Software Requirements Specification

for

Apple Watch Heart Rate Variability Application

Version 1.0 approved

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February 23 2023

Table of Contents

Revision History

Name	Date	Reason For Changes	Version

1. Introduction

1.1 Purpose

The purpose of this SRS is to specify the functional and non-functional requirements of the application to calculate and store near-real-time Heart Rate Variability data from patients, provide intrusive feedback in case of dangerous HRV levels, and determine if a patient's HRV will lead to a stressful event. A stressful event is an activation of the "fight or flight" response. Activation in this area can cause undesired outbursts like road rage.

1.2 Document Conventions

This document shall be written in Times New Roman font with proper grammar and spelling. The font size shall be 12pts in size.

1.3 Intended Audience and Reading Suggestions

The intended readers are the developers, the project sponsor, and the professor. This document contains sections related to requirements and design specifications. A reader should start with the User Stories and Requirements before moving on to the

1.4 Product Scope

The HRV monitoring application for the Apple Watch will provide near-real-time tracking of HRV and provide alerts if a patient's HRV is decreasing below a stress threshold and trending toward a stressful event. The benefits of these HRV alerts are to increase the awareness of the patient to their current stress levels and possible interventions to reduce stressful events. The intended users are currently patients with Post-Traumatic-Stress-Disorder or Traumatic-Brain-Injurys.

1.5 References

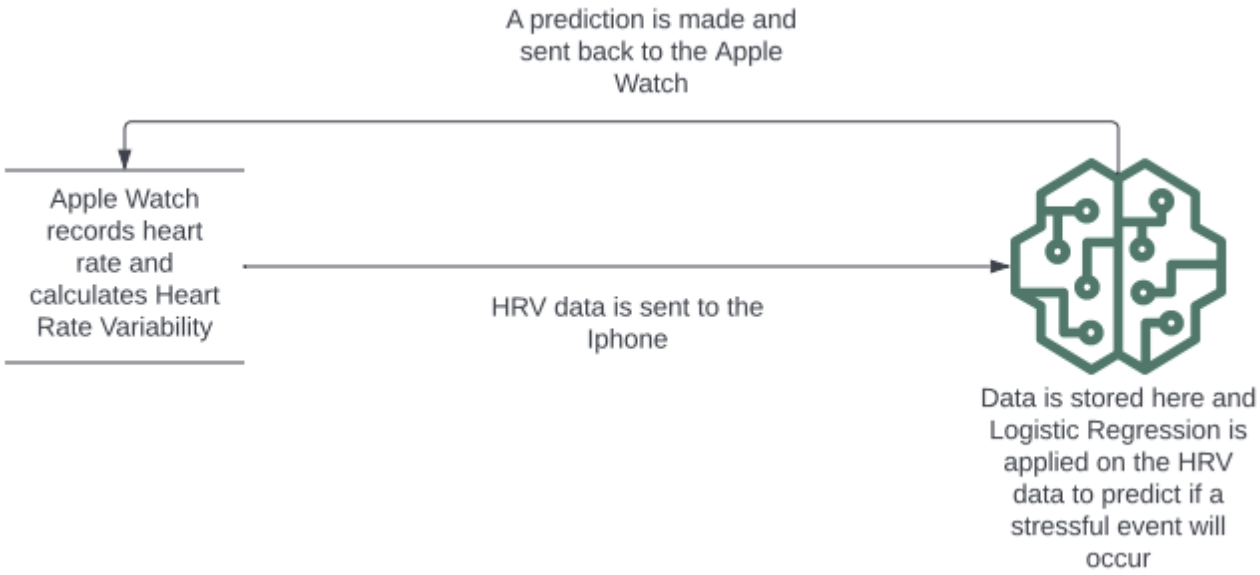
- *(n.d.). Everything You Need to Know About Heart Rate Variability (HRV). Whoop.com. https://www.whoop.com/thelocker/heart-rate-variability-hrv/*
- *(2021, August 10). The essential guide to Heart Rate Variability on Apple Watch. Apple Must. Retrieved February 23, 2023, from https://www.applemust.com/the-essential-guide-to-heart-rate-variability-on-apple-watch/*
- *(2017, September 28). An Overview of Heart Rate Variability Metrics and Norms. NIH. Retrieved February 23, 2023, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5624990/#:~:text=It%20is%20calculated%20by%20first,average%20of%20these%20288%20values.*

2. Overall Description

2.1 Product Perspective

This project is a continuation of the work done by a previous team that was left as future work that needed to be completed. The first task to be completed is the creation of a fully functional companion application that will: move the data storage to the iPhone, move the machine learning model training to the iPhone, and improve the data export feature.

Here is a diagram to illustrate the first task:



The second task to be completed is to deploy the application to patient devices. The third and final task is to improve the HRV threat detection algorithm.

2.2 Product Functions

The application shall provide the following functionalities:

- *Get live heart rate data from patients and calculate HRV on the Apple Watch.*
- *Store patient HRV data on the iPhone.*
- *Add capability to export data to a CSV file on the companion application*
- *Increase the number of attributes to the data set that includes.*
    - *[hrv_calc_id, heart_rate, age, weight, sex, time_stamp, alert_threshold, hrv_recording, is_stressed (Class label)]*
- *Provide intrusive feedback in case of dangerous HRV levels.*
- *Improve the HRV threat algorithm by adding*
    - *dynamic epochs, z-transforming data, and more attributes to the training data.*
- *train the HRV machine learning model on the iPhone.*
- *Optionally store an emergency contact for the patient.*
- *Run as a background service, always monitoring HRV. This is done by keeping the watch in "workout" mode*

2.3 User Classes and Characteristics

1. Patient
    a. This user shall have the ability to record HRV
    b. This user shall have the ability to set their demographics
    c. This user shall have the ability to export their HRV data via the companion application
    d. This user shall receive alerts if they are trending toward a stressful event
2. Health Care Provider
    a. This user shall have the ability to review HRV data that was exported by the patient

2.4 Operating Environment

- Apple Watch Series 4 and later
- iPhone 8 and later
- The most recent versions of watchOS and IOS
- A Mac computer for development with the most recent version of MacOS

2.5 Design and Implementation Constraints

- HIPAA Requirements for data storage (confidentiality, integrity, and availability of e-PHI)
- Programming language: Swift
- Access to a Mac computer
- Apple Developer License

2.6 User Documentation

- https://hrvapplewatch.atlassian.net/wiki/home - *Link to wiki*

2.7 Assumptions and Dependencies

1. HRV is being calculated correctly.
2. The Threat Detection algorithm is required for stressful event prediction
3. The application is effective as an intervention
4. Patient data is never stored in a server and only stored on their phones or watches

3. External Interface Requirements

3.1 User Interfaces

There will be two different interfaces that the user can interact with. One interface is the Apple Watch while the other is the companion app that will be hosted on the corresponding iPhone. The Apple Watch application will mainly be confined by the size of the screen which is enough to display real-time HRV and other basic information. There will be little user activity on the Apple Watch application, only when an alert is pushed and the user needs to respond to the application. In this case, a pop-up will appear with a button that the user can either confirm or decline the accuracy of the alert. The corresponding application in the iPhone will have a couple of features that include a page to view your past alerts along with a page that will allow you to export your data to an external system. Each device UI will be able to be independent of the other meaning that the watch can interact with the user without the phone and vice versa.

3.2 Hardware Interfaces

The main connection between the UI and the software will be the screen of both the Apple Watch and the iPhone. The watch screen allows the user to give the program needed feedback for it to be more accurate. The supported device types will be fairly limited to Apple Watches and iPhones. The data nature will be numeric variables and metadata of alerts which the watch will communicate to the phone by Bluetooth connectivity.

3.3 Software Interfaces

The majority of this program will be built from scratch where it will have to interact with the system, Bluetooth, and heart rate sensor. The system libraries will be used to access the system of the watch to make sure that the watch is on the proper version to ensure compatibility along with notifications for the user. Bluetooth will be used to send and receive the data from the complaint application needed for alerts. The heart rate sensor will be used to get the current heart rate from the user. The data that will be shared across the Apple Watch and the iPhone will be the heart rate and the metadata of alerts. These will both be shared through Bluetooth to the companion application.

3.4 Communications Interfaces

For the communications of this application to work both the Apple Watch and the corresponding iPhone will need to have Bluetooth capability. The information between the two will not have a specific format as it will be in data rather than a message that the user reads. Communication security and encryption are not a concern at this point so will be ignored. The data transfer rate will be the standard Bluetooth rate of 24 Mbps in BLE mode. There will be a specific cycle that the application will follow that will prevent the corruption of the data.

4. System Features

4.1 Accurately Measure HRV Using Heart Rate Sensor on Apple Watch

4.1.1 Description and Priority

The goal is to accurately measure and calculate HRV using the Apple Watch's heart rate sensor. To do this the best way possible we must mirror the SWELL dataset that we acquired from an open source to include several HRV measures to get the most accurate calculation. An accurate calculation is the most important thing. Without accuracy, the purpose of the app is missed. This is a High priority feature. Without this feature, a patient cannot accurately calculate their HRV and be misled. This is beneficial for the patient so they can determine if they are entering a stressful state(10). There is only a risk if the HRV is not calculated correctly(5).

4.1.2 Stimulus/Response Sequences

As a patient I want an accurate HRV reading so I can be prepared and aware of when I get stressed.

As a doctor, I want an accurate HRV reading so I can adjust treatment as needed to provide better help for my patient.

4.1.3 Functional Requirements

R1: Calculation needs to be accurate
R2: User-friendly interface
R3: Ability to store patient data
R4: Application records metadata about stressful events
R5: Export data to the connected device for review by physician

4.2 Predict if Stressful Event is Going to Occur Based on HRV Trend

4.2.1 Description and Priority

The goal is to predict a stressful event based on the patient's HRV trend. This gives the patient the ability to try stress reduction strategies and avoid an increase or decrease in their HRV. This is a High priority feature. With this feature, a patient can potentially avoid an increase or decrease in their HRV because they are being provided live data that they can view. This is beneficial for the patient for their overall health(8).

4.2.2 Stimulus/Response Sequences

As a patient I want consistent data that is viewable so I can predict through my HRV trend if I am entering a high-stress situation and be able to reduce that stress before it gets out of hand.

As a doctor, I want to be able to review these HRV trends and provide feedback so treatment can be adjusted as needed to provide better help for my patient.

4.2.3 Functional Requirements

R1: User-friendly interface
R2: Get live heart rate data from patients
R3: Patient demographic configuration
R4: Ability to store patient data
R5: Application records metadata about stressful events
R6: Application uses an algorithm to detect dangerous HRV
R7: Application provides intrusive feedback
R8: Application will always run in the background

4.3 Alert User if there HRV is Increasing or Decreasing to Dangerous Levels

4.4.1 Description and Priority

The goal is to alert the patient if their HRV threshold has been crossed. We want to notify them and have a physical vibration from the watch so the patient can feel the alert in case they don't see the notification. This is a High priority feature. With this feature, a patient can be aware when they have entered a high stress area and take measures to reduce it as soon as possible. This is beneficial for the patient for faster feedback on their data(8).

4.4.2 Stimulus/Response Sequences

As a patient I want alerts if my HRV levels are increasing or decreasing to dangerous levels, so I can attempt to reduce my HRV levels to a normal state.

4.4.3 Functional Requirements

R1: User-friendly interface
R2: Get live heart rate data from patients
R3: Patient demographic configuration
R4: Ability to store patient data
R5: Application records metadata about stressful events
R6: Application uses an algorithm to detect dangerous HRV
R7: Application provides intrusive feedback
R8: Application will always run in the background

4.4 Threshold Adjustment for HRV Trigger Rate

4.5.1 Description and Priority

The goal is to export the data gathered from the watch into an excel file. This way it can be shared/sent to a professional or a family member and be easily read. This is a High priority feature. Without this feature, a patient could not easily let a professional know how they are doing. This is beneficial for the patient for faster feedback on their data(8). There is a slight risk of the transfer of personal information/data(4).

4.5.2 Stimulus/Response Sequences

As a patient I want to have threshold adjustments to set parameters based on my body characteristics so I can get accurate HRV feedback.

4.5.3 Functional Requirements

R1: User-friendly interface
R2: Patient demographic configuration
R3: Get live heart rate data from patients
R4: Ability to store patient data
R5: Application records metadata about stressful events
R6: Application uses an algorithm to detect dangerous HRV
R7: Application provides intrusive feedback
R8: Application will always run in the background

4.5 Export Data from Watch to Phone

4.6.1 Description and Priority

The goal is to export the data gathered from the watch as a .csv file. This way it can be shared/sent to a professional or a family member, dropped into excel, and be easily read. This is a High priority feature. Without this feature, a patient could not easily let a professional know how they are doing. This also allows for the validation of different measures that are used for HRV calculation. This is beneficial for the patient for faster feedback on their data(8). There is a slight risk of the transfer of personal information/data(4).

4.6.2 Stimulus/Response Sequences

As a patient I want to track my heart rate variability so that I can be aware of when I get stressed.

As a doctor, I want to be able to review previous alerts so that I can adjust treatment as needed to provide better help for my patient.

4.6.3 Functional Requirements

R1: User-friendly interface
R2: Ability to store patient data
R3: Optional patient emergency contact
R4: Application records metadata about stressful events
R5: Export data to the connected device for review by physician

4.6 Tracking HRV(Heart Rate Variability)

4.7.1 Description and Priority

The goal is to accurately calculate the HRV and be able to track and view the data gathered from the watch. This way the patient can see the history of their HRV and determine from their day-to-day life where their stress is potentially coming from. This is a High priority feature. With this feature, a patient could easily see from routine events in their life, what is causing the most stress and an increase or decrease in their HRV. This is beneficial for the patient. It gives them a chance to decrease stressful events or work through them when they know they are coming(8).

4.7.2 Stimulus/Response Sequences

As a patient, I want to track my heart rate variability so that I can be aware of when I get stressed.

As a patient, I want to be alerted when my heart rate variability decreases in a way that indicates stress.

As a patient, I want to be able to review my previous alerts so that I can track my progress.

As a doctor, I want to be able to review previous alerts so that I can adjust treatment as needed to provide better help for my patient.

As a family member, I want to be alerted of a parent/grandparent's heart rate variability decreasing or increasing in a way that indicates stress.

4.7.3 Functional Requirements

R1: User-friendly interface
R2: Get live heart rate data from patients
R3: Ability to store patient data
R4: Application provides intrusive feedback
R5: Patient demographic configuration
R6: Application uses an algorithm to detect dangerous HRV
R7: Application records metadata about stressful events
R8: Application will always run in the background

4.7 **UI Work on Companion App**

4.9.1 Description and Priority

The goal is to redesign and improve the companion app so when data is exported the patient or doctor can easily read the data. This is a high priority. With this feature, a patient can send their HRV data to a professional where it can be reviewed as well as view their own data to see where their negative HRV trends are throughout their day. This is beneficial for the patient for faster feedback on their data(8). There is a risk in terms of transferring data/personal information(7).

4.9.2 Stimulus/Response Sequences

As a patient I want to easily view the data gathered from my watch and be able to send it to a professional.

4.9.3 Functional Requirements

R1: User-friendly interface
R2: Ability to store patient data
R3: Export data to the connected device for review by physician

5. Other Nonfunctional Requirements

5.1 Performance Requirements

The app needs to be able to constantly pull data from the Apple Healthkit extension, so the Apple Watch needs to have the most current updates. Since HRV will be calculated every couple of seconds we need to keep battery life in mind. Our app will constantly be running in the background to track this so keeping battery life in mind is important so that a user is able to tack their HRV all day.

5.2 Safety Requirements

While there do not seem to be too many safety requirements one of them could be that the interface is easy to navigate for the user. Keeping in mind that they may have a lower patience so making it easy to navigate so they end up frustrated with the app. As well as making sure that our app doesn't have any type of dramatic haptic feedback or vibrating on the wrist.

5.3 Security Requirements

The iPhone connected to the Apple Watch should be within a couple of feet of the user just in case a family member/friend of theirs doesn't put on the watch and it tracks their HRV. As well when the watch is put on, HRV shouldn't be starting to be tracked until a user has put their watch password in.

5.4 Software Quality Attributes

The app will be created in the most recent version of Swift so that the app doesn't need to be updated drastically when a new software update is released. Keeping in mind that not all users will have the most recent Apple Watch we need to be sure the app works just as well on previous generations, not overloading the features. There needs to be a way that a user is able to transfer their information and verify it, in case of an upgrade to an iPhone and/or Apple Watch. The machine learning algorithm we use will need to be tested with various amounts of data we understand to make sure it is the best possible algorithm.

5.5 **Business Rules**

Only the developers should be able to make internal changes to the app's tracking of data. Users should be able to specify to whom they want the data to be sent, however, their doctor will always be able to have access. Developers should have access to the data with the user's permission to improve the HRV Threat Detection Algorithm. Users can decide to decline the share of data with the developers and keep it confidential to their doctor and family only.

R1: User-friendly interface for Export feature q
R2: Get live heart rate data from patients
R3: Patient demographic configuration
R4: Ability to store patient data on the iPhone
R5: Application records metadata about stressful events
R6: Application uses an algorithm to detect dangerous HRV
R7: Application provides intrusive feedback
R8: Application will always run in the background
R9: Mirror the SWELL Dataset for HRV Calculations