ENGR 103 - Spring 2014
Freshman Engineering Design Lab

"Simple 2-lead wearable ECG monitor counting and documenting Heart Rate "
Project Design Proposal

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Abstract:

This design project will utilize Arduino technology to monitor heart rate. The final product will be a wearable heart rate monitor that checks for irregularities in the user's heart rate and notify them through a LCD display and emergency services through text. This is meant to reduce the amount of unrecognized and untreated heart problems and heart attacks. The project will require learning circuitry, programming for Arduino and for Android. Literature research will be used to guide group members' learning of these skills for this project. The project will consist of four steps; setting up hardware and circuitry, programming the Arduino, programming the Android app, and testing the integrated system.

1   Introduction

1.1 Motivation, goals, and desired outcomes

The goal of this project was to design a wearable Arduino based device to measure and record heart rates. Arduino boards and sensors will be used to prototype a wearable ECG monitor that will be connected to a user's mobile device. The device will report any abnormalities in heart rate to the user, and if needed, send a text message to emergency medical services or a preset phone number. The project is planned to be aimed at the elderly or ill who live alone. It is meant to improve quality of life and minimize risk of untreated heart attacks and arrhythmia for those at risk of heart disease.

1.2 Learning objectives, major tasks, and technical challenges

The project will be split up into two main components, electrical design and programming. Learning objectives for this project include learning circuitry, how to setup hardware and program the Arduino, and learning how to create a compatible application for the desired cell phone function. The major tasks of this project will follow the learning objectives listed above. The first of these being hardware and electrical design. The boards, sensors, and displays for the Arduino will have to be connected and working before programming it to display and record a heart rate signal. The Arduino will then be programmed to detect irregularities in an individual's heart rate and connect to a cell phone. Time permitting, a cell phone app will then be created to text for emergency medical services in the event of a prolonged irregularity in the user's heart rate. Technical challenges of this project will be mostly due to learning new skills, including circuitry, and programming in Java and Processing.

2   Deliverables

2.1 Physical prototype

The prototype for the project will be a wearable Arduino device that measures the wearer's heart rate with an ECG sensor that the user will wear. The ECG sensor will either be one that the user wears on their arms and legs or on the earlobe. The arduino will also be be worn on the user in a carrier bag. The Arduino will include a LCD display and speaker to notify the user of an irregularity in their heart rate. A bluetooth module will be added to the Arduino board to allow for connection to a cell phone. A kill switch will be attached to the Arduino to prevent any accidental calls to emergency services (should an Android app be included).

2.2 Program for the Arduino and Android app

The Arduino will be programmed to recognize a user's normal heart rate and detect any irregularities that show up after it has established the user's normal heart rate. The Arduino program will display either a message and play a noise to notify the user of any detected irregularities in their heart rate. If there is enough time, the Arduino will also be programmed to start an app on an Android device that will text emergency medical services for the user in the case of a prolonged irregularity in their heart rate (indicating a possible heart attack). The kill switch on the Arduino will be programmed to stop the display, noise, and cell phone functions.

3   Technical Activities

3.1   Electrical design

The first major task is to get each component on the Arduino connected and working. The Arduino will be connected to an ECG sensor and shield, a bluetooth module, LCD display, speaker, button (kill switch), and LEDs. There is ample amounts of literature on setting up Arduino hardware. Research using this resource and trial and error will allow for the group to set up a functioning ECG monitor. The electrical design component is expected to be mostly completed in the first four weeks of the project. Fine tuning of the Arduino unit will continue indefinitely.

3.2 *Programming*

3.2.1 Arduino program

After the hardware has been set up and functioning, the Arduino will have to be programmed to read a person's heart rate. The main function of the Arduino will be to serve as an arrhythmia or heart attack notification device for the wearer. The ECG sensor came with software that reads and displays the wearer's heart rate. Some of this code will be used and added to to produce a program that makes the Arduino record the wearer's heart rate. The program will include a calibration period at the start of the program to find and record the user's normal heart rate. Using this data, the program will then read through new data from the sensors and pick out any irregularities, or any large deviations from the previously recorded normal heart rate. If any irregularities are detected, the program will then start a display or noise to notify the user of the problem with their heart rate. The programming of the Arduino will begin as soon as the hardware is set up. The expected start and end of this task can be seen in Table 1.

3.2.2 Android app

If time permits, the group will develop an Android app to go along with the ECG monitor. If the irregularity in heart rate notification is ignored (indicating distress), the Arduino will then prompt an Android app to text emergency services or a user set phone number for help. The app will be a simple program that starts when a signal is received from the Arduino and sends a text message to either 911 or a preset phone number. The development of the Android app will serve to minimize the risk of the wearer having an untreated heart attack. The programming of the cell phone app will begin when most of the Arduino program is finished. The expected start and end of this task can be seen in Table 1.

3.3 *Testing*

The project's components will be tested as the group works on them. The Arduino's

function as an ECG monitor will be tested on group members. The bluetooth and texting capabilities will be tested using various Android phones. The testing of the device and programs will allow for the group to make sure that each component of the project works on their own, with each other, and with different users.

4   Project Timeline

Task	Week 1	2	3	4	5	6	7	8	9	10
Literature study	x	x	x	x						
Electrical design	x	x	x	x	x	x	x			
Programming Arduino			x	x	x	x	x	x	x	
Programming Android app						x	x	x	x	
System integration							x	x	x	x
Testing								x	x	x
Final report preparation									x	x

Table 1: Project timeline

5   Facilities and Resources

An on-campus workspace will be needed to do the prototyping for the project. Soldering tools will be used during lab hours to complete the circuitry in the Arduino. Machine shop tools or a 3D printer may be used to create a case for the Arduino to improve

portability.

6   Expertise

- Familiarity with Arduino Uno and Lilypad Arduino
- Computer programming experience in Java and Processing
- Knowledge of basic circuit theory
- Knowledge of basic biometric sensors
- Use of machine tools

7   Budget

Category	Projected Cost
Arduino	$25.00
Sensors	$85.00
Connectivity	$15.00
Peripherals	$25.00
Miscellaneous electrical components	$10.00
Power source	$15.00
Casing	$20.00
TOTAL	**$195.00**

Table 2: Project budget

7.1   Arduino

An Arduino Uno will be the main board used for this project (the one provided in lab will be used if a second is needed). All sensors, connectivity modules, and any peripherals will be connected to the Arduino.

7.2   Sensors

An ECG sensor and shield will be used to read and monitor the user's heart rate. This will be the primary function of the project. There are two ECG sensors that are being

used in the project, one is a wristband and the other clips onto the user's ear. The final version of the prototype will include whichever one performs better during testing.

7.3   Connectivity

A bluetooth transceiver will be used to connect the Arduino to an Android phone. This will serve to signal the phone to text for help should the Arduino detect any prolonged irregularities with the wearer's heart rate.

7.4   Peripherals

Because of the project's main function as a notification device for the user, a LCD display module, LEDs, and a speaker will be used to alert the wearer when the Arduino detects irregularities in the wearer's heart rate.

7.5   Miscellaneous electrical components

The breadboard and resistors function to connect all of the previously described components together in a way that is safe and works.

7.6   Power source

A portable battery pack and short USB connector will be used to power the Arduino. This method of powering the Arduino will allow the user to carry around the device and recharge it when it is not in use.

7.7   Casing

Materials for a case were purchased in preparation for the fabrication of a case when the device is finished. A case would protect the device and increase portability.