Lab 2 - Seizsmart Product Specification

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2019-11-06

Version 2

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1 Introduction

50 million patients who suffer from clonic seizures have to face unique lifestyle challenges[0]. The most common form, Tonic-Clonic seizures, cause the patient to convulse uncontrollably which puts him/her at risk of death from a multitude of sources. The seizures themselves are not the only cause of death; patients will die from inhaling vomit immediately after a seizure. To prevent deaths, caregivers are required to constantly watch seizure patients. This requires significant effort which may be reduced through modern communication systems, leading to effectively the same amount of care with fewer constraints on the patient's lifestyle.

The patient and caregiver may be freed from these constraints by means of a communication system — patients do not need care before a seizure, only immediately after. Figure. 1 shows the timeline of patient motion associated with clonic seizures. The timeline indicates a detectable change in patient disposition which may be used to trigger an alert to caregivers, who have approximately five minutes to respond during the postictal phase when the patient needs care. Five minutes is enough time to allow a neighbor to be an emergency caregiver, allowing patients to live more ordinary lives without the imposition of a nurse or family member constantly watching them.

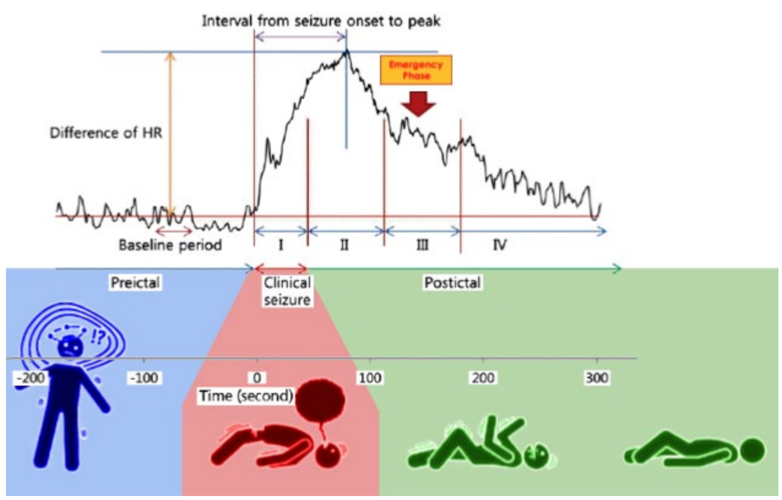

Figure. 1: Timeframe of seizure showing preictal, ictal, and postictal phases

Solutions to this problem already exist, but have reported difficulties because their detection algorithms are generic and cannot track an individual patient's seizure symptoms[2][3]. Instead existing solutions generalize the detection of a seizure across a huge corpus of data which may not represent the patient's actual symptoms. Another problem with existing alert systems is an outdated requirement of a relay device to transmit alerts — the watch transmits to a phone or relay box which in turn transmits to caregivers. Modern smartwatches have LTE and WIFI connections, meaning they can now directly push notifications to caregivers, reducing the number of moving parts and improving the reliability of alerts.

1.1 Purpose

SeizSmart will be a detection product for Seizure patients and their caregivers. SeizSmart will be a system which enables wearable electronics (e.g. Android smartwatch) to leverage advances in machine learning for the purpose of detecting seizures within minutes of their onset, if not immediately[1]. After detection several user-configurable alerts and messaging systems may be used to notify caregivers of the emergency, improving the efficiency of care and reducing the number of hours patients need to spend being constantly watched. A second component, the server, will be used to provide the machine learning required to accurately detect seizures[1]. SeizSmart will not predict future seizures.

1.2 Scope

SeizSmart is designed to be used by seizure patients and their caregivers to detect and alert caregivers about seizure events. The smartwatch and smartphone components will only be used by patients. Caregivers may use the server to receive non-SMS alerts via a Progressive Web Apps (PWA), but the primary interaction with caregivers will be an SMS alert sent directly from the smartwatch.

The goal of the SeizSmart prototype is to show that machine learning can be effectively applied using consumer-grade hardware to detect seizure activity. A secondary goal of the prototype is to show that alerts can be sent directly from a smartwatch to caregivers. The direct alert strategy will reduce the number of moving parts thereby improving reliability. Figure 2 displays a diagram of the process flow existing systems use.

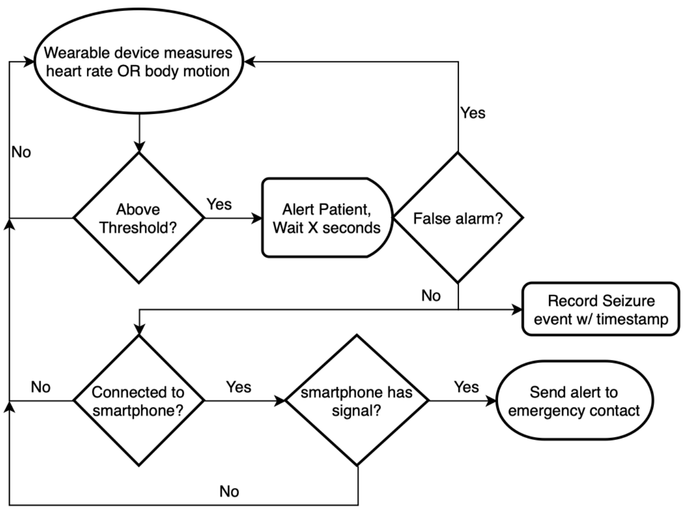

Figure. 2: Existing process flow

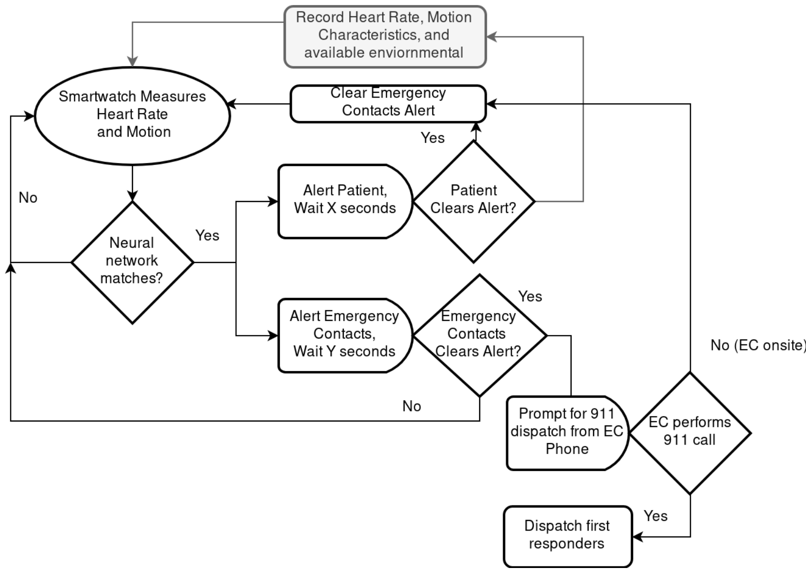

Figure. 3: SeizSmart process flow

Figure 3 displays the process flow SeizSmart will use. Note the removal of the smartphone from the alert path and the addition of an alert to caregivers instead of merely an alert to the patient (who is likely to be incapacitated).

1.3 Definitions, Acronyms, and Abbreviations

Patient - A patient is an end user who experiences generalized seizures and wants to use SeizSmart to alert caregivers.

Caregiver - A caregiver is an end user who cares for a Patient.

Seizure Profile - A Seizure Profile is a set of numbers used to evaluate how confident the watch is that a time interval of biometric data corresponds to a seizure.

Training Server - The training server is a component of SeizSmart responsible for providing the ability to learn what biometric data corresponds to seizure events.

1.4 References

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

[1] Team Silver., "Lab 1 - SeizSmart Product Description", ODU, 2019.

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

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

2 General Description

The SeizSmart prototype is designed to show the viability of a watch-centric machine-learning approach to detecting and reporting seizures.

2.1 Prototype Architecture Description

The SeizSmart prototype consists of two major user-facing components: a smartwatch application, and a smartphone application. Both are used by the patient. The patient used to evaluate the prototype will be an ODU student, and in place of seizures we will instruct them to place the smartwatch on their arm and move their arm in different patterns, tagging one of the patterns as a “seizure”. The patient will also be instructed to use the smartphone application to add an emergency contact. After a training period, the evaluator will be instructed to move their arm in the “seizure” pattern. The prototype works if the watch detects a seizure, makes an audible alert, times out, and finally sends a message to the emergency contact. Another test that will be performed is to instruct the evaluator to move their arm randomly. The prototype passes this test if it does not alert that the patient is having a seizure when subjected to non-seizure motion.

2.2 Prototype Functional Description

The SeizSmart prototype will perform the following tasks (not necessarily in the order displayed):

- Record biometric data
- Store biometric data
- Evaluate biometric data against a given seizure profile to determine confidence that the data represents a seizure event
- Upload biometric data to a Training Server
- Alert Caregivers when a seizure event is detected
- Allow Patients to configure their emergency contacts and seizure detection threshold.
- Train and improve a seizure profile over a 24-hour time period.

The smartwatch component is responsible for reading biometric data and storing the data short-term. Every hour it must attempt to upload whatever biometric data it has to the server and trim the data kept on the watch. The server is responsible for training a seizure profile from the given biometric data. The watch must then request an updated seizure profile every hour and store that profile for use when evaluating seizure events. The watch continuously feeds 10-second periods of biometric data through the seizure profile to produce a confidence number between 0.0 and 1.0. 0.0 indicates we are confident the patient is not having a seizure while values near 1.0 indicate we are confident the patient is having a seizure. The exact confidence threshold may be set by the patient, but a value of 0.85 will be set as the default. After detecting a seizure event the watch will sound an alert, ask the Patient if they are safe, and without a response from the Patient send an SMS to every Caregiver in a list specified in advance by the Patient.

2.3 External Interfaces

The SeizSmart prototype relies on a virtual server running on a hypervisor provided by the Old Dominion University Systems Group (hereafter “root”). While it is possible to run seizsmart from a PC the prototype uses a centralized server to reduce set-up time during evaluations.

2.3.1 Hardware Interfaces

The SeizSmart smartwatch application requires an Android 28+ smartwatch with a cellular network connection, an accelerometer, and a battery capable of powering the device for 24 hours. The SeizSmart smartphone application requires an Android 28+ smartphone and a WiFi or cellular network connection. The SeizSmart Training Server requires a publicly-routable IP address and a DNS record mapping the hostname 411silverf19-mgmt.cs.odu.edu to the given IP address.

2.3.2 Software Interfaces

The SeizSmart smartwatch application requires an Android 28+ runtime containing all of the android APIs for accessing networks, biometric sensors, and for creating graphical user interfaces. The SeizSmart smartphone application requires an Android 28+ runtime containing all of the android APIs for accessing networks and for creating graphical user interfaces. The SeizSmart Training Server requires a MySQL database and a driver to access the database. The Training Server also requires a Tensorflow 2.0 runtime and a software driver to interact with the Tensorflow runtime.

2.3.3 User Interfaces

The SeizSmart smartwatch application requires a screen capable of displaying at least 256x256 RGB pixels of graphical user interface. The SeizSmart smartphone application requires a screen capable of displaying at least 256x256 RGB pixels of graphical user interface. The SeizSmart Training Server requires an SSH connection to facilitate development during the prototyping phase.

2.3.4 Communications Protocols and Interfaces

The SeizSmart prototype uses the following protocols to communicate between the smartwatch, smartphone, and Training Server components:

- TCP kernel API which implements RFC 793
- HTTP android runtime API capable of connecting to, reading data from, and posting data to an HTTP server over TCP
- MySQL unix socket connection
- The Training Server requires a runtime capable of executing Java 8 bytecode contained within a standard .jar file (see "The Java® Virtual Machine Specification - Java SE 8 Edition" available from https://docs.oracle.com/javase/specs/jvms/se8/html/)

3 Specific Requirements

Section 3 has been omitted from this draft for political reasons. A working draft of section 3 is available at git-community.cs.odu.edu/jmcateer/lab02-sect03-numbering-nonsense/blob/master/not_index.md

4 Appendix

4.1 List of Prototype Materials

1x Android 28+ Smart Phone

1x Android 28+ Smart Watch

1x Server

1x Phone capable of receiving SMS

1x ODU Student capable of waving their arms in different patterns

4.2 List of Code Repositories

https://git-community.cs.odu.edu/fall2019-411-silver/seizsmart-watch

https://git-community.cs.odu.edu/fall2019-411-silver/seizsmart-android

https://git-community.cs.odu.edu/fall2019-411-silver/SeizSmart-Server