Lab 2 – Product Specification

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CS 411

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Version 2

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1 Introduction

SeizSmart is envisioned to be a mobile application for detecting, tracking, and reporting epileptic seizures in real time. SeizSmart will allow users to notify their emergency contacts in cases where they are having a seizure. It will also provide users the ability to view data collected from the smartwatch sensors.

1.1 Purpose

SeizSmart is designed to be an application that will run both on the smartwatch and the smartphone. The smartwatch application will use the 3-axes of acceleration, gyroscope, and heart rate readings to build a trained neural network that will determine when a user is having a seizure. The smartphone component will be able to build visualizations from the data collected from the smartwatch, display alerts in cases where a seizure is detected, and give users the ability to configure their emergency contacts.

One of the unique features of SeizSmart is that it uses a trained neural network to build a seizure profile that will be unique for each individual user. It detects seizures based on a combination of heart rate and body movement behavior. SeizSmart uses the two metrics of heart rate and body motion as opposed to its competitors that only use one or the other. It will not require a relay device because the smartwatch and smartphone run independently of each other. This increases the mobility of the user by not requiring them to be in close proximity of the smartphone. As shown in Figure 1, SeizSmart begins by measuring the user's heart rate and body motion, then compares those measurements against the users' seizure profile. If it is a match, it alerts the user and the user's emergency contact. If either the user or the emergency contact clear the alert, then the last resort emergency contact will not be notified. Data about the patient will be consistently collected from the smartwatch and will be tagged as seizure or non-seizure data.

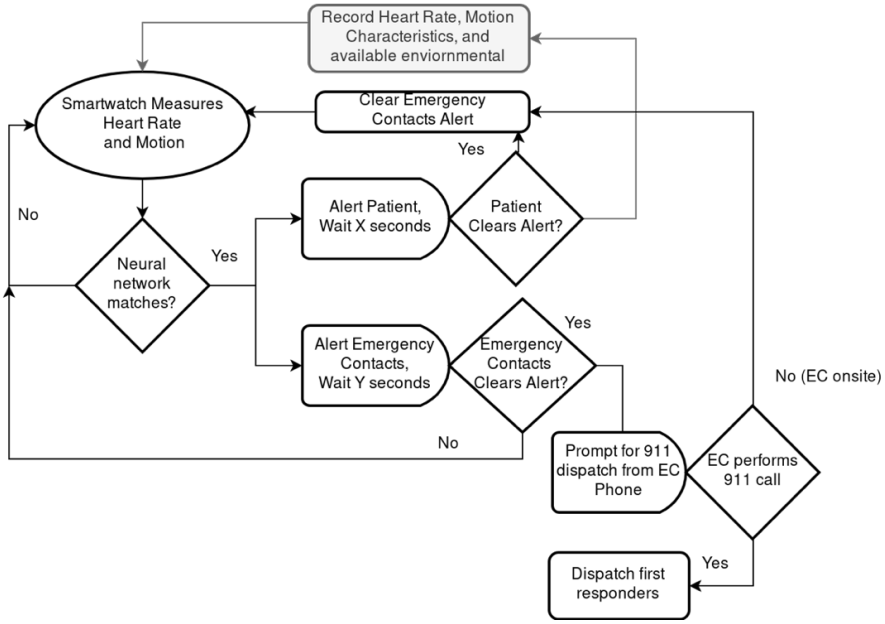

Figure 1: Solution Process Flow

1.2 Scope

The SeizSmart prototype will implement all algorithms required for the final product. The seizure data will be generated by simulating the characteristics of generalized seizures, which are a rapid change in heart rate and repetitive body motion. The distribution of the smartphone and smartwatch application will be limited to an internal development team. The key benefits of implementing the prototype are that it will validate all algorithms, and highlight flaws in design and implementation.

The prototype will have minor differences compared to the final product. The prototype will be limited to smart devices running Android and some features will be eliminated from the prototype due to the shortage of development time. A complete comparison of features that will be implemented for the prototype can be found in Table 1.

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 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 of seizure event
Fully functional without dependence on a smartphone or external device	Fully Functional	Fully Completed

Table 1 Prototype Features

The prototype will perform the detection algorithm on simulated data. The data will be generated based on publicly available data to determine a baseline set of data, as well as, data that represents the onset of a seizure. The prototype will be able to record and track generalized seizures in real time, which will be implemented through the simulation of a seizure event. The prototype will also be able to alert emergency contacts directly from the smartwatch by having the smartwatch application run independently of the smartphone.

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 the patient lists to contact during an emergency; 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; a type of generalized seizure that involves a loss of consciousness and violent muscle contractions.

Last resort emergency contact: the last person that will be notified in cases where emergency contacts do not respond.

1.4 References

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1.5 Overview

The product specification provides the hardware and software configuration, external interfaces, capabilities and features of the SeizSmart prototype. The information provided in the remaining sections of this document includes a detailed description of the hardware, software, and external interface architecture of the SeizSmart prototype; the key features of the prototype; the parameters that will be used to control, manage, or establish that feature; and the performance characteristics of that feature in terms of outputs, displays, and user interaction.

2 General Description

SeizSmart consists of three main components. The smartwatch application will be responsible for detecting seizures and sending an alert to the user and the user's emergency contact(s)when a seizure is detected. The smartphone application gives users the ability to view data collected from the smartwatch, report false positives, and configure their account. The server will be responsible for hosting the database that consists of two main tables: the User Profile and Seizure Data. The User Profile will contain basic user information such as their account credentials and emergency contacts. Seizure Data will contain data collected from the sensors on the watch with a Boolean value to indicate if a seizure occurred. There will also be an internal database that will be running on the smartwatch. It will hold temporary data that will be sent to the external database hosted on the server.

2.1 Prototype Architecture Description

SeizSmart will utilize the hardware specified in Figure 2. The smartwatch application will utilize cellular network to contact emergency contacts when a seizure is detected. The smartphone will be responsible for configuring and updating seizure tracking as well as editing emergency contacts. The smartwatch will be collecting accelerometer, gyroscope, and heart rate

data from the end-user as well as environmental data that can act as a potential trigger to a seizure. The algorithm that will be used to detect seizures will run on Google's TensorFlow library and will receive heart rate and motion data from the external database running on the server. The output of the detection algorithm will be used to tune the detection performance parameters on the smartwatch.

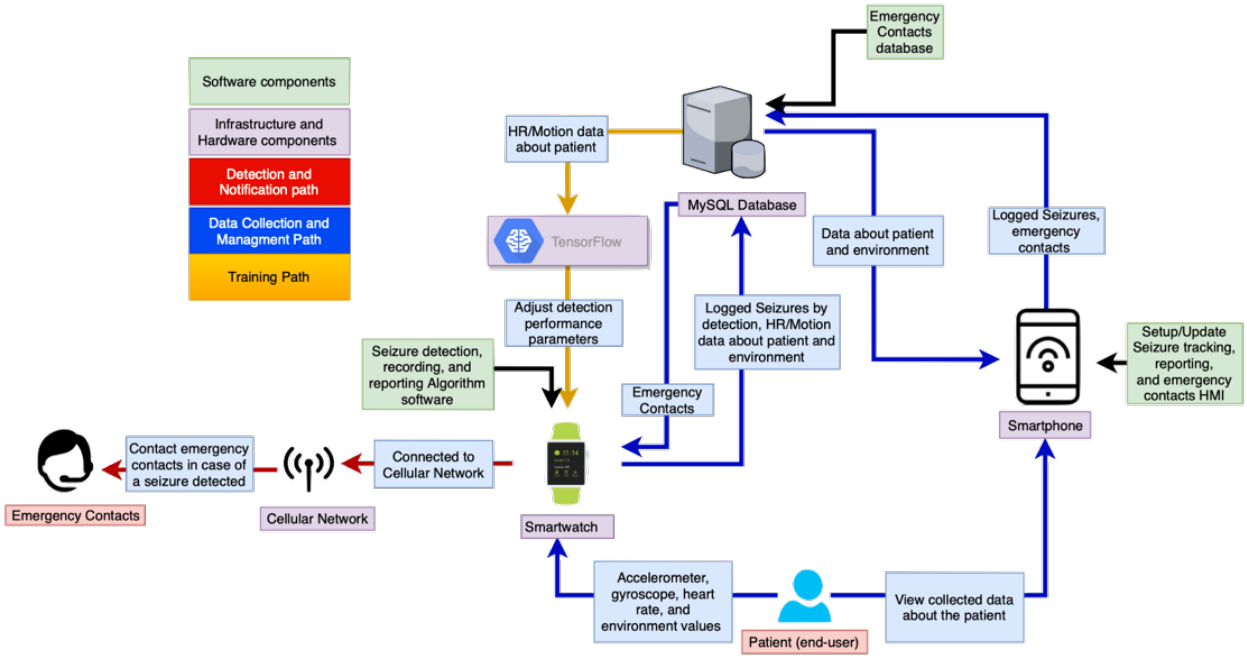

Figure 2: Major Functional Component Diagram

2.2 Prototype Functional Description

The major functional components of the SeizSmart prototype will include the following: a recording algorithm, a detection algorithm, and a reporting algorithm.

The purpose of the recording algorithm is to record seizure related data that will be used in the detection algorithm. The cycle begins by the smartwatch collecting data and storing it in the internal smartwatch database called SQLite. At a specific time interval, the data collected will be pushed to the MySQL database for permanent storage. After receiving a successful

response from the server on the watch, the uploaded data will be removed from the smartwatch to free up space and the cycle will restart.

The data collected from the recording algorithm will be used in the detection algorithm. If the data collected is not based on simulation data, it will be multiplied by ten (10) and normalized between one and zero to be fed through a trained neural network. If the confidence from the trained neural network is above the predetermined action threshold, which is a value between 0 and 1, it will proceed to the reporting algorithm, where the patient's emergency contact will be notified.

The reporting algorithm will be invoked as soon as a seizure is detected. One of the unique features of SeizSmart is that it announces a public first aid audio alert from the watch, which can potentially get the attention of someone to help the patient. It will also push notifications to all emergency contacts directly from the smartwatch after verifying cellular or WiFi connection. The emergency contacts will be contacted via text message. If the emergency contact confirms the seizure, they will be prompted to call 911.

2.3 External Interfaces

SeizSmart is composed of two hardware interfaces: a smartphone and a smartwatch. The smartphone will be responsible for displaying collected data about the patient, manually logging missed seizure events, and configuring the user profile. The smartwatch will be responsible for determining the onset of a seizure and notifying emergency contacts.

2.3.1 Hardware Interfaces

The SeizSmart prototype will also use the following internal sensors: accelerometer, gyroscope, and ambient light sensor. The accelerometer and gyroscope sensors will be used to collect motion data about the patient. The ambient light sensor will be used to collect heart rate values from the patient.

2.3.2 Software Interfaces

The software interfaces will consist of the internal SQLite database, the external MySQL database, and the REST API endpoints. The SQLite database running on the smartwatch and smartphone. The smartwatch SQLite database will be responsible for temporarily storing collected seizure data. It will also be responsible for storing the patient's emergency contact, user settings, and seizure threshold values. The smartphone SQLite database will be responsible for storing data that will be visualized on the smartphone and information collected about the patient's emergency contact. The REST API endpoints will be responsible for providing a communication path between the Android application and the external MySQL database. The MySQL database will be responsible for permanently storing seizure data collected about the patient and the patient's user profile.

2.3.3 User Interfaces

The user interface is composed of the following fragments: Home, Statistics, Seizure Detected, and Log Seizures. The Home fragment will be the initial screen when the application launches. The statistics fragment will be where the user can interact with visualizations of seizure data. A seizure detected fragment will display a countdown alert when a seizure is detected.

2.3.4 Communications Protocols and Interfaces

There will be three REST API endpoints to provide a communication path between the Android applications and the external MySQL database running on the server. The /biometrics REST endpoint will upload all biometric data from the smartwatch to the MySQL database. The /trained-algo REST endpoint will return the trained weights that will be used for determining the onset of a seizure on the smartwatch. The /notify REST endpoint will be used to notify a list of emergency contacts.