February 12, 2016

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

RE: ENSC 440 Functional Specifications – Intelligent wearable wristband for personal safety

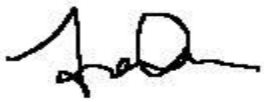
Dear Dr. Rawicz,

The attached document is our functional specifications for an intelligent wearable wristband for personal safety. Our goal, as a team, is to design a lightweight wearable sensor and integrate its services with the user's smart phone. By measuring the user's vitals and external elements, the wristband is capable of detecting emergency events. When said events are detected, the user's smart phone will automatically relay a real time notification to the user's emergency contacts.

The purpose of functional specification is to provide an in-depth analysis of our scope, intended audience, system overview, and our product requirements including proof of concept, prototype, and final production. In addition, we will cover which engineering standards must be satisfied and lastly, we will also cover our product's sustainability and safety.

Smart Trak Solutions is founded by five dedicated senior engineering students: Tom Ou Yang, Ashton Novak-Louie, Farah Ishita, Peter Le, and Gifty Quansah. If you have any questions or concerns regarding our proposal, please do not hesitate to contact me at touyang@sfu.ca.

Sincerely,



Tom Ou Yang
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Smart Trak Solutions

Enclosure: Functional specification for an intelligent wearable wristband for personal safety

Smart Band

by

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Date: February 14, 2016

Executive summary

In a dire situation such as having a sudden stroke or heart attack, falling down and being unable to get up, sudden loss of consciousness, or even in perilous fight or flight situations, people often rely on others for help. However, what happens if there are no immediate people around your surroundings? Who will be able to take care of us when such an event occurs? At Smart Trak Solutions, we are proposing to alleviate this problem by designing our customized wearable, Smart Band by Smart Trak, an intelligent personal safety device.
The development of Smart Band will occur in two phases, the prototype phase and the production phase.

Stage 1: Prototype phase

To develop Smart Band by Smart Trak, we will be conducting a rapid prototype using open source hardware currently available on today's market. Specifically, we will be using Angel Sensor, an open source wearable device [1]. Using the onboard sensors such as the accelerometer, gyroscope, temperature sensor and heart rate monitor, we can create an algorithm that can accurately determine when a user is in distress, falls down or becomes unconscious. Once such an event is detected, the user will be given a brief period to disable any false alarm, otherwise the device will send an SOS to the user's emergency contacts. By the end of our 4 month development cycle, which will be completed by early April, we plan to have a working prototype with the following features

- Fall detection
- GPS tracking
- Mobile companion app for Android devices
- Detection algorithm for other events

Stage 2: Production phase

After developing the necessary software and finalizing the prototype in stage 1, we plan to design our own band, which we intend to remove any unnecessary hardware from the prototyping stage. Not only will designing our own custom band increase battery life, but also reduce overall costs. Once the hardware is finalized, we will design the wristband module which will house all the necessary electronic components. The final product should also conform to all necessary engineering standards, specifically IEC 60950-01, the general safety requirement for electronic devices.

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Glossary

Smartband Computerized wristwatch, wearable computer

SOS Distress signal acronym for “save our souls”

SMS Acronym for Short message service, more commonly known as text messaging

Java Computer programming language developed by Oracle Corporation

Android Mobile device operating system developed by Google Inc.

BLE Bluetooth Low Energy

IEEE Institute of Electrical and Electronics Engineers

CSA Canadian Standards Association

ISO International Standardization Organization

IEC International Electrotechnical Commission

1 Introduction

Smart Band by Smart Trak is an intelligent wearable wristband integrated to the user's smart phone and is intended to be used as a personal safety device. Using the onboard sensors built within the wristband, we can develop an algorithm that can detect certain events. For example, using the accelerometer we can detect when a person falls down and can't get up, in this instance Smart Band is able to notify user's emergency contacts via SMS. The requirements for Smart Band by Smart Trak, as proposed by Smart Trak Solutions, are described in this functional specifications document.

1.1 Scope

This document describes the functional requirements that must be met by the Smart Band. This set of requirements fully describes the proof of concept of this device, as well as the prototype. The engineers at Smart Trak Solutions will conform to the requirements listed within this document and will continue so into Smart Band's future development.

1.2 Intended Audience

The functional specification is intended for use by all members of Smart Trak Solutions. The project manager shall refer to this document as a measure of progress throughout the development phase. The design and test engineers shall reference this document for its listed requirements as well as the overall design goals classified by the functional specifications.

1.3 *Classification*

The following syntax will be used in this document to state functional requirements:

> **[Rn-p]** A functional requirement.

Where **n** is the functional requirement number, and **p** is the priority of the functional requirement as denoted by one of three values:

> **I:** The requirement applies to the proof of concept system only.
> **II:** The requirement applies to both, the proof of conceptual system and the final production system.
> **III:** The requirement applies to the final production system only.

2. System Requirements

In this section we outline general requirements relevant to the entire system as a complete functioning unit.

2.1 System Overview

In Figure 1, we show a brief overview of the process flow of the device from inputs to outputs.

Figure 1: Overview of smart wristband and application.

Although the wristband's electronic hardware components could be implemented with any arbitrary brand of sensors, we choose to use the preassembled Angel Sensor device and its associated development tools in order to realize our initial proof of concept prototype.
The inputs begin with the information collected by the Angel Sensor module. In particular, we are interested in the heart rate, temperature, acceleration, and orientation sensors. The Angel Sensor then transmits this data via Bluetooth low energy (BLE) to the user's mobile device and an associated mobile application.

As a constraint for the purposes of our prototype, the mobile application will only be developed on the Android platform, but will be compatible with all versions of Android devices currently available. Additionally, the Android device must be capable of sending SMS messages, and naturally the emergency contact must be able to receive SMS messages. The final production will support alternative methods of sending emergency alerts, such as an automated call or via any other designated messaging application, which will help circumvent the SMS constraint.

The mobile application itself will act as a portal for the user and serves as the primary way to interact with the device. The application must have a clean, intuitive, and complete interface that provides the user with a welcoming user experience ensuring that all functions of the device can be utilized quickly, simply, and effectively. In the prototype version, we will be merely implementing raw functionality to process the data from the sensors and decide the appropriate outputs. For the final production version, we will implement additional features to improve the user's overall experience, including user profile settings, extensive contact support (address book, Facebook, etc.), and profiles for Bluetooth device pairing.

Data processed by the mobile application will be evaluated constantly to determine whether the user is in a normal state or an emergency state. Examples of an emergency state would include a greatly elevated heart rate, abnormally high temperature, or a sudden drop. In the case of an emergency state, the application will then send an alert to the designated emergency contact via SMS. During the time the emergency state is active, the user will have an option to manually dismiss the alert in the case of a false positive. The emergency state will persist for a set amount of time, after which the device will return to the normal state.

2.2 General Requirements

[R1-III] The device shall be easy to use
[R2-III] The retail price of the system shall be under $200
[R3-III] The wearer is the intended operator of the system
[R4-III] The mobile application shall be available for free in Google play store

2.3 Physical Requirements

[R5-III] Device must be aesthetically pleasing to eliminate stigma

2.4 Electrical Requirements

[R5 –II] The USB cable is required to be used with a wall supply of 110V/120V at 60 HZ AC (North American Standard)
[R6 –II] The battery life of the wristband is expected not to be less than 10 hours
[R7 –II] The smart band should have an automatic power saving mode
[R8 –II] The total charging time for the battery should not be more than 2 hours
[R9 –III] The internal electric circuit of the band should be able to respond in less than 4 seconds

2.5Environmental Requirements

[R10–III] Final product must be made of reusable or easily recyclable materials
[R11–II] Functioning state should be configured to consume a little energy as possible from both the final wearable device and the paired smartphone
[R12–III] Battery must not contain toxic metals lead or cadmium
[R13–III] Production process of final device should leave a minimal environmental footprint

2.6 Standards

[R13–III] The system shall conform to the IEEE 1451 standard
[R14–III] The system shall conform to the CSA requirement C22.2 NO. 205-12
[R15–III] The system shall conform to IEEE 805.15.1 standard
[R16–III] The system shall conform to the ISO/IEC 12207 standard

2.7 Software Requirements

[R16–II] The application will be simple to learn and use with or without a user manual.
[R17–III] The Android application will be easily accessible via the Google Play Store. Other versions of the application developed for alternate platforms will be available through their respective app stores.
[R18–II] The application will be unobtrusive even while not directly in use.
[R19–III] The application will be lightweight (will not exceed 25 MB internal storage).
[R20–II] The application will not exceed 10 MB RAM usage.
[R21–III] The application will not exceed 5 MB data usage per day.

2.8 Communication Requirements

[R22–II] All collected information will be cleanly presented to the user.
[R23–II] The user will be able to choose which data is more important or relevant.
[R24–II] The user will be notified when an emergency alert has been activated.

2.9 Usability Requirements

[R25–II] The wristband strap shall be made adjustable to comfortably fit both men and female
[R26–II] The wristband shall be unobtrusive and be comfortable enough to wear throughout the day
[R27–II] The wristband shall perform monitoring service assuming the user has calibrated the device properly
[R28–II] The mobile companion application should be intuitive and user friendly
[R29–II] The device firmware should upgradeable via USB or Bluetooth connection

2.10 Performance Requirements

[R30–I] The algorithm should be able to detect events with at least 50% accuracy
[R31–III] The algorithm should be able to detect events with at least 80% accuracy
[R32–II] The device shall be able to detect events in real time, less than 100ms response time
[R33–II] The battery life of the wristband should be able to last at least two days with moderate usage on a single charge
[R34–III] The battery life of the wristband should be able to last at least three days on standby with a single charge

2.11 Safety Requirements

[R35–I] The system will not cause any harm to it user
[R36–I] Data processed by the mobile application will be evaluated in real time to determine whether the user is in a normal state or an emergency state. Notification shall be sent in the case of emergency state
[R37–II] All electronic components shall be enclosed to prevent direct contact with user
[R38–II] The electronic component shall not cause interference with other devices

3 Band

The smart wrist band is expected to have the following requirements for the band:

3.1 General Requirements

[R39–II] The wrist band should be water proof, durable, flexible and easy to wear
[R40–II] The price of the entire smart wrist band should be under $100
[R41–II] The user should be able to wear and set up the entire smart band in less than 5 minutes
[R42–II] There should be a reset and on/off switch placed on the band

3.2 Physical Requirements

[R43–I] The entire weight of the band should not be heavier than 32 grams
[R44–I] The overall dimension of the complete smart band is not expected to be bigger than 80 x 40x20 mm
[R45–II] The electronic parts of the wrist band should be sealed efficiently for protecting the parts from water/ liquid elements
[R46–II] The band should look similar to any other types of smart bands available in the market and should look good with any clothing style

3.3 Electrical Requirements

[R47–II] The battery attached to the band is required to be efficient enough for supporting all the frivolous movements of the electronic parts attached to the band
[R48–II] The USB adapter that will be attached to the band for charging should have a length of around 30 cm in order for the adapter to be easily portable

3.4 Environmental Requirements

[R49–II] The straps of the band should be able to tolerate temperature between -60 to 40 degree Celsius
[R50–II] The straps of the band should be able to tolerate humidity from 0 % to 90 %

[R51–II] The electronic parts attached to the band should not make any sound louder than 10 dB while wearing it or resetting the options

4 Sensors

The heart rate, temperature, acceleration and orientation in the system will collect data from user to be processed and evaluated.

4.1 Body Temperature Sensor

Temperature Sensor is used to measure user's body temperature by attaching to user's wrist. The system monitors body temperature data sent from body temperature sensor. This data is processed and analyzed in real time. Once the body temperature is above or below certain normal region (deemed fatal) the system will send notifications to pre-determined emergency contact user, in order to receive the necessary assistance

4.1.1 Electronic Requirements

[R52–II] Temperature data measured by the body temperature sensor shall be within ±0.5C accuracy
[R53–II] The range of the body temperature sensor is -50 ºC to 150 ºC
[R54–I] The operating voltage of the body temperature sensor should be 5.0V

4.1.2 Physical Requirement

[R55–III] The device shall be worn in the right position around the wrist to detect accurate temperature measurement
[R56–III] The sensor shall be water proof

4.2 Heart Rate Sensor

Hear Rate Sensor is used to measure user's heart rate by attaching to user's wrist. The system monitors data sent from the sensor. This data is processed and analyzed in real time. Once the heart rate is above or below certain normal region (deemed fatal) without any physical activity the system will send notifications to pre-determined emergency contact user, in order to receive the necessary assistance

4.2.1. Electronic Requirements

[R57–I] The operating voltage of the pulse and oxygen in blood sensor shall be in range of 3.0 V to 5 V DC.
[R58–II] Power consumption of the pulse and oxygen in blood sensor shall be at 8 mA at 5V
[R59–II] Data measured by the heart rate sensor is within ±0.15 accuracy range

4.2.2 Physical Requirements

[R60–III] The heart rate sensor should be waterproof

4.3 Acceleration Sensor

4.3.1. Electronic Requirements

[R61–I] Measures acceleration in range ±1.5g
[R64–I] The system measures body motion within 40-60 Hz Bandwidth

4.3.2. Physical Requirements

[R63–I] The sensor should be waterproof
[R64–I] The materials used for the senor should not cause any harm to user

4.4 Orientation sensor

The Orientation Sensor detects several specific human body positions: standing/sitting, rotational left and right. This function can help to have a quick response when the user need emergency help.

4.4.1. Electronic Requirements

[R64–I] The working voltage of the patient position sensor shall be 5 V DC.
[R65–II] The sensor should detect rotational motion
[R66–I] The sensor should be able to detect the amount of angular velocity produced

4.4.2. Physical Requirements

[R67–III] This type of sensor should be water resistance.
[R68–III] The band attached to the sensor should be adjustable in size.
[R69–III] The material used for the sensor should not Cause any reaction to user.
[R70–III] The material used for the sensor should be smell free.

5 Mobile Application

In order to process the data from the hardware device and present meaningful results to the user, we implement a mobile smartphone application. The application provides a clean and simple interface to show the user vital information and will also facilitate alerting the user's designated emergency contact. For the purposes of our initial prototype, the application will only be developed for the Android platform.

5.1 General Requirements

[R71–II] The application will require a smartphone to use.
[R72–II] The application will have an interface for displaying information and otherwise interacting with the application.
[R73–II] The application will notify the emergency contact under the designated circumstances.
[R74–II] The application will indicate the connectivity status with the wristband device.
[R75–II] The application will be usable with Android mobile devices.
[R76–III] The application will be usable with Apple and Windows mobile devices.

5.2 Usability Requirements

[R76–II] The interface menu will be intuitive and simplistic.
[R77–II] The user will be able to cancel the emergency contact alert in the event of a false positive.
[R77–III] Users will be able to create individual profiles for tracking data and alert history.

5.3 Software Requirements

[R78–II] The Android application will require Android version 10 or higher.
[R79–II] The smartphone will require Bluetooth low energy support and permissions.
[R80–II] The smartphone will require SMS capability permissions.
[R81–II] The application will require a target phone number capable of receiving SMS messages.
[R82–I] The smartphone must be able to utilize Angel Sensor's provided source development kit (SDK).
[R83–III] The smartphone will require WiFi or 3G/LTE capabilities for integration with messaging applications.
[R84–II] The smartphone will require GPS location service permissions.
[R85–I] The application will be implemented through Android Studio and its associated compliances.

6 Communication

Usability is a key factor in creating a device that will cater to a wide range of consumers. To enhance the usability of the product, the device should be able to effectively communicate with

both the user and the smartphone it is connected to. Proper indicators should be put in place so that the device can communicate to the user what it is doing, what mode it is in and what it is capable of. The electrical and general requirements of device's Bluetooth connection are defined by Bluetooth Smart Technology specifications [1].

6.1 General Requirements

[R86–II] Device should have activity indicator lights to signal that it is charging and pairing or paired with a smartphone
[R87–II] A label or indicator light must be put in place to show that the device on
[R88–II] Bluetooth wireless data transfer rate must be approximately 1 Mbit/s
[R89–II] Bluetooth communication range must be over 100 m
[R90–II] Bluetooth Latency must be approximately 6ms or lower when not connected

6.2 Physical Requirements

[R91–II] Indicator lights must be strategically placed so they can be easily seen when worn
[R92–III] Bluetooth module must be no larger in area than 15mm x 15mm as to keep electronics section small

6.3 Electrical Requirements

[R93–III] Power consumption must be approximately within 0.01 to 0.5W
[R94–III] Peak current consumption must be lower than 15mA

7.0 User documentation

[R95–III] The user manual shall include step by step pictorial diagrams for quick installation
[R96–III] User documentation and manual will be available on the company webpage
[R97–III] The user manual shall include general and technical support information and a contact page for any further issues
[R98–III] The user manual shall be written for an audience with minimal knowledge and include large pictorial diagrams for ease of use

8 Sustainability & Safety

The current prototype for the Smart Trak Solutions Smart Band utilizes the Angel Sensor M1, which is a prebuilt smart wearable device with support for open-source development. Since our hardware is already assembled, we had no control over what materials were used. However, the Cradle-to-Cradle cycle can still be considered with our chosen hardware.
All components of the Angel Sensor M1 wearable could be recycled or repurposed to follow the Cradle-to-Cradle design philosophy. The housing for the device uses plastic and silicone both of which could be sent to a recycling facility for processing into reusable raw materials [2]. The hard plastic could be melted down and extruded into reusable pellets while silicone could be pulverized and merged with a binding agent for remolding [3] [4]. As for the internals of the device, the printed circuit board as well as the wiring and connections could all be recycled as well. Copper was used for wiring as well as the printed circuit board and lead was used for solder, both metals could be removed and melted for reuse.

The non-conductive substrate of the printed circuit board could be reused as glass fibre after the flame retardant coating has been chemically separated into valuable elements [5]. Circuit board elements such as microelectronic chips, switches, motors and LED's could be unsoldered and reused by us for the next iteration of our Smart Band or could be sent to a recycling facility. Lastly, since the Angel Sensor M1, is a fully functioning hardware device, it could be repurposed by installing software by other developers and using it for ourselves after our project has been concluded.

The production model of our device will have to be designed with several safety and sustainability factors in mind. The first obstacle to overcome would be how the internal circuitry can be configured as to minimize the likelihood of spontaneous combustion, electrocution or explosion of components such as the battery. New, safer and more environmentally friendly batteries such as the organic carbon battery fulfill our requirements quite well. No rare metals, heavy metals or unstable active materials are used in organic carbon batteries which makes them completely recyclable as well as significantly less likely to cause fires or explosions [6].

The device would also be sustainable in the sense that as little electricity as possible will be consumed throughout the product's lifespan through using the more efficient and reliable battery as well as BLE for wireless communication. Waterproofing of the final production device is needed so that it can be worn at all times without short circuiting and or electrocuting the user. Sustainable and non-hazardous materials used for internal circuitry as well as the outer casing for the device need to be used. A suitable material for housing our device needs to be carefully studied in order to be lightweight, strong and easily recyclable. Materials easily recycled and widely available in recycled forms such as hard plastic, silicone and aluminum are ideal for the implementation of the Smart Band [7]. Non hazardous materials are also a priority, by using them, need for consumers to be around dangerous materials as well as the harm they cause to the environment can be eliminated. Much more sustainable materials such as lead-free solder alloys, organic carbon batteries and recycled materials would be used.

Conclusion

A clear desired end-product requires careful planning, this can be achieved by outlining the functions that the final product should have and placing constraints on the materials and required abilities of the device. The envisioned Smart Band by Smart Trak Solutions has been meticulously devised to have numerous practical functionalities and be up to industry standards while still being a sustainable and safe product. Constraints were put on what the device should be capable of in the areas of the band, sensors, communication, mobile application and user documentation. These constraints have allowed Smart Trak Solutions to prioritize what the device needs and strive for a final product that delivers high quality performance, usability and robust enough to be worn in nearly any environment. A device capable of fulfilling all the design goals can be achieved without sacrificing sustainability when coupled with the cradle to cradle design approach. The Smart Band is intended to be a device that would allow users to feel safe with the knowledge that emergency help can be quickly requested. Both the safety of customers and the environment can be prioritized with our product, thanks to all the considerations put into the final product by Smart Trak Solutions.

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