eart Guard Technologies

October 15, 2007

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

RE: ENSC 440 FUNCTIONAL SPECIFICATION FOR PORTABLE HEART RATE MONITOR

Dear Dr. Rawicz,

The attached document outlines insight to the functional specifications of our project. The goal of our product is to assist lifeguards in rescue situations by monitoring a victim's pulse rate.

This document was created in order to provide an overview of the system functionalities of our heart rate monitor device and presents reasons why it will be advantageous for usage. Furthermore, on outline of the budget, funding and a description of previous designs of similar products are included.

Out team, Heart Guard Technologies consists of four talented, enthusiastic and hard-working engineering students from Simon Fraser University. These individuals include: Bryan Schurko, CEO; Stephen Czerniej, CFO; John Azer, VP Operations; and Vahid Shababi, VP Marketing. Please feel free to contact us at bns3@sfu.ca, if you have any questions or concerns regarding out product.

Sincerely,

Bryan Schurko
CEO
Heart Guard Technologies

ENCLOSED: FUNCTIONAL SPECIFICATION FOR HEART GUARD PORTABLE HEART RATE MONITOR

CONTENTS

EXECUTIVE SUMMERY

Finding a pulse in a rescued victim is a highly challenging task, and often weak pulses cannot be detected by the usual methods of sensing the wrist, or the side of the neck. Almost all lifeguards claim that much time is wasted, after a rescue, in finding the pulse of a victim. A major problem that arises when using the off the shelf heart rate measuring products, is that the conditions they are to be used in are very limited. For example, in wet conditions, such as a swimming pool, an ordinary pulse monitor can be damaged if water leaks into the case. Moreover, if a drop of water comes in contact between the victim's ears and the sensor, inaccurate results will occur, if the product is not particularly designed to operate under such conditions.

Our group (Heart Guard Tech.) have realized the need for such a product to overcome these limitations and have decided to invent a full proof product, not only to operate under the sever conditions mentioned above, but also to significantly reduce the time invested in finding the victim's pulse. The water proof casing of our product differentiates our product from previously designed heart monitors in such a way that the victim's heart rate can be measured accurately, even if the product is immersed under water. Also, the ear clip sensor to be used in this product is highly tolerant to water.

This document lays out the functional specification of the product Heart Guard Tech will be designing and implementing. The functional specifications of the entire product are segmented into subsystems, and the functional specifications of each subsystem are further explained in detail. It is important to note that the functional specification outlines outlined in this document will be severely tested under a wide variety of conditions, to ensure the robustness of this product in the hands of the end user.

ABSTRACT

We at Heart Guard Technologies propose to design a portable heart rate monitor, which is capable of measuring the number of heart beats per minute and displaying the heart rate information in a clear and simple way to avoid any confusion in chaotic situations. This device is composed of a small ear clip, which is similar to those used in hospitals and exercise equipments. In order to increase noise immunity, infrared light is used to for pulse rate measurements. Furthermore, the completion cost of this project will be kept low, since the use of pulse sensing equipment used for exercise means is widespread.

Heart Guard Technologies consists of four engineering students from Simon Fraser University, who bring extensive experiences and ideas to the design of our project. Our products must be conventional to the highest quality and usability standards. Due to the marketing expertise of one of out group members, our company is capable of coming up with plans to reduce its costs for a higher profit. Moreover, due to the high financial costs, we will try to obtain more funding through SFU as much as possible. However, our group members believe that it may not be possible to generate enough capital in order to support the entire project through funding. If such situations arise, the company members are willing to share the outstanding financial costs equally.

We at Heart Guard Technologies plan to compete with other engineers all over Canada, by attending in Western Engineering Competition, WEC, and hopefully to CEC.

The integration and development of our project contains two different sections. The first phase of our project develops a portable heart rate monitor. In the second phase, Heart Guard Technologies members try to move the project even further ahead and making it actually practical for future swimmers.

This document outlines the functional specifications of the first phase of our project at Heart Guard Technologies.

SYSTEM REQUIREMENTS

3.1 SYSTEM OVERVIEW

Figure 1 illustrates the overall system functionality. The system has the detachable ear sensor and the main circuitry/display box encapsulating the two main parts of the system. The entire system including the detachable sensor is waterproof and can be submerged.

The ear sensor is the input to the system as it sends in data to the main box. The main box then processes the input given and determines if there is a signal present and displays the appropriate heart rate of the user. Light sources will illuminate when the system is powered on, when there is a signal present, and when there is no signal present. Each possible situation will illuminate a different light source as can be seen by Figure 1.

The box itself will have an On/Off switch attached to the side that is waterproof in itself and will keep the entire main box waterproof as well. The system will display no signal found until the ear sensor is attached to a user. Once attached, the display will react quickly and produce a heart rate on the display.

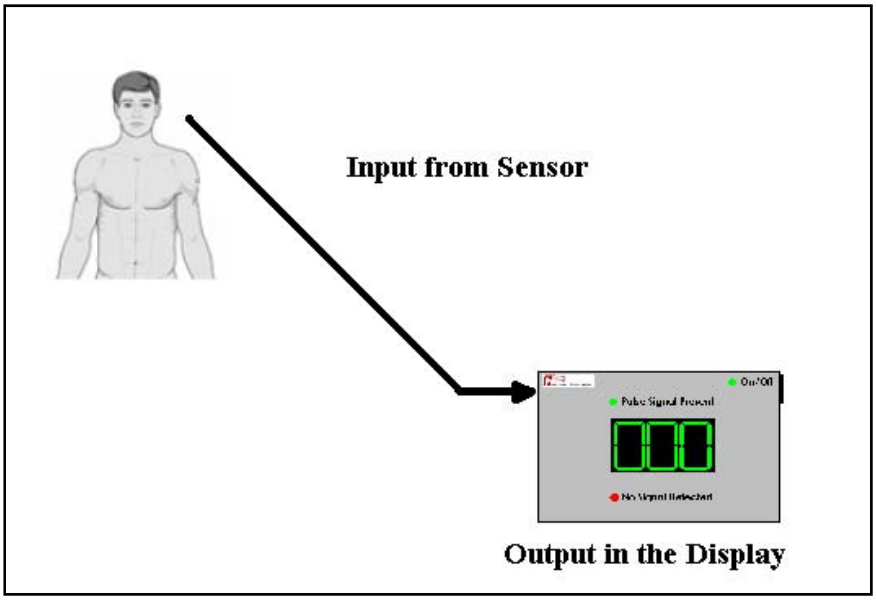

Figure 1: General System Overview

3.2 Overall System Requirement/Usage

3.2.1 General Requirement

(Req 1) The voltage needed for the controller to work should be no more than 9 Volts to coincide with a 9 Volt Power Supply.

(Req 2) Using the entire device should be foolproof, easy and fast.

3.2.2 Physical Requirement

(Req 3) The enclosure shall be made of a non-toxic material, in order to not harm the users.

(Req 4) The enclosure will not have any sharp edges in order to not harm the user.

(Req 5) The enclosure encompassing the controller will be rigid and be able to withstand compression stress.

(Req 6) The ear sensor will be able to detach from the enclosure.

(Req 7) The entire system should be fully waterproof.

(Req 8) All displays on the enclosure will be easily visible and interpretable.

3.2.3 Environmental Requirement

(Req 9) The controller must be able to handle temperatures within the range -10 to 40 degrees Celsius.

(Req 10) The entire enclosure holding the controller and electrical components should be waterproof and susceptible to submerged aquatic environments.

(Req 11) The system components should not cause any harm to the user when in contact with an aquatic environment.

3.2.3 Requirements for the Pulse Sensor:

(Req 12) An infrared transmitter is mounted into the top left edge of an ear clip to sense changes in heart rate.

(Req 13) An infrared receiver is mounted into the bottom left edge, beneath the infrared sensor to receive information from the sensor.

(Req 14) The infrared transmitter will send a signal through the ear lobe of the victim.

(Req 15) The infrared receiver will receive the signal coming through the ear lobe of the victim.

(Req 16) The infrared transmitter and receiver must be capable of detecting weak pulses due to lower than average blood pressure, equally well as stronger pulses.

(Req 17) The top and bottom right edge of the ear clip can be pushed towards one another, resulting in the separation of the left side (i.e. infrared sensor and receiver).

(Req 18) When not enough pressure is applied by the user, such that the top and bottom right edge of the ear clip are not pushed towards each other, the transmitter and receiver on the left end will be clipped together.

(Req 19) The middle of the ear clip contains a spring to allow for the previous two requirements.

(Req 20) The infrared transmitter and receiver are placed under a glass shield to increase durability in wet conditions.

(Req 21) Information sensed by the receiver, are carried through a wire to an intermediate connector.

3.2.4 Requirements for Signal processing:

(Req 22) An amplifier must be created so that the signal coming from the wire of the intermediate connecter can be amplified to emphasize weaker signals due to weaker pulses.

(Req 23) A filter must be designed after the amplification stage in order to remove unwanted distortions in the amplified signal.

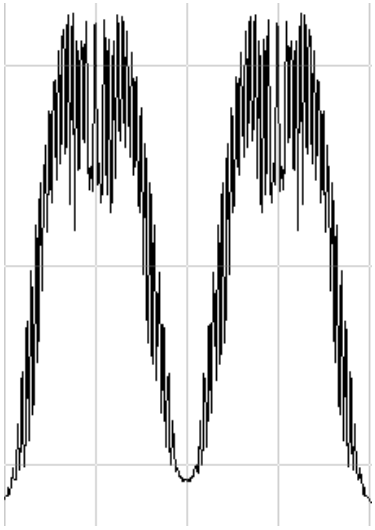

Figure 3.2.1: Received Signal (Unfiltered)

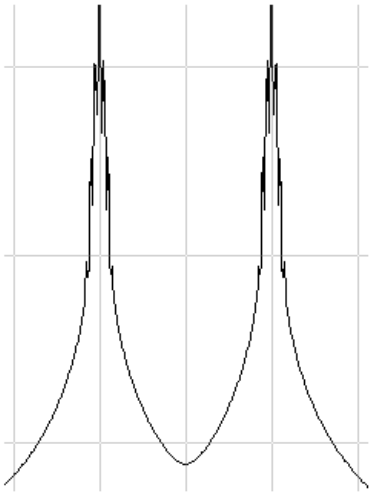

Figure 3.2.2: Filtered Signal

3.2.5 REQUIREMENT FOR CONTROLLER BOARD

The following is the requirements for the controller board and how it will work in our system.

3.2.5.1 General Requirements:

(Req 24) The voltage needed for the controller to work should be no more than 9 Volts to coincide with our 9V power source.

(Req 25) The maximum current required to power the controller should be no more than 100mA.

(Req 26) Controller must be in-circuit programmable.

3.2.5.2 Physical Requirements:

The controller will fit into a card deck sized enclosure to maintain durability and waterproof ability. This controller must be at least $1/5^{th}$ the size of the enclosure to ensure all parts fit in properly.

(Req 27) The dimensions of the controller should be no more than 5cm x 2cm.

(Req 28) The mass of the controller should be less than or equal to 200g.

3.5.2.3 Functional Requirements:

(Req 29) The controller must have at least 1 analog to digital converter input to deal with the incoming pulse waveform. The ATD must be able to sample data at least 100HZ or 100 Samples/Second.

(Req 30) The controller must have at least 1 digital input to deal with power control.

(Req 31) The controller must have at least 10 digital output pins to controller the display and various light sources that will indicate pulses and pulse data.

(Req 32) The controller must be able to run at no lower than 100 kHz to deal with high speed calculations of the signal processing that will be needed.

(Req 33) The controller must have at least 512 bytes of ram to deal with pulse calculations and to monitor changes in the pulse rate.

(Req 34) The controller must be able to use (internal) interrupts to calculate pulse rates.

3.5.2.4 Environmental Requirements:

(Req 35) The controller must be able to hand temperatures within the range -10 to 40 degrees Celsius.

3.5.2.5 Cost Requirements:

(Req 36) The controller alone must cost no more than $20 CND to satisfy budgetary concerns.

3.2.5.3 Test Requirements:

(Req 37) Various levels of pulse amplitude will be input to the controller to test the effectiveness of the ATD.

(Req 38) Fast movements using our hands will be created to simulate the effectiveness of the controller in a volatile environment.

3.2.6 REQUIREMENT FOR SOFTWARE

The following will discuss the requirements needed to program the controller and run the controller.

3.2.6.1 Requirements for programmability:

(Req 39) Code must be written in C or C++ due to complexity of pulse sensing algorithms

(Req 40) Code for operations should not exceed 384kB.

3.2.6.2 Requirements for Operation:

(Req 41) View victims current pulse rate.

(Req 42) Graphical display must be set to '---'when no pulse is detected by controller.

(Req 43) Light display pulse indicator must be used as soon as a pulse is detected by the software.

(Req 44) Software must display number of beats per minute on graphical display

(Req 45) Software must display beats per minute at least 5 seconds after a pulse is detected.

(Req 46) If no pulse is detected after 60 seconds, software will shut down graphical display and light sources to conserve power. When a pulse is detected thereafter, the light display and graphical display will be powered up.

3.2.6.3 Requirements for Performance:

(Req 47) The software must be able to calculate both low amplitude (20% of regular amplitude) and normal amplitude pulse waveforms.

(Req 48) User must not be exposed to faulty pulses from noisy environment

(Req) Software must be able to determine when a spike in the pulse is not a heart beat but rather stray noise or static.

3.2.6.4 Test Requirements:

(Req 49) Low pulse amplitudes will be tested to simulate victims who have a very weak pulse. We will do this by modifying the pulse sensor.

(Req 50) Various pulse frequencies will be tested to determine our range of operation.

(Req 51) No pulse situations will be simulated such that the software can detect when no pulse is present.

CONCLUSION:

The functional requirements for *Heart Monitor System* have been outlined in this document. The requirements given in this document are tentative and should be modified as necessary throughout the completion of the project. Furthermore, this document will provide a clear guideline to the completion of the product.

The company's proposed solution is to design and build a small pulse detection device capable of creating an unheard of device by lifeguards. The primary goal of this Heart Guard Detection Device is to find a pulse signal quickly and accurately on the ear lob of swimmers in water. Not only employed lifeguards will be able to benefit from our product, but also life savers and swimmers in general will be able to use this device in emergency situations in order to save lives.

Our goal is to complete the first phase of the project by mid December 2007. Then, we will plan to incorporate some features of the second phase in order to make our product as practical as possible for future swimmers.

We at Heart Guard Technologies hope these functional specifications will provide our audiences with essential insights of our product.

GLOSSARY

This document is provided for managers, designers, and marketing personnel. Managers are able to use this document as a guide for scheduling and other managements. Designers may use this document as a guideline for the development of the system. Finally, marketing personnel may look at this paper as a guide fro product promotion. We at Heart Guard Technologies have tried to make this document as easy as possible to understand.

LED: Light Emitting Diode

AED: Automated External Defibrillator

IR: Infrared

PIC: Peripheral Interface Controller

PCB: Printed Circuit Board

REFERENCES:

[1] Marge Czerniej. Registered Nuse at Maple Ridge Hospital. Sept 29, 2007

[2] Gerry Warby. Head Biomedical Engineer at Maple Ridge Hospital. Oct 11, 2007

[3] Center for Disease Control and Prevention. 2007. Measuring Target Heart Rate
<http://www.cdc.gov/nccdphp/dnpa/physical/measuring/target_heart_rate.htm>

[4] Smart Q Sensors. 2007. Heart Rate Monitor
<www.arborsci.com/Data_Sheets/Files/Sensor_Books/Heart_Rate1.pdf>

[5] EKG Signals. 2007. Atrial Fribrillation
<http://www.a-fib.com/EKGsignal.htm>