Purdue ECE 49022 ABET Senior Design Semester Report

Course Number and Title	**ECE 49022, Electrical Engineering Senior Design Projects**
Semester / Year	**Fall 2017**
Advisor(s)	**Prof. Lehnert**, **Nathan Conrad** (TA), **Andrew Balmos**
Team ID	Section: **001** Team **CIVIC**
Project Title	**Smart Armband**

Team Composition

Name	Major	Area(s) of Expertise	Expected Graduation
Veronica Vera	BSEE	Hardware, Circuit Design, Soldering	Fall 2017
Dongjin Kim	BSEE	Hardware Circuit Design, Soldering	Spring 2018
Junyan Zhai	BSEE	Integrated Circuit Design	Spring 2018
Haoyu Zhang	BSEE	Integrated Circuit Design, Java/Python Programing	Spring 2018

Project Description: Provide a brief (one or two page) technical description of the design project, as outlined below:

1 Summary of the project, including customer, purpose, specifications, and approach

The project is a smart armband with a GPS module, heart rate sensor, step counter, thermometer and Bluetooth low energy (BLE) module. Our target customers are runners and the elderly who want to track daily physical activity. The purpose of this project is to design and build a small device that can help people track these activities accurately without having a cellphone connected to the device all the time.

The device uses a rechargeable battery as a power source that is charged through a micro USB power source (5V, 2A). The user can interact with the device through an Android app. Data will be stored in the armband until downloaded to the app's database through BLE and measured in 6-hour intervals. The device gathers step-counting data constantly (not only during intervals). Additionally, the armband starts gathering data upon request from the user. The app displays and stores heart rate, step count, temperature, and location (on a map) data. The battery level is also read and displayed on the App through BLE.

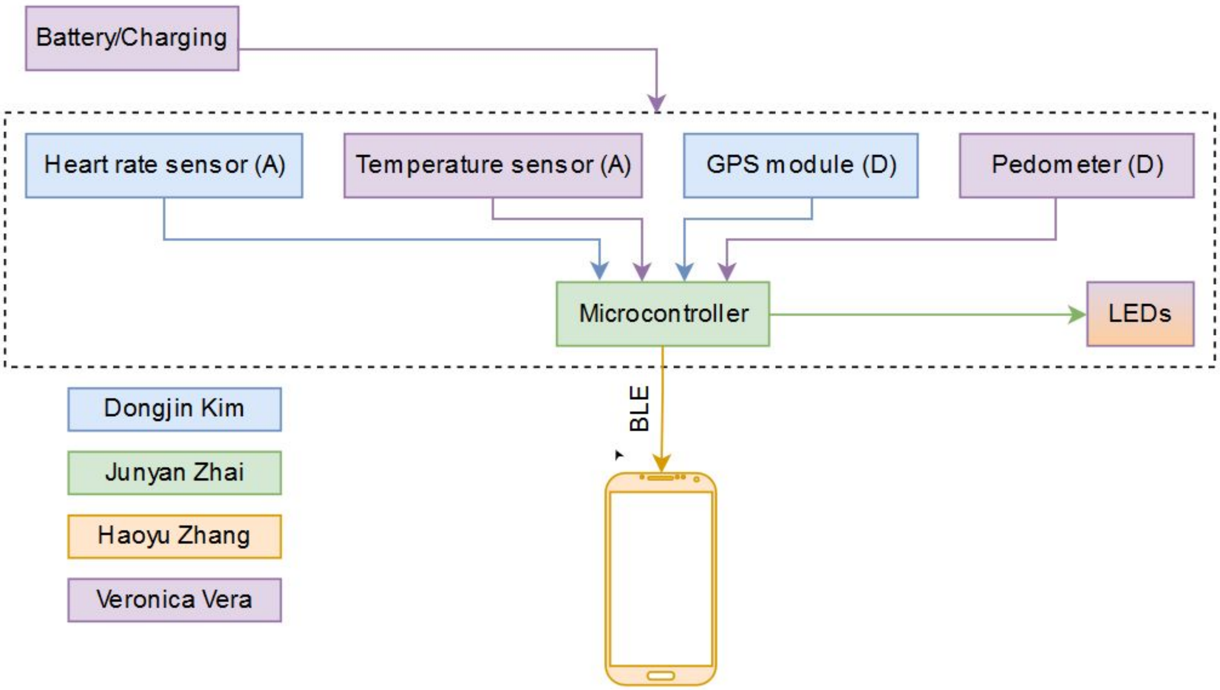

Figure 1: Overall system block diagram

2 Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework (include course numbers)

Programming skills learned in CS 159 and ECE 270 were used by Veronica to design the accelerometer. Power distribution and circuit simulation skills she learned in ECE 321, 323, and 432 were used in the power subsystem. Circuit design and troubleshooting techniques she learned in ECE 207 and 208 were used in implementing the temperature sensor. Schematic design skills she learned in ECE 255 and ECE 270 were used to visualize the power, accelerometer and thermometer parts of the project. Lastly, Arduino programming she learned during her co-oping rotations was used to program the accelerometer.

Circuit design skills and simulation skills that Haoyu and Junyan learned in ECE 455 were used to design the PCB of the project.

Junyan learned how to program the Cypress microcontroller based on the programing skills and knowledge learned from ECE 270 and CS 159.

Haoyu learned Java programing skills by himself during this semester based on the C programing concepts learned while taking CS 159 and during a summer internship.

Circuit design skills and knowledge that Dongjin learned from ECE 207, 208 and 305 and online resources were used in the heart rate sensor section of the project. He also learned how to simulate a circuit of the sensor to analyze the signal using OrCAD simulation software from online resources and the TA's help. Furthermore, the design skills and knowledge used to obtain latitude and longitude information for the GPS came from experiences in ECE 207, 208, 301, and from U-blox software and online resources.

3 Description of what new technical knowledge and skills were acquired in doing the project

Veronica learned how to design schematics using Altium software, and soldering components on a PCB board. She also learned about the different power regulators that can be used to boost or reduce voltage, and their different advantages. Lastly, she also learned how to use SPI protocols with microcontrollers.

Haoyu taught himself Java and Android developing skills from the basic concepts of programing that he learned from CS 195 as well as various online resources.

Junyan learned the details of both analog and digital processing with microcontrollers, programming of microcontrollers, building BLE custom profiles, and designing PCB layouts.

Dongjin learned how to solder on PCB boards, design hardware circuits as well as simulate and analyze signals using OrCAD software with the TA's help, and concepts from ECE 301.

4 Description of how the engineering design process was incorporated into the project. Reference must be made to most of the following fundamental steps of the design process: *establishment of objectives and criteria, synthesis, analysis, construction, testing, and evaluation*

- ***Establishment of objectives and criteria:*** In order to make sure that all the components would be able to communicate with the Cypress microcontroller, we checked the datasheets to know what protocols were supported. From there, we used SPI (for the accelerometer), ADC (for the thermometer and the heart rate sensor), UART (for the GPS), and BLE (for data transfer). We also made sure that all the components could be powered with a 3.7V rechargeable battery, by using a regulator (with outputs of 3.3V or 5V).

- *Synthesis:* Initially, each team member ordered the components necessary to test each subsystem independently and data could be gathered from all sensors. Then, we made sure the data from each subsystem / sensor could be interpreted with a microcontroller. Lastly, we incorporated all the subsystems into one breadboard to make sure they all seamlessly interact with the Cypress microcontroller.

- *Analysis:* The main concerns for the project were the power, memory and space consumption. Each team member made sure that the components in their subsystem used 3.3V or 5V in order to use a 3.7V rechargeable battery that lasted a reasonable amount of time when all the subsystems were in use. We calculated the amount of data and frequency that every sensor should gather in order to use the flash memory of the Cypress microcontroller. Lastly, we selected components that were small enough to fit onto one

PCB board that could be carried on an armband, but large enough to solder and prototype.

- ***Construction:***
  - Circuit design: We designed the circuit based on the datasheets of our components and the knowledge that we learned from circuit design courses such as ECE 455. Also, we received help from the professor and TA.
  - Android App Developing: Haoyu had almost no experience with Java and Android app development. Yet, he learned Java programing skills through online resources and tutorials, and with help from TA as well.
  - Power distribution: Since the battery did not output constant voltage or current, we used two regulators that we selected with help from the TA. We needed to use more than one regulator in order to power components that needed 3.3V or 5V. We also designed a simple circuit to decrease the voltage and current necessary to connect the battery to a 5V / 2A adapter and charge it using a microUSB connector.
  - PCB design: During the last week of the project, we were not able to solder the microcontroller / BLE module onto the PCB board and program it; therefore, we decided to demonstrate our project on a breadboard, where all the components could interact with the Cypress microcontroller.
- ***Testing and Evaluation:*** In order to test our app, we used an Android phone with our team app installed. First, we focused on making sure the BLE connection is built and designed correctly. Next, we read data from the different sensors with the microcontroller and displayed it on the app. Then, we compared the values gathered from the sensors with the following expected data values:
  - The number of steps measured (by moving the device a set amount of times) should fall within a 5 step accuracy.
  - The GPS location gathered should be within 5 meters of the current location.
  - The temperature measured with the thermometer (and compared with a thermometer available in lab) should be within 3 degrees Celsius
  - The battery regulators should output a constant 5V and 3.3V.
  - The heart rate monitor should measure heart beats within a 5 bpm accuracy.

Lastly, we used line graphs and a Google Map API to display the data gathered and test whether the database was built and working functionally. Due to lack of testing time, we were not able to test the battery charging aspect of the project.

5 Summary of how appropriate engineering standards and multiple realistic design constraints were incorporated into the project (see definitions above). Consideration of most of following is required: *economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints*

- *Economic*: All the components used in the design were low cost. The overall product design was less than $400. If produced at a large scale, the price of each armband should be lower than $80.

- *Environment*: Not all the components used in the design of the device we RoHS compliant, but if the product went to market, RoHS compliant components can be easily selected. Additionally, the lead based solder was used to connect components to the PCB would be substituted for lead-free solder to make the product safer for consumers.

- *Ethical*: The construction of the armband did not require any ethical decisions. Nor does the product require any unethical procedures while in use, since it mostly tracks data that the user desires to visualize.

- *Health and Safety:* The original design includes LEDs to indicate the battery level of the device. This informs users when to charge the battery and how to avoid overcharging. The device has no voltage leakage that could harm people. If this device was brought to market, all the components purchased should be RoHS compliant the PCB solder used should also be lead-free.

- *Manufacturability*: The components used in our project design are all easily obtained and readily available. The only components tailored to our device was the PCB layout, used mostly to organize the components and subsystems together. If the PCB design is made available publicly, this product may be manufactured easily and economically.

- *Political*: There are no political implications associated with this product except for the heart rate monitor. If this product is sold on the public market, the accuracy of the heart rate monitor should be verified by NEMA.

- *Social*: The social impact of our project mostly concerns the Android application. It allows the user to measure heart rate, temperature, current location and daily steps while wearing it.

- *Sustainability:* If this device is mass produced, RoHS components should be selected. The PCB, integrated circuits (ICs), battery, and connectors should be recycled by the user instead of being thrown away.

6 Description of the multidisciplinary nature of the project

- Dongjin : Soldering skills, hardware circuit design, and signal simulation skill (OrCAD)

- Veronica: Soldering skills, hardware circuit design, and signal processing.

- Haoyu: Java and Android development programing skill.
- Junyan: Microcontroller programing skill, signal processing skills, PCB design skills, and circuit design skills.

7 Description of project deliverables and their final status

The following acceptance tests passed within our subsystems as stated on the FATs of the team agreement:

- GPS module: GPS reading was accurate within 5 meters.
- BLE: the connection was stable with BLE for an extended amount of time.
- Step counter: the counter was accurate within 5 steps.
- Thermometer: the thermometer was accurate with 3 degrees Celsius.
- App: the App was able to read data from the microcontroller and write data through BLE, as well as store and display the data on the phone.

The team was able to demonstrate that the following subsystems worked correctly and interacted with each other:

- Microcontroller / BLE
- Accelerometer
- Thermometer
- Heart rate monitor
- GPS module
- User app (Android)

The only subsystem that stood by itself during the demonstration was the power distribution subsystem, with the 5V and the 3.3V regulation functioning, but not the charging of the rechargeable battery.