. The types of generalized seizures are Tonic-clonic, Absence, Myoclonic, Clonic, Tonic and Atonic. SeizSmart will only be able to detect five of these it is not possible to detect Absence seizures because the patient just blanks out in this type of seizure

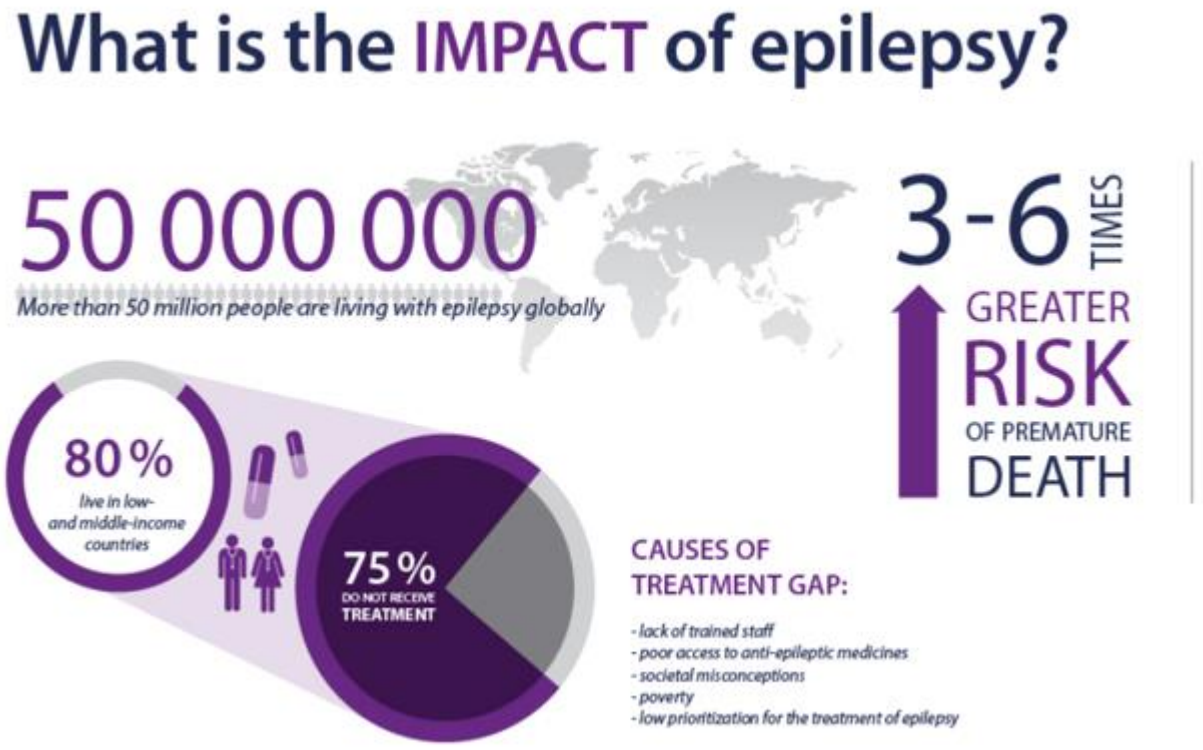

Figure 1: Background of epilepsy

Epileptic seizures are difficult detect but based on some of the characteristics of generalized seizures which include rapid change in heart rate and rapid convulsions in limbs. SeizSmart intends to use these characteristics to detect an oncoming seizure which could lead to potential injury or even death if the proper steps are not taken. Figure 2 shows the typical heart rate of a patient that is suffering from a seizure; the most damage can be done to the patient after the peak of the seizure this is when the patient will be vulnerable and will require help.

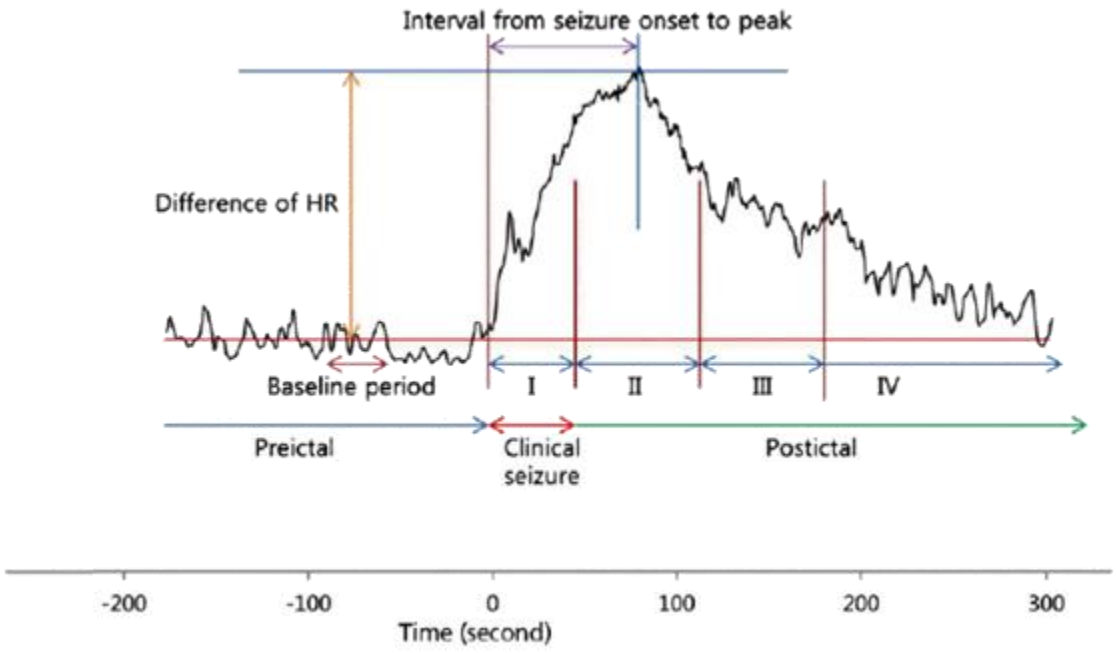

Figure 2: Interval from seizure onset to peak

SeizSmart is not the only application in the market that intends to help individuals suffering from generalized seizures. Some of the competitors include Empatica Embrace 2, SmartMonitor, SeizAlarm. The difference between the competitors is that they 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 contact

once a seizure is detected. SeizSmart will be a free application that anyone who suffers from generalized seizures can download and use if they have access to a smartphone and a smartwatch.

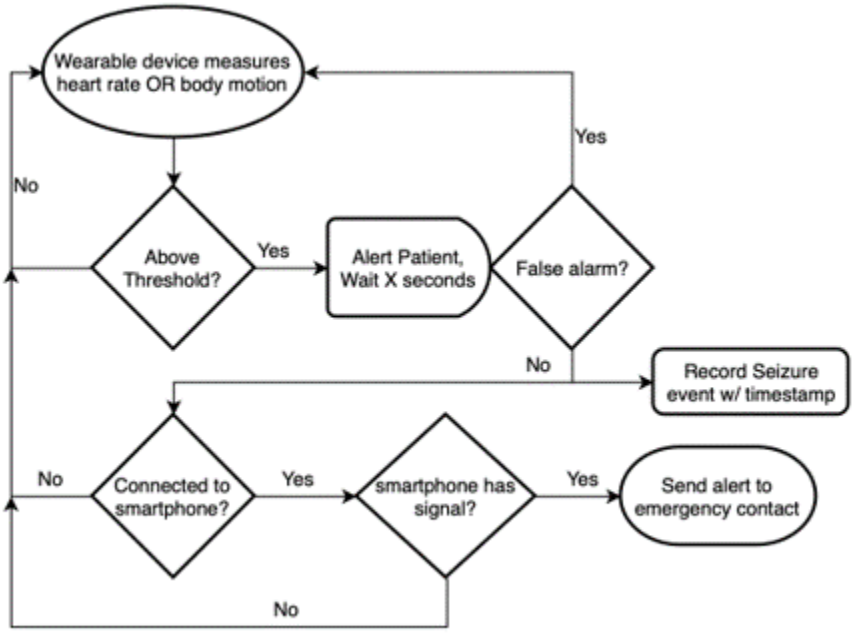

Figure 3: Current process flow with detection of seizures

When dealing with a neurological condition such as this accuracy should be one of the most important areas to investigate as 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, so 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, for such a scenario the user could inform the application that they are about to partake in such an activity and a new threshold value will be set for detection.

2. SeizSmart Product Description

SeizSmart will consist of three different components, the first component will be the smartphone application, the next one will be smartwatch application and the last one will be the cloud server. 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, recording and adjusting of detection of threshold values. The server will be using biometric data sent from the smartwatch for the training of the machine learning algorithm.

2.1. Key Product Features and Capabilities

SeizSmart will utilize three main different algorithms to detect and track potential seizure. The first algorithm will be the detection algorithm itself, the second one will be the recording algorithm and the last one will be reporting algorithm.

Detection Algorithm will use ten seconds of Accelerometer, gyroscope and heart rates. These values will then be compared to the threshold for the neural network based on this a seizure might or might not be detected. Figure 4 gives a basic overview of this process.

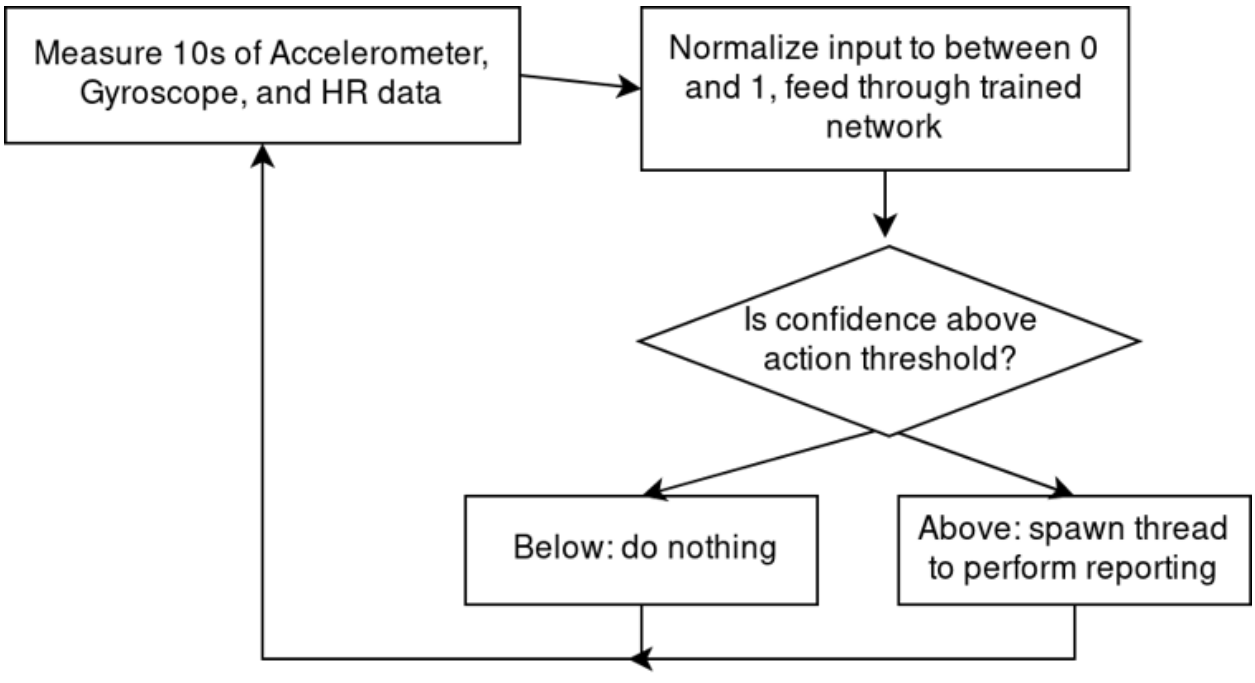

Figure 3: Detection algorithm flow

Recording algorithm, the purpose of this algorithm is to record all the data that will be necessary to be used by the machine learning algorithm. 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. Figure 5 gives a brief overview

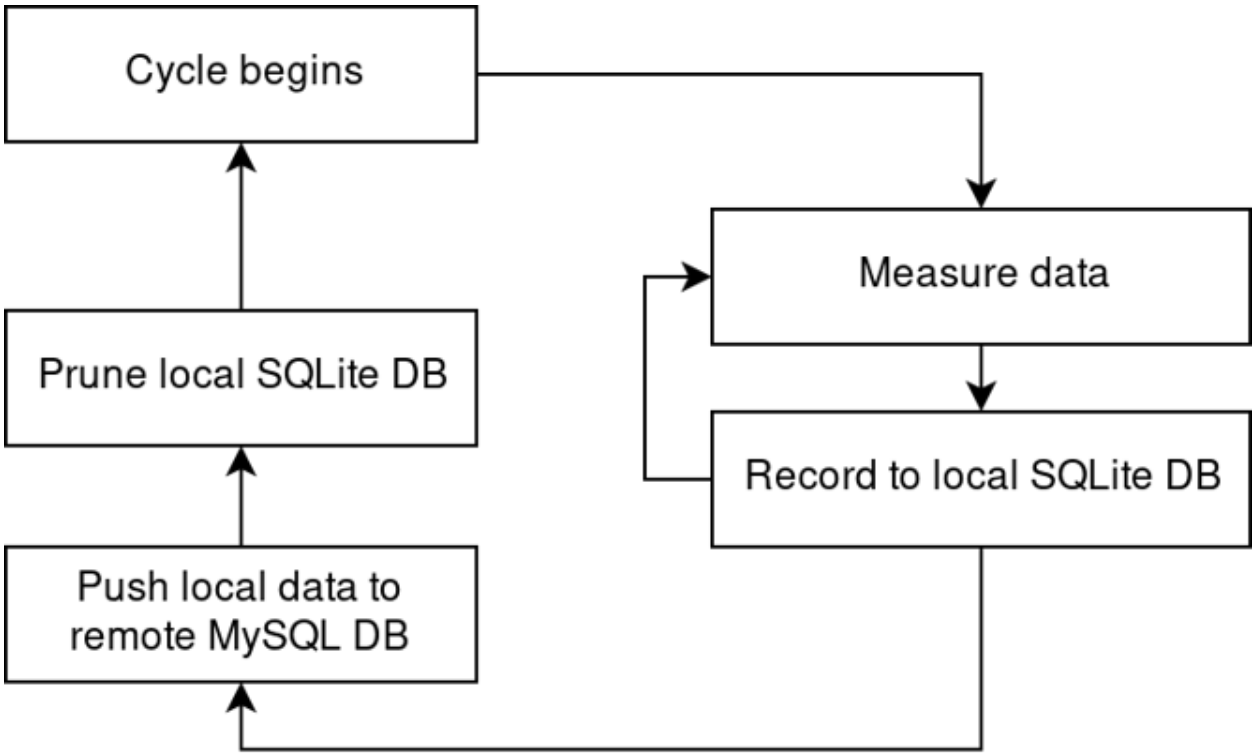

Figure 5: Recording Algorithm

Reporting algorithm the purpose of this 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. Figure 6 illustrate the process flow

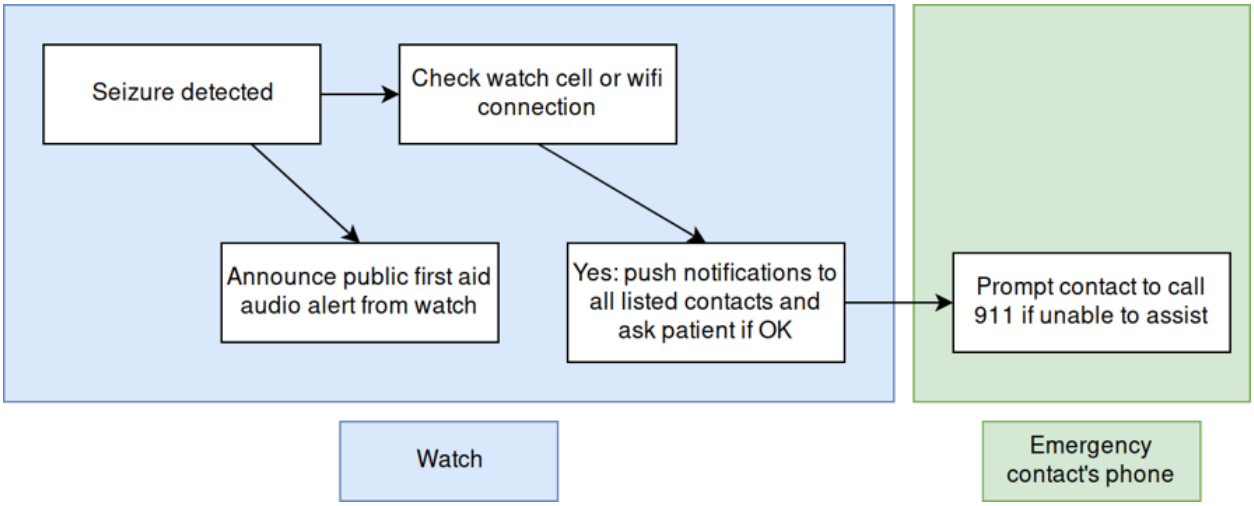

Figure 6: Reporting algorithm flow

2.2. Prototype Architecture

Seizsmart requires multiple components to be fully functional. The smartphone application will be utilized by the patient to view their seizure data. The smartwatch application will be worn by the patient which will be recording seizure data and detecting seizure. The local server will contain a database of the patient seizure data and emergency contact list. There is also the machine learning component which will be trained using the patient seizure data from the local server. Figure 7 illustrates the MFCD. SeizSmart also contains three vital algorithm as stated earlier; Detection algorithm, Reporting algorithm and the Recording algorithm most of these algorithm will be running on the server or smartwatch.

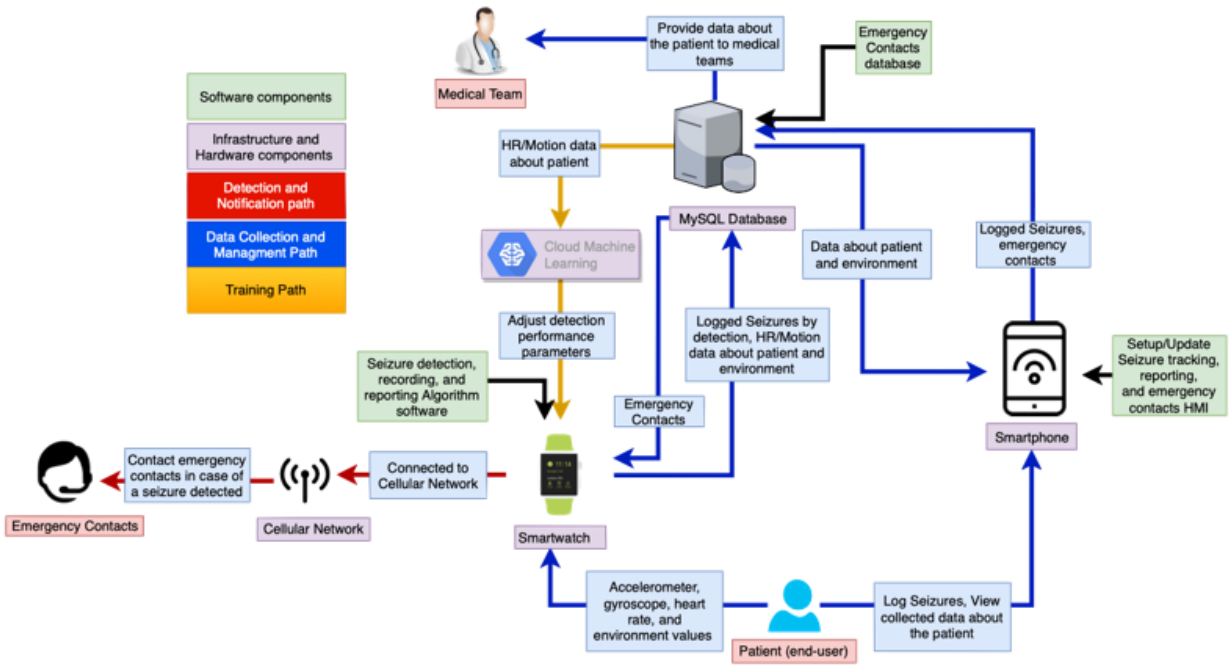

Figure 7: Multi Functional Component Diagram

The mobile application will be most important when it comes to the setting up 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. This smartphone will require an internet connection to get or post to the server.

The next application will be the smartwatch application. This application will be the most vital application because it is the application that gets patient biometric, to get this data the application will be using gyroscope, accelerometer and optical sensors on the smartwatch. This data will be stored on the smartwatch but will be eventually sent to the MySQL database on the server which will require it to be connected 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 a cellular network.

SeizSmart also requires a server. This server will contain a MySQL database which all hold all patients data. This data will be from the smartwatch and from smartphone. The biometric data will be the data that will be sent to the machine learning algorithm to train for threshold values. Once the algorithm is trained it will be sent to the smartwatch for detection.

Seizure Detection will consist of the three different algorithms. Detection algorithm will mostly be running on the smartwatch it just requires a trained neural network which will be done on the server. This algorithm will be comparing real time data from the smartwatch to detect if a seizure is happening. The Recording algorithm will also be running on the smartwatch this algorithm stores data into a local SQLite database on the smartwatch which will be pushed to the server database once every twenty-four hours. The Reporting algorithm requires that the smartwatch have access to a cellular network to send alert to emergency contacts.

2.3. Identification of Case study

SeizSmart will be used by individuals with generalized seizures. So the customers could be caregivers of people suffering from generalized seizures, for example a mother would get their child suffering from generalized seizures a smartwatch compatible with this application.

3. SeizSmart Prototype Description

This project is a very large project and can not be done in the span of one semester. As a result, some of the functionality will have to be faked for the scale of this class. Table 1 summaries which features will be faked and the ones that will be implemented.

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

3.1. Prototype Functional Goals and Objectives

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.

Based on the previous data the prototype should be able to detect a potential seizure as the testers normal biometrics would have been fed into the neural network to train so the simulated data should be detected as a potential seizure as it should be past the threshold.

3.2. Prototype Architecture (Hardware/Software)

This is a placeholder.

3.3. Prototype Features and Capabilities

This is a placeholder

3.4. Prototype Development Challenges

One of the major challenges the team will face is fully learning the technology required for this product in the allocated time given, the smartphone and smartwatch will not be too difficult to learn as the team has experience with JAVA. But working with Tensorflow API will be daunting as this is the first time the majority of team will be learning about this API and neural networks in general. Another development challenge is the accuracy of the sensors on the smartwatch this could negatively affect seizure detection as it could affect false positives and negatives. Another problem the team might encounter is that finding sufficient training data might be problematic.

4. Glossary

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

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

Seizure Profile: Personalized for each patient, describes information regarding the individual's typical seizure, such as physical indicators, or their typical 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.

5. References

[1] "Website." [Online]. Available: Tzallas, A. T., Tsipouras, M. G., Tsalikakis, D. G., Karvounis, E. C., Astrakas, L., Konitsiotis, S., & Tzaphlidou, M. (2012, February 29). Automated Epileptic Seizure Detection Methods: A Review Study. Retrieved from https://www.intechopen.com/books/epilepsy-histological-electroencephalographic-and-psychological-aspects/automated-epileptic-seizure-detection-methods-a-review-study. [Accessed: 11-Sep-2019].

[2] "Website." [Online]. Available: Giannakakis, G., Sakkalis, V., Pediaditis, M., & Tsiknakis, M. (1970, January 01). Methods for Seizure Detection and Prediction: An Overview. Retrieved from https://link.springer.com/protocol/10.1007/7657_2014_68. [Accessed: 11-Sep-2019].

[3] "Website." [Online]. Available: Devices & Technology. (n.d.). Retrieved from https://www.dannydid.org/epilepsy-sudep/devices-technology/. [Accessed: 11-Sep-2019].

[4] "About SmartWatch InspyreTM by Smart Monitor – smart-monitor." [Online]. Available: https://smart-monitor.com/about-smartwatch-inspyre-by-smart-monitor/. [Accessed: 11-Sep-2019].

[5] "Website." [Online]. Available: Velez, Mariel, et al. "Tracking Generalized Tonic-Clonic Seizures with a Wrist Accelerometer Linked to an Online Database." Seizure, U.S. National Library of Medicine, July 2016, www.ncbi.nlm.nih.gov/pubmed/27205871. [Accessed: 11-Sep-2019].

[6] "Website." [Online]. Available: Borujeny, Golshan Taheri, et al. "Detection of Epileptic Seizure Using Wireless Sensor Networks." Journal of Medical Signals and Sensors, Medknow

Publications & Media Pvt Ltd, 2013, www.ncbi.nlm.nih.gov/pmc/articles/PMC3788195/. [Accessed: 11-Sep-2019].

[7] February;25(2):28-29, N. R., Publish date: December 6, 2., & Publish date: December 18, 2. (2019, January 07). Mobile Devices May Provide Accurate Seizure Detection and Help Prevent SUDEP. Retrieved from https://www.mdedge.com/neurology/epilepsyresourcecenter/article/130162/epilepsy-seizures/mobile-devices-may-provide

[8] van Elmpt, Wouter J C, et al. "A Model of Heart Rate Changes to Detect Seizures in Severe Epilepsy." Seizure, U.S. National Library of Medicine, Sept. 2006, www.ncbi.nlm.nih.gov/pubmed/16828317.

[9] Borujeny, Golshan Taheri, et al. "Detection of Epileptic Seizure Using Wireless Sensor Networks." Medical Signals and Sensors, Medknow Publications & Media Pvt Ltd, 2013,

www.ncbi.nlm.nih.gov/pmc/articles/PMC3788195/.

[10] Velez, Mariel, et al. "Tracking Generalized Tonic-Clonic Seizures with a Wrist Accelerometer Linked to an Online Database." Seizure, U.S. National Library of Medicine, July 2016,

www.ncbi.nlm.nih.gov/pubmed/27205871.

[11] Kołodziej, M., Majkowski, A., Rak, R. J., Świderski, B., & Rysz, A. (2017, September). System for automatic heart rate calculation in epileptic seizures. Retrieved from

https://www.ncbi.nlm.nih.gov/pubmed/28523469

[12] Nei, M. (2019). Cardiac Effects of Seizures. American Epilepsy Society.

[13] Zijlmans, Maeike, et al. “Heart Rate Changes and ECG Abnormalities during Epileptic Seizures: Prevalence and Definition of an Objective Clinical Sign.”

www.ncbi.nlm.nih.gov/pubmed/12181003.

[14] “Demystifying Epilepsy and Increasing Awareness.” and Research, Mayo Clinic, Mayo Foundation for Medical Education https://newsnetwork.mayoclinic.org/discussion/epilepsy-demystify-disease-and-increase-awareness/.

[15] “Epilepsy Foundation.” Epilepsy Foundation, 13 Mar. 2019, www.epilepsy.com/.

[16] “About SmartWatch Inspyre™ by Smart Monitor – Smart-Monitor.” Smart,

smart-monitor.com/about-smartwatch-inspyre-by-smart-monitor/.

[17] “Embrace2 Seizure Monitoring | Smarter Epilepsy Management | Embrace Watch.” www.empatica.com/embrace2/.

[18] “SeizAlarm Epilepsy Seizure Detection.” SeizAlarm Epilepsy Seizure Detection, seizalarm.com/.

[19] “Epilepsy Journal App | OllyTree Applications.” Epilepsy Journal, www.epilepsy-journal.com/.

[20] “Health Storylines™.” Health Storylines™, www.healthstorylines.com/.