Running Head: Lab I - SeizSmart Description

Lab 1 - SeizSmart Description

Kevin Sokol

CS 411

Professor Thomas J. Kennedy

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1 Introduction

Epilepsy is the fourth most common neurological disease in the world, and more than 50 million people are suffering from epilepsy globally. As can be seen in the figure below, the number of people who have epilepsy have increased over the past few years, and this increase is expected to continue to increase.

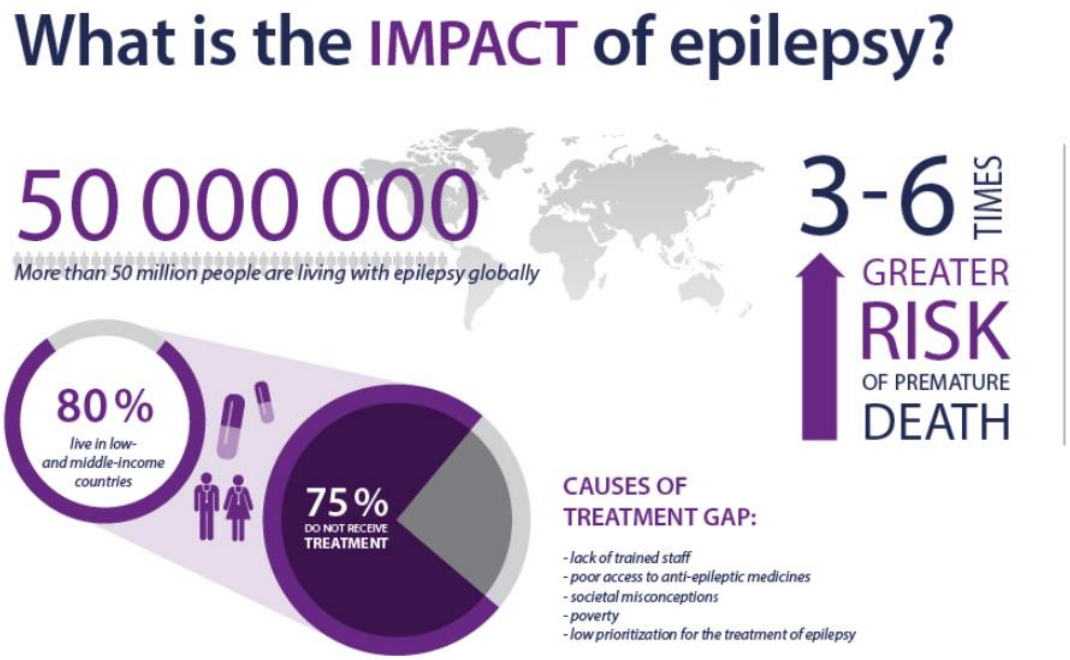

Figure 1: Epilepsy Statistics

Epilepsy causes a person to have reoccurring seizures, and can cause a disturbance in motor, sensory, and/or mental functions in someone who is suffering from a seizure. There are multiple types of seizures, and people suffering from epilepsy can often have different symptoms from each other, which can make it difficult for a generalized program to detect them. As a result of this, using some of the symptoms of a seizure, such as a change in heartrate or erratic movement is unable to detect all people suffering from one. As a result of this, there is a need for

an application which is able to detect seizures which uses unique data to detect them in its users in order to reduce as many false negatives and false positives as possible.

SeizSmart is an application which will use a smartwatch to gather heartrate as well as movement data in its users in order to detect those suffering from generalized seizure. Of the five types of generalized seizures, SeizSmart will be able to detect five of them, Myoclonic, Clonic, Tonic, and Atonic, while being unable to detect Absence seizures due to the lack of a change in heartrate or movement associated with them. When a seizure occurs, there is often a rapid change in heartrate, as well as the occurrence of heartrate, as can be seen in the figure below.

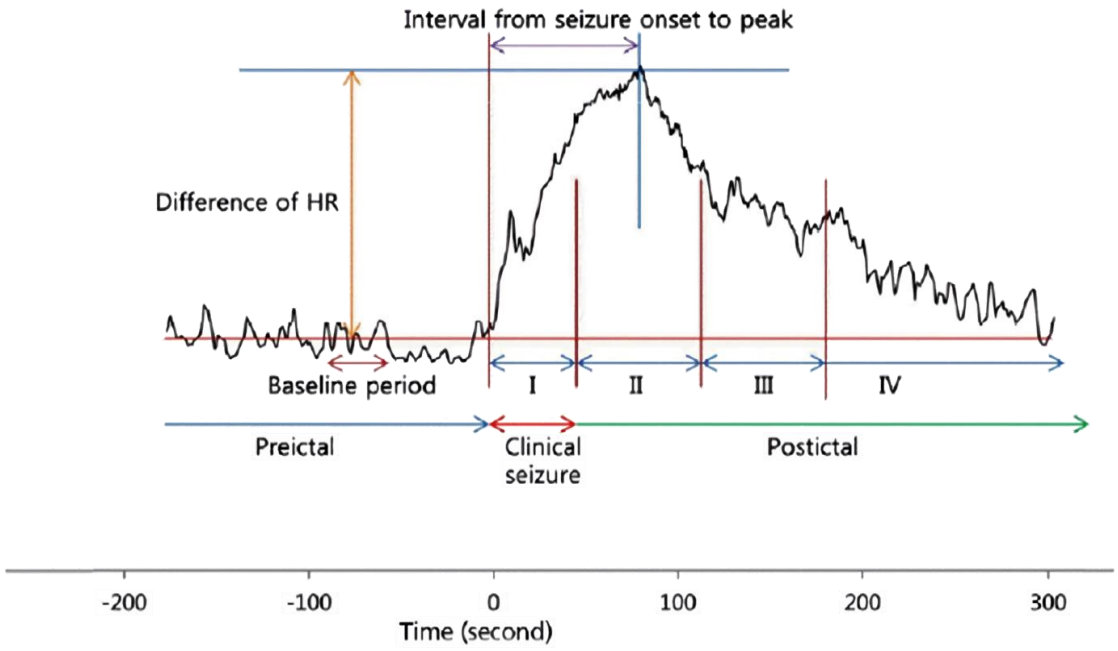

Figure 2: Timeframe of a Seizure

2 SeizSmart Description

SeizSmart is planned to be able to detect seizures through the use of biometric data such as heartrate and motion readings, as well as through general seizure data, as well as data specific for each individual user. The software will be available on both smartwatches and smartphones. While using a smartphone will be optional, the use of a smartwatch will be mandatory in order to

collect required information. Seizures detected will be recorded, and notifications will be sent out to the user as well as any emergency contacts in the event of a seizure being detected. This data collected will be used with a machine learning algorithm in order to more accurately detect seizures in users.

2.1 Key Product Features and Capabilities

One of the unique features of SeizSmart is that its seizure detection algorithms will be individualized between each user. Every users' starting profile will begin using generalized data, however as the program is used the user's profile will be individualized using their data. Smartwatches will record a patient's heartrate as well as body movement in real time and use these in order to detect possible seizures. As can be seen in the table below, this is more than SeizSmart's competitors when it comes to detecting seizures.

Competition Matrix		Direct			Indirect	
	SeizSmart	SmartMonitor	empatica embrace 2	SeizAlarm	Epilepsy Journal	Epilepsy Health Storylines
Detect, record and track generalized seizures in real time	✓	✓	✓	✗	✗	✗
Monitor repetitive shaking motion	✓	✓	✓	✓	✗	✗
Continuously monitor the user's heart rate	✓	✗	✗	Only checks for elevated heart rate	✗	✗
Alert emergency contact when the user does not respond	✓	✓	✓	✓	✗	✗
Report data about the environment at the onset of a seizure being detected	✓	✗	✗	✗	✗	✗
Function fully without dependence on a smartphone or external device	✓	✗	✗	✗	✗	✗
Use machine learning to detect generalized seizures	✓	✗	✓	✗	✗	✗
Require a subscription or prescription	✗	✓	✓	✗	✗	✗

Table 1: Competitors

A user will be able to adjust the detection algorithm in order to change how sensitive the program is to detecting seizures. Depending on the patient, either more false positives or false negatives may be preferred over the other, so this functionality is there in order to ensure that each users expectations and needs are met on an individual basis.

When a Seizure is detected, a notification will be sent from the user's smartwatch to all emergency contacts listed for the user. A notification will be displayed on the user's smartwatch, as well as a smartphone if one is connected. Using either the smartphone or smartwatch, the user can disable the notification if a false positive is occurring, and emergency contacts will be prompted to check on the patient if they are able to, as well as being asked to call emergency services.

2.2 Major Components

SeizSmart will use three major components, which are a smartwatch, smartphone, as well as the server. The smartwatch will be used for collecting heartrate and motion data, as well as sending an alert to both the user and emergency contacts if a seizure is detected. In addition, the smartwatch will also be in charge of sending collected data to the server so that it can be interpreted and used. The smartwatch can also be used to change the sensitivity of the detection algorithm and add or remove emergency contacts. The smartwatch will temporarily store biometric data detected until it can be later sent to the server for storage there. The smartwatch must have access to Wifi and/or LTE data, as well as possess the necessary components to detect heartrate and motion data.

A smartphone can be used to view previous data such as historical heartrate and times when previous seizures were detected. In addition, changes to the sensitivity of the detection algorithm as well as adding or removing emergency contacts can be performed here.

The server will be used for storing collected data, as well as training each individual user's seizure detection profile. The server will use SQL to store this data, as well as information regarding a user's account information and settings. In addition, the server will be used to train and store each user's patient profile.

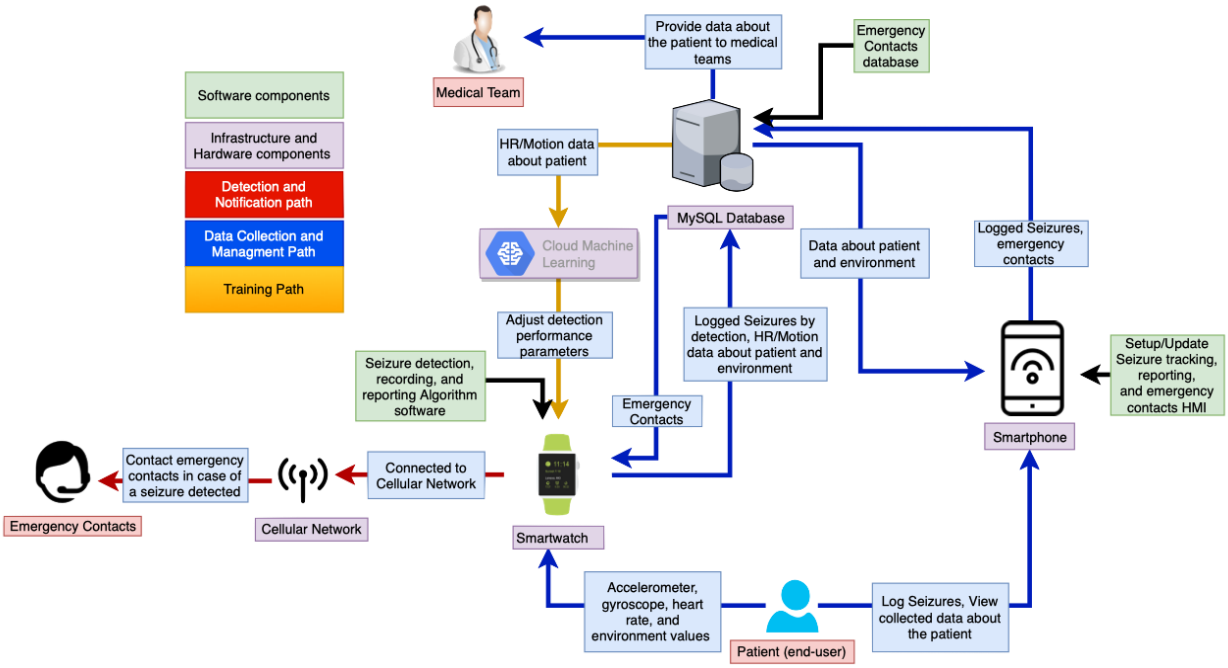

Figure 3: Major Functional Component Diagram

2.3 Identification of Case Study

SeizSmart is being developed for those who either suffer from epilepsy themselves, or who know someone who suffers from epilepsy, either as a friend, family member or doctor.

3 SeizSmart Prototype Description

The purpose of the prototype will be a proof of concept for the algorithms needed for SeizSmart. Test data will be simulated in order to test these algorithms, as well as to iron out any potential bugs that may be occurring in them.

3.1 Prototype Functional Goals and Objectives

The functional goal of the SeizSmart prototype is to ensure that the program will be able to detect, record, and report inputted data. This will be performed by testing a user's profile by performing an action repeatedly and flagging this action as a seizure. If this action begins to be flagged as a seizure, then we can ascertain whether the smartwatch is collecting data correctly, this data is being sent to the server, as well as whether the machine learning algorithm is able to use this data to make an accurate patient profile.

3.2 Prototype Architecture (Hardware/Software)

The prototype architecture will use an android smartwatch, two or more smartphones, as well as a server. The smartwatch will be used to collect and send data to the server. The smartphones will be used to configure user settings, as well as receive notification about detected seizures as both a patient and an emergency contact. The server will read the biometric data from the smartwatch, and train and store the user profile.

3.3 Prototype Features and Capabilities

For the most part the prototype will be similar to the final product, however some features will be changed or eliminated. The prototype will only be able to be run on Android smartphones and smartwatches. In addition, the data that will be used to make the default patient profiles will be based on publicly available data in order to make a baseline for seizure detection.

The completed product is expected to use data gathered through SeizSmart eventually in order to have an accurate as possible profile. In addition, some data may be simulated for the prototype.

Functional Elements	Real World Product	Prototype
Detect generalized seizures in real time	Fully Functional	Implemented through simulation
Record generalized seizures in real time	Fully Functional	Implemented through simulation
Track generalized seizures in real time	Fully Functional	Implemented through simulation
Monitor repetitive shaking motion	Fully Functional	Fully Functional
Continuously monitor the user's heart rate	Fully Functional	Fully Functional
Alert emergency contact when the user 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
Fully functional without dependence on a smartphone or external device	Fully Functional	Fully Completed

Table 2: Prototype Functional Elements

3.4 Prototype Development Challenges

One challenge that may occur while we are developing the prototype is the fact that our group will need to learn how to use some of the technologies required for this product. Some examples of this would be learning how to use the smartwatch that will be used for testing, as well as how to make use of the TensorFlow API that will be used for the machine learning algorithm. The TensorFlow API in particular may be one of the most difficult aspects of SeizSmart to learn, as our members do not have any experience with it.

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 Inspyre™ 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/.