Senior Design Proposal Team 7

1 Introduction

Liz Callahan, Jimmy Duke, Alex Kaup, Shaggy "Joe" Lubetski, and John Sexton

Team 7: SmartCycle

2 Problem Description

For both amateur and more experienced bike riders, focusing on gear shifting, heart rate, and other bike and health functions can distract them from being aware of their surroundings. There are 130,000 injury-inducing bike accidents that happen every year due to unpredictable urban areas, higher speed situations, and unaware car-bike accidents (CDC Report on Bicycle Safety). About $23 billion is lost every year from hospital, injury, and productivity-loss expenses related to bike accidents (CDC Report on Bicycle Safety). Because of these reasons and circumstances, a solution that maintains speed and gear, or automatically adjusts the settings of the bike to slow it down, can not only save lives, but also save money.

Another problem for the personal-health-focused portion of this biker market is the price of at-home stationary and exercise bikes. With high quality stationary bikes such as Peloton and SoulCycle ranging from $1,500 to $2,500, an alternative solution that costs at least a third of the price, produces similar results, and can be used in a non-stationary sense could meet all of the needs for the customer segment while again, saving money. While there are some stationary bikes that are cheaper (~$400), they are limited to a gym or household rather than an outside experience.

3 Proposed Solution

Our solution is a smart bike that automatically shifts gears and collects health information to allow for a safer ride and easier transmission of health data. To automatically calculate and shift gears for a smooth ride, our bike will use an infrared motion sensor on the frame to determine how fast a biker is pedaling and use a gyroscope to determine the bike's incline. Once the necessary gear is calculated, a solenoid actuator will be used to manually shift the gears on the handle bars.

Additionally, we will have a sensor on the wheel to collect distance and speed data as well as a heart rate sensor on the handlebars, and all of the aforementioned data will be displayed on an LCD. The information collected will then be transmitted via Bluetooth to an app on an iPhone, which may integrate into the Apple Health app. Health data such as speed, distance, calories, and heart rate will be transmitted, and calories burned will be calculated by the force of gravity induced with incline, pedaling speed, and gear level resistance.

4 Demonstrated Features

1. Can effectively use a motion sensor and a gyroscope to determine what gear the bike should be in
2. Automatically shifts the gear to the ideal gear setting based on incoming data
3. Has the ability to electrically interface with the mechanical gear shifter
4. Safety check to prevent gear switching if the pedals aren't actively turning
5. Has an LCD display that shows exercise stats such as distance traveled, bike gear, etc.
6. Connects using Bluetooth to a smartphone app that analyzes bike workouts
7. Measures heart rate of rider using a sensor

5 Available Technologies

First, we will need a device to convert our electrical power to mechanical power that can push the gear shifter to change gears. We picked out the push-pull solenoid shown below. We would need four solenoids, which cost $7.50 each and can ship immediately. There are currently 173 in stock on digikey.

- https://www.digikey.com/en/products/detail/adafruit-industries-llc/3992/9826285?s=N4IgTCBcDaIA4FcDOALABIgNptSD2mApgHZ4CWAJiALoC%2BQA

We will also need a motion sensor to detect the rotational pedal speed. Linked below is our choice, a passive infrared sensor, which would be attached to the bike so that it can detect the foot on the pedal each time the pedals are rotated. This would be converted to an rpm and used, alongside the gyroscope, to determine the optimal gear choice. This item has 844 in stock, can ship immediately, and costs $4.90 (we will only need one).

- https://www.digikey.com/en/products/detail/excelitas-technologies/PYD-1398-7085/14557074

A gyroscope will be used in conjunction with the PIR sensor to determine the optimal gear choice. This option is listed at $4.67 and has over 90,000 in stock. Its dimensions are 2.5 x 3 x 0.83mm and can use either I2C or SPI comms.

- https://www.digikey.com/en/products/detail/stmicroelectronics/LSM6DSMTR/6192777

We will need another sensor to detect the distance the bike has traveled. Our idea for this is to use a Hall Effect sensor. We will attach a magnet to one of the spokes on the front wheel, and put the sensor attached to the frame on the front wheel, and the magnetic field spike when the magnet is next to the sensor can give us an rpm of the wheel, which using the circumference of the wheel can be converted into distance. The sensor is $1.07 and the magnet is under $1.

- https://www.digikey.com/en/products/detail/ablic-inc/S-5712ACDL3-I4T1U/14664163

To make the heart rate monitor, we are planning to create a small board loosely using the instruction guide below. This would be attached to the handlebars to measure heart rate in the palm. The list of items we would need for this is as follows:

- LM324N quad channel op amp
- 2N3904 general purpose NPN transistor
- 1 μF capacitor
- .1μF capacitor
- 470kΩ resistor
- 68kΩ resistor
- 39kΩ resistor
- 8.2kΩ resistor
- 1kΩ resistor
- 1.8kΩ resistor
- 220Ω resistor
- 880nm, 5mm infrared emitter LED
- 5mm phototransistor
- https://www.jameco.com/Jameco/workshop/JamecoBuilds/arduino-pulse-sensor.html

  The total price for parts not in RCL is $2.38 with an almost negligible cost for resistors and capacitors.

The LCD panel will sit on the handlebars of the bike and be able to display exercise information for the user in real time. The option selected has 61 in stock, can ship immediately, and costs $17.85 (linked below).

- https://www.digikey.com/en/products/detail/pervasive-displays/E2370JS0C1/13572390

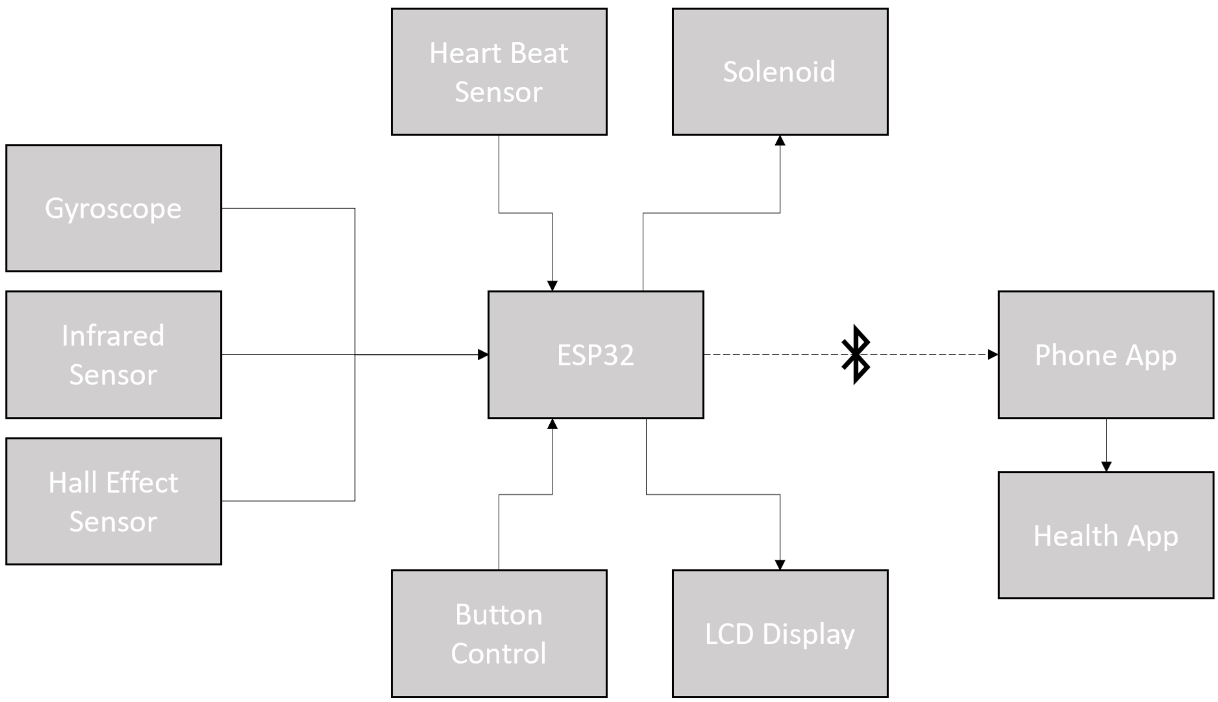
Power system includes a 2Ah, 3.7 LiPo battery and a USB type C interface for recharging it. Both are likely to be placed with the LCD on the handlebars. The battery cost is $12.50 and the USB C interface cost is $4.90.

- https://www.digikey.com/en/products/detail/adafruit-industries-llc/2011/6612469
- https://www.digikey.com/en/products/detail/seeed-technology-co-ltd/106990290/10451861

We intend to get a bike for free from the South Bend Bike Garage (an individual is eligible for a free bike after volunteering at the bike garage for six hours). Including all of these components and the cost of the circuit board, our total cost estimation comes to around $110, which gives us plenty of room for error in case we need to order different components at a later time.

6 Engineering Content

We will have to start by designing the individual interfaces on the different parts of the bike. We will need someone working on the electrical-mechanical interface meant to move the gear-shifter and where to angle the solenoids and someone working on the code for the fitness app and the bluetooth component connecting to the heartbeat sensor. We will also need one or a few people working on programming the different functions of the system – the speed and distance analysis with the wheel sensor and LCD, the safety check with the pedal sensor, the motion sensor boundaries and gyroscope settings for the gear shifter to act upon – into the board and how all of the different components will wire to the board. Finally, someone will need to work on how to fit the different devices to the bike and assemble everything together so that the whole SmartCycle functions as one cohesive system.



7 Conclusions

This product facilitates both a more smooth and enjoyable biking experience, as well as providing a cheaper alternative to the stationary exercise bike. It also allows users to translate the technological advantages of using a stationary bike for exercise into an outdoor setting. As younger generations become more interested in cycling as a form of transportation, we believe that this technology will allow them to navigate their commuting environment with more security.