Executive Summary

Team: Brian Hayt, Rachid Lamouri, Matt McKee, Ken Akiki, Casey Stoessl

Technical Advisor: George Daher

The bluetooth bicycle diagnostics module will provide cyclists with all of the vital data necessary to improve him or herself as a rider. Professional cyclists and casual rides alike need to collect data on their ride so that they can calculate the intensity of their workout, the consistency of their pace, and the status of their bicycle in order to ensure an efficient workout and a safe ride. This project provides the rider with all of this information in a simple-to-install package which will connect via bluetooth to the rider’s smartphone. The rider will be able to monitor these vital statistics both in real-time and view a graph of the cumulative data after the ride all on their phones.

There will be four unique sensors included in this project. A hall-effect sensor will be used to measure RPM, speed, and distance. This will be mounted on the fork while a magnet is mounted on the spoke, using the time between detection of the magnet and the circumference of the wheel to calculate the distance, distance per time, and revolutions per minute of the bicycle. A gyroscope will be able to measure the gradient of the slope which the bicycle is on, contributing to data on the intensity of the ride and allowing the rider to determine which route he or she wants to go one based on prior data. A heart-rate monitor will provide real-time data to the user about whether or not he or she needs to increase or decrease the intensity of the ride. A pressure sensor will be screwed onto the tire in order to provide accurate data on the pressure of the tire. This data will be used to ensure the safety of the bicycle, alerting the rider when the tire is down to a dangerous level. This is particularly useful for long rides or through changing temperatures where the tire pressure could change fairly dramatically in a short period of time and could fall out of the optimal range. This device would also be able to alert the rider of a potential leak well before he or she notices it.

Bicycle Bluetooth Diagnostics Module

EECS 398/399

January 26, 2014

Team Members:

- Team Leader: Brian Hayt (Electrical Engineer)

- Kenneth Akiki (Electrical Engineer)

- Matthew McKee (Computer Engineer)

- Rachid Lamouri (Computer Engineer)

- Casey Stoessl (Computer Engineer)

Technical Advisor: George Daher

1. Technical

1.1. Problem Description

Bicycle computers today are stand-alone products which provide data on speed, RPM, distance, temperature, time, and calories burned. This project attempts to greatly expand that list and provide easy connectivity with a smartphone rather than a stand-alone computer. Currently cyclists are missing a whole host of information that could be vital in planning a trip or workout in terms of safety and workout efficiency and effectiveness. The bluetooth bicycle diagnostics module will fill the void, providing information on heart rate, speed, RPM, distance, calories burned, tire pressure, and gradient.

The ride and rider information will be obtained through a host of sensors attached to the bicycle and rider and will be powered by the bicycle. These sensors include a hall-effect sensor that will be mounted to the fork with a magnet mounted to a spoke, a heart-rate monitor attached to the wrist or bicep of the rider, a pressure measuring IC will be screwed onto the tire pressure valve on the tube, and a gyroscope IC will be mounted onto the frame of the bicycle to measure the gradient. All of the sensors except the tire pressure sensor will be powered by a battery which will be recharged by a generator attached to the bicycle. All of the data will be collected and interpreted by an Arduino micro controller which will then transmit the data via bluetooth to a bluetooth enabled device.

The smartphone which will receive the bluetooth signal will have an app designed specifically for this application. It will be able to store all of the data, view it in real-time, graph the accumulated data, and perform calculations on the data to give usable statistics on the ride and information on how the user should improve the ride next time.

1.2. Project Specifications

1.2.1 - Analog Hardware

* Generator capable of generating 6W, 24Vpp.
* 12V, 600mA regulated supply for Li-Poly battery charger.
* 5V, 500mA regulated supply for device charger.
* 5V, 500mA regulated supply for Bluno Microcontroller.
* Device charger capable of charging standard micro-USB devices such as cell phone and GPS.
* Battery charger charges 11.1V, 2200mAH LiPo battery for reserve power.
* Battery capable of powering supported sensors.
* Ability to go into a “low power” mode when not charging battery or powering Bluno microcontroller.
* Over-current, over-voltage, and over temperature circuitry in insure safety and stability.

1.2.2 - Digital Hardware

* Bluno microcontroller
  + Arduino Uno controller
    - Atmega328 processor
    - Size: 6cm \* 5.3cm
    - 32KB memory space for program
    - DC current draw for I/O pin: 40mA
  + integrated TI CC2540 BT 4.0 chip

1.2.3 - Software

* Bluetooth 4.0 network
* Microcontroller
  + Sensor data collection routines
  + Transmission of data over bluetooth
* Android Application
  + Application for Android version 4.3 and higher
  + Maintainable and easy to understand user interface
  + Real time heart rate display
  + Real time RPM display
  + Real time tire pressure display
  + Ability to save and upload ride data
  + Post-workout statistics: tire pressure, calories burned, avg speed
  + Post-workout graphs (vs time): speed, gradient, distance
  + User inputs: wheel diameter, user height, user weight

1.3. Strategy for Achieving Objectives

In order to successfully implement this project all components will need to be thoroughly researched, designed with all necessary specification in mind, prototyped and tested individually, and finally put on a bicycle to be tested with everything working together. There are currently many bicycle diagnostic computers offered and some with bluetooth integration. These devices will need to be researched in order to have a point with which to begin the project. There are also currently available heart-rate monitors and generators powered by bicycles. These portions of this project will need to be researched in order to figure out the method that others have used in the successful implementation of these components. After the methods for implementing these devices are discovered, the circuitry for each component within this specific project will need to be designed. After the design phase, the group must look at every component together in order to figure out power specifications and modify the designs such that it falls within the group’s specifications. After the second design phase, all components will be ordered, assembled, tested individually, and then tested as a whole.

1.4. Verification and/or Testing

1.4.1 - Analog Hardware

The multi-output power supply and battery charger must be able to produce maximum power to devices under many conditions. Full load and no-load specifications will be tested by attaching various loads (resistive, capacitive, and inductive in response) to the circuits, and responses will be monitored via DMM and oscilloscope where appropriate. Responses such as step response and drift over time will be monitored to insure no damage will be caused to device in any condition, and that protection circuitry is meeting spec.

1.4.2 - Digital Hardware

Testing of the digital hardware components will rely upon the analog hardware and the software components. Testing the data gathering features of the microcontroller will rely upon the values provided by the sensors, and use of known good values to test that the microcontroller properly receives data (e.g., that one rotation of the wheel is recorded, when a signal is sent by the hall sensor). This collection of good data will be tested independently of the bluetooth connection and Android application.

Testing of the bluetooth connection will require simultaneous testing of the Android application, and will involve two main verifications: first, that the phone and the microcontroller are able to properly pair, and second, that messages are properly transmitted to and decoded by the phone to display. This testing can occur prior to and independent of the actual collection of data by sensor by forming a connection and passing dummy data to the application to display.

1.4.3 - Software

A basic Bluetooth connection can be tested by passing simple predefined messages. Messages passed from each sensor will have to be tested individually. Data that is collected by the phone from each sensor test can be displayed and analyzed to make sure that the range and representation of the data is correct. To verify tire pressure display we can vary the tire pressure with a physical gauge attached to the bicycle tire and compare the value to what is displayed on the phone. Speed display can be tested by externally measuring the time it takes to travel a certain distance. Finally, using twenty to thirty randomly selected individuals, we will perform a usability survey on the ease of use of the Android application.

2. Management

2.1. Team Complement

Brian Hayt will be the project lead, developing the timeline and making sure the group is either on time or ahead of the scheduled timeline. Brian will be responsible for keeping the task management software up-to-date and timely informing others of their responsibilities as well as keeping an eye on the big picture, making sure the objectives outlined in this document are completed. Brian will also compliment Ken in working on the analog circuitry in this project.

Ken Akiki is the main contributor towards the design of power circuitry, and will contribute towards the analog design component of some of the sensors. He will be the primary designer for the generator, power-supply, and battery charging circuitry, and will be in charge of testing and verification of said devices. He will work closely with all other team members to ensure that the sensors and controllers receive sufficient power.

Matt McKee is the main contributor on all aspects relating to the microcontroller. He will be the primary programmer for the controller, including the data collection from the sensors and the transmission of that data to the phone. Further, he will assist in the physical integration of the sensors with the controller.

Rachid Lamouri is the lead member for the development of the Android application. He is responsible for designing an application that can communicate over BLE, capture data in real time and then save and store that data. He is also working on the Arduino application, primarily focusing on the BLE network.

Casey Stoessl will be assisting the development of the Android application. She will be responsible for the displays of real time data collected and the end-of-ride data presentation. Casey will be working alongside Ken and Matt to construct a viable method of retrieving and monitoring heart rate.

2.2. Project Management Plan

2.3. Budget

See below for the initial proposed budget. The group will be seeking funding from the SOURCE SAGES Capstone Grant.

|  |  |  |
| --- | --- | --- |
| Item | Cost | Information |
| Bicycle | $137.99 | http://www.amazon.com/Takara-Kabuto-Single-Speed-Frame/dp/B0041QF9EQ/ref=sr\_1\_1?s=cycling&ie=UTF8&qid=1390675851&sr=1-1&keywords=bicycle |
| microcontroller (Arduino) | $47 | <http://www.dfrobot.com/index.php?route=product/product&product_id=1044#.UuQMGSco5rQ>  ($35+$12 estimate shipping)  Arduino Uno board with built in bluetooth low energy chip. Less expensive than seperate Arduino and bluetooth components |
| pressure sensor | $42.44 | http://www.digikey.com/product-detail/en/26PCFFA6G/480-2521-ND/1248856 |
| Bicycle generator | $35 | http://www.amazon.com/Bike-Bicycle-Dynamo-Generator-12V/dp/B000OBWMGK/ref=cm\_cr\_pr\_pb\_t |
| Batteries | $25.37 | http://www.amazon.com/Venom-2100mAh-Battery-Universal-System/dp/B004UZD4Q8/ref=sr\_1\_cc\_2?s=aps&ie=UTF8&qid=1390678249&sr=1-2-catcorr&keywords=11.1v+lipo+battery |
| enclosure | $100 | thinkbox.case.edu |
| hall effect sensor | $5 | [Sparkfun](https://www.sparkfun.com/products/9312) |
| magnet | $2 |  |
| Android Phone | $0 |  |
| Heart Rate Monitor | $80 | http://www.zephyranywhere.com/products/hxm-bluetooth-heart-rate-monitor/ |
| Power Supply components | $15 |  |
| Unexpected Costs | $150 |  |
| Total | $639.80 |  |