# Brief Technical Documentation of Master Thesis Project

# "Facilitating Technology-based Mental Health Interventions with Mobile Virtual Reality and Wearable Smartwatches"

*Use-Case Analyzing Heart Rate Variability during Slow-Breathing Relaxation Exercises*

**Author:**  **Luis Quintero**

http://luiseduve.github.io

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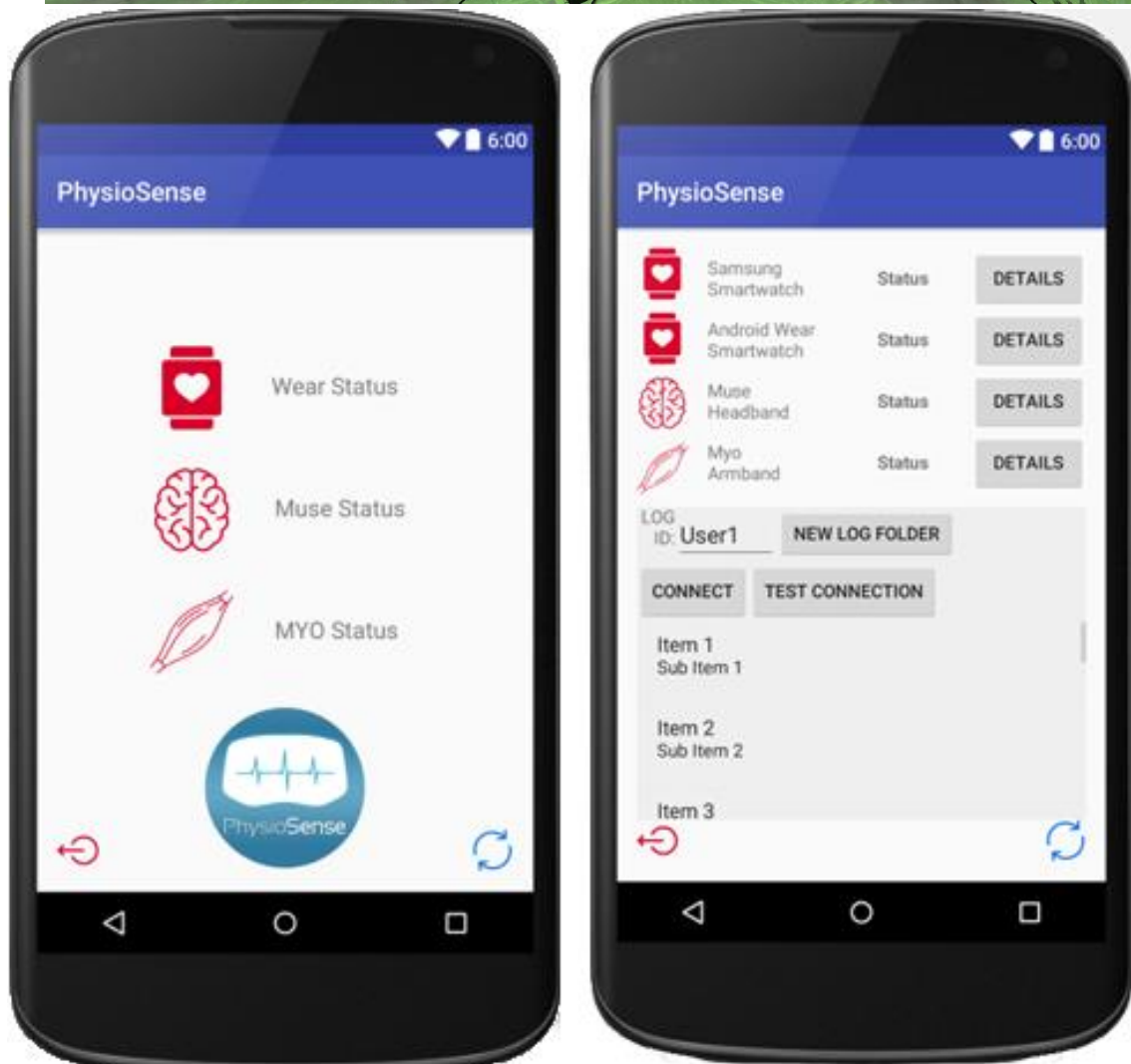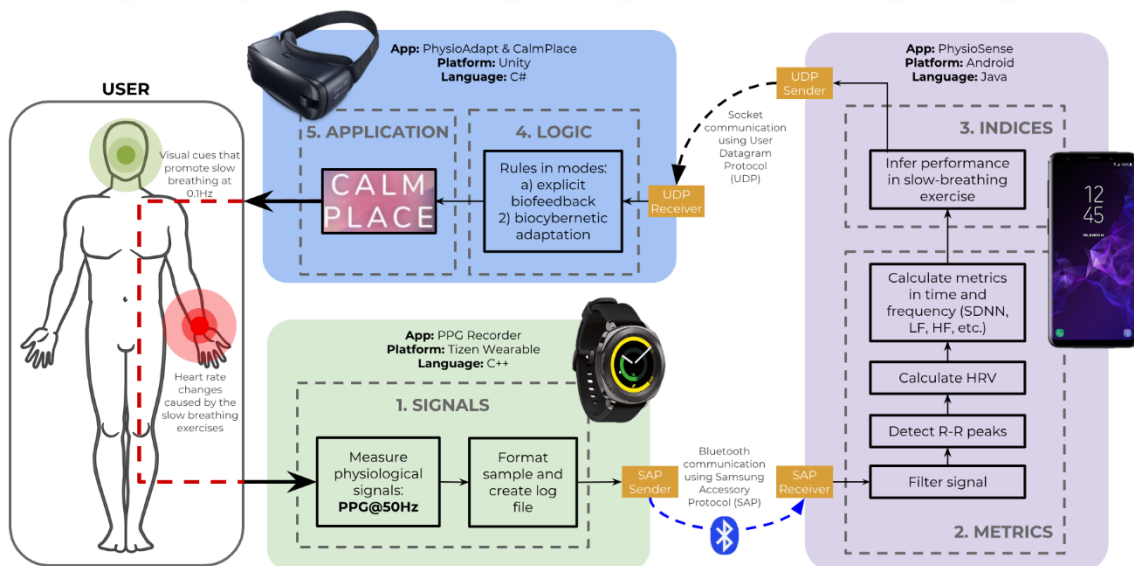
## 1.4. References

# 2. System Description

## 2.1. Hardware Resources

The project was developed using three devices.

- Smartphone: Samsung Galaxy S9
- VR headset: Samsung Gear VR
- Smartwatch: Samsung Gear Sport

## 2.2. Overall Architecture

## 2.3. App 1: PPG Recorder

## 2.4. App2: PhysioSense

**2.5. App3: CalmPlace**

## 3. Environment Setup

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## 6. Hardware Specifications

## 7. Smartphone Setup

### 7.1. Enable developer mode in the Android smartphone
Tap Build 8 times to enable developer mode.

Activate USB Debug.

### 7.2. Pair the smartwatch with the smartphone
Bluetooth connection with the smartwatch Samsung Gear Sport.

### 7.3. Install Samsung S9 driver
https://www.samsung.com/us/support/owners/product/galaxy-s9-unlocked

https://developer.samsung.com/galaxy/others/android-usb-driver-for-windows

## 8. Mobile-VR headset Setup

### 8.1. Pair the Samsung Gear VR with the smartphone
The Samsung Gear application can only be installed by connecting the smartphone to the VR headset. Plug in the cellphone in the USB-C port and an installation assistant will start immediately.

Follow the process and a new application called Oculus with the icon Oculus Gear VR will set up the Samsung Gear VR headset and controller once it is connected.

## 9. Smartwatch Setup

### 9.1. Software Installation
The smartwatch uses the operating system called Tizen (not Android Wear OS), hence, it is necessary to install its own SDK to build custom applications.

The link to download and set up the Tizen Studio application is:

The specifications of the SDK used are:
- Profile and Version: Wearable v5.0

To build a Companion application, it means, an application for the wearable that can connect to the Android phone, it is necessary to install special packages, as detailed in https://developer.samsung.com/galaxy-watch/develop/creating-your-first-app/native-companion/setup-sdk:

- In the main SDK tab, install the packet "5.0 Wearable", and
- From the tab Extension SDK install the "Samsung Certificate Extension" and "Samsung Wearable Extension".

### 9.2. Connection of Tizen Studio with Wearable

Go to Settings > About Gear > Software Information >Software Version and tap five times over the option until the message "Developer mode turned on" is shown.

Enable Debugging in the smartwatch: Settings > About Gear > Debugging

Create an emulator device and connect the smartwatch via IDE or Wi-Fi following the guide: https://developer.samsung.com/galaxy-watch/develop/testing-your-app-on-gear

To be able to deploy the application it is necessary to create a Certificate Profile, a Samsung account is required, is important to have the emulator and the physical smartwatch connected to Tizen Studio (Check in Tools>Device Manager) so that DUIDs are filled in automatically for the certificate.

**Create Certificate Profile**

Device Type ✓ | Certificate Profile ✓ | Author Certificate ✓ | **4 Distributor Certificate**

Step 4-1. To install applications to a Samsung device, the device DUID (Device Unique Identifier) must be included in the distributor certificate.

| | |
|---|---|
| Privilege* | Public ▼ |
| Password* | ●●●●●●●●●●●● |
| Password Confirm* | ●●●●●●●●●●●● |

◉ Add individual DUIDs*

1.0#ROYexsr3ytkS8Dr348OGkUKnyMk=

| (empty) |
| Enter DUID manually or connect to a device |
| Enter DUID manually or connect to a device |
| Enter DUID manually or connect to a device |
| Enter DUID manually or connect to a device |

○ Import a DUID list file*    [ Browse ]

[ < Previous ] [ Next > ] [ Finish ] [ Cancel ]

### 9.2.1. Create a New Project

Web Application project is the type that compiles on the smartwatch without errors. Start a New Project > Wearable 5.0 > Web Application > Template TAU Basic (Tizen Advanced User Interfaces)

The config.xml file should be set in the tab "Tizen" as follows: Required Version: 2.3.2, otherwise the IDE shows an error when installing the application on the device.

### 9.2.2. Native Development instead of Web Development

Web development as a bug in the SDK when trying to put the callback of the HRM_RAW sensor, check in the websites:

- https://developer.samsung.com/forum/board/thread/view.do?boardName=SDK&messageId=356484&startId=zzzzz~
- https://developer.tizen.org/ko/forums/native-application-development/samsung-gear-s3-can-sample-rate-sensor_hrm_led_green-be-increased-above-20-hz?langswitch=ko
- https://developer.samsung.com/forum/board/thread/view.do?boardName=SDK&messageId=356484&startId=zzzzz~

### 9.3. Smartwatch Acquisition Specifications

By default, the acquisition of raw heart rate signal is done each 100ms (10Hz), the custom application was designed to acquire data each 20ms (50Hz).

The timestamp received from the PPG acquisition uses a monotonic time, which means that the reference point of the returned value is undefined, so that only the difference between the results of consecutive calls is valid. This is used to counteract the effect of a user changing the time of the smartwatch.

The HR signal sends only the value of calculated HR over a timeframe. The first 25-30 seconds the sensor will provide a ZERO VALUE. This is caused because the device is collecting the data necessary to estimate the HR from the first time, from this point forward, the value shown is calculated from a movable window. The custom application was designed to send data each 500ms (2Hz).

## 10. Communication Protocol

The smartwatch communicates using RFCOMM Bluetooth, Profile SPP: https://www.amd.e-technik.uni-rostock.de/ma/gol/lectures/wirlec/bluetooth_info/k5_spp.html

NOTE:

According to the specifications, the Samsung Gear Sport only has the following Bluetooth profiles: A2DP, AVRCP, HID. Maybe means that SPP won't work.

According to forums, the wearable's Bluetooth is meant to be used only with the host Android smartphone until Tizen 2.3.1. SAP had to be used. Nowadays SPP should work.

### 10.1. Using Samsung Accessory Protocol (SAP)

Guide: https://developer.samsung.com/galaxy-watch/develop/creating-your-first-app/native-companion/use-sap

SAP Base source code: https://developer.samsung.com/galaxy-watch/develop/samples/companion/hello-message-native

The APP_PROFILE_ID needs to be the same in "sap.c" than the service profile in the file "res/xml/accessoryservices.xml".

## 11. Design of Android Plugin to be used in Unity applications

Tutorial: http://eppz.eu/blog/unity-android-plugin-tutorial-1/

Objective: The background service receives the message from the smartwatch and these values are sent to Unity, instead of shown in the MainActivity of the native Android application.

- Create an Android Library.
- Import the Unity's library to the Android Studio Project from: "<Unity-install-directory>\Editor\Data\PlaybackEngines\AndroidPlayer\Variations\mono\Release\Classes"

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## 12. PhysioVR integration

PhysioVR only sends data through UDP in a Timer controlled by the Mobile phone activity.

CHANGE DONE: Send UDP data in mobile each time a new packet from Tizen SAP is detected, regardless the frequency of reception of datagrams.

## 13. Unity Setup

Setup Unity to build applications for Oculus Go and Samsung Gear VR:

https://developer.oculus.com/documentation/unity/latest/concepts/unity-build-android/

All Gear VR applications must be signed with an Oculus Signature File (osig) during development to access low-level VR functionality on your mobile device. This signature comes in the form of an Oculus-issued file that you include in your application.

https://developer.oculus.com/documentation/unity/latest/concepts/unity-mobileprep/

To generate the osig file, go to: https://dashboard.oculus.com/tools/osig-generator/

Best Practices:

https://developer.oculus.com/documentation/unity/latest/concepts/unity-best-practices-intro/

Place the SIG file in the path: Plugins/Android/Assets/ without renaming the file

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*SAMSUNG CERTIFICATE INFORMATION FOR TIZEN:*
*LuisQuintero*
*Pass: mimerse-vr*

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