Health Station Final Report

BY MOIS BOURLA, VIKRAM BELTHUR AND TANMAY GOYAL (120)

Introduction:

The purpose of our project was to create a system that would aid people in safely consuming their medicine. We chose the concept of a “health station” that would be used to give a patient a pill, depending on their heart rate. That is, if an individual’s heart rate exceeds a set threshold, our system would, theoretically, output a pill. In short, the goal of this project was to have a person put their finger atop a heart rate sensor which would read their heart rate in beats per minute. Then, when the station had detected heart beats above a certain threshold, it would dispense a pill.

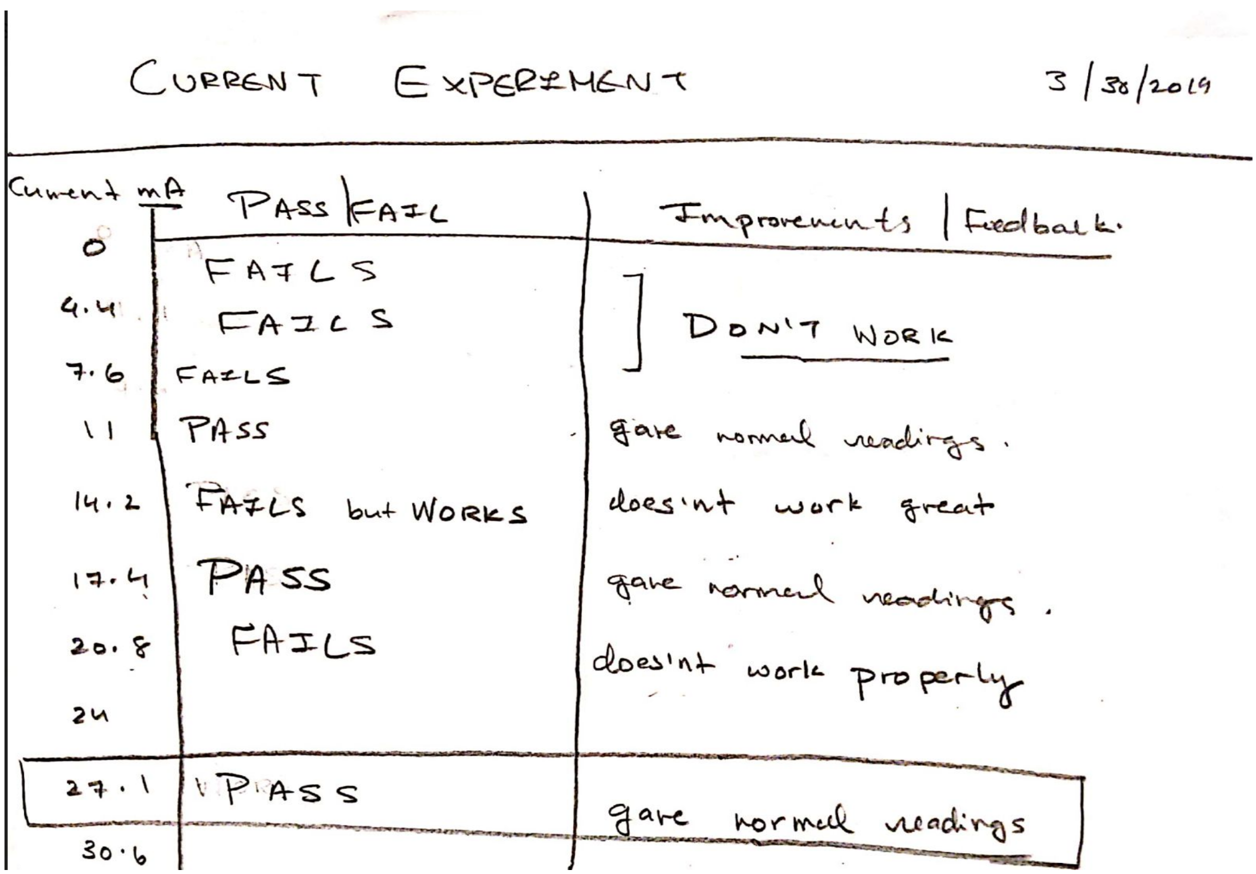
At a high level, our project would consist of three parts: the heart rate sensor, a pill dispensary, and an app for mobile phones. In addition to these elements, an Arduino Uno microcontroller should be used to interface with the various components of the project. The heart rate sensor detects an individual's heart rate in beats per minute (bpm). We envisioned the pill dispensary to resemble a medium size canister. Inside the canister there would be a system to dispense the pills, which ultimately would be the job of a servo. The final element of this project would be an android app. One purpose of the app would be generally used to aid the user with, say, deciding a schedule for taking the pills, setting reminders, etc. The other purpose of our app, for the sake of this design, was to interact directly with the health station via bluetooth communication (through a sensor). This way, a user can communicate directly with the sensor without having to be in the immediate presence of it.

Analysis of Components

In order to accomplish our objective of ensuring the safe consumption of medications that require a specific vital sign be reached, we combined an HC-05 bluetooth sensor, a MAX30100 sensor, an HS-311 servo and an arduino to create the Health Station. Moreover, we used an operational amplifier in open differential mode to serve as a comparator. This component was used to satisfy the logical element requirement of the course. In this section we will describe these four components and their uses in depth.

The most important component was our MAX30100 sensor. This sensor IC was developed by MAXIM technologies. It performs two functions: it measures a user’s pulse and it also measures the blood oxygen saturation. These are critical health indicators, and serve as metrics with which to gauge a person’s cardiovascular and respiratory health. The sensor performs its functions by using two LEDs, an near IR LED and a red LED. As Dr. Edward Chan and his colleagues explain, *“Pulse oximetry is based on the principle that O2Hb and HHb differentially absorb red and near-infrared (IR) light. It is fortuitous that O2Hb and HHb have significant differences in absorption at red and near-IR light because these two wavelengths penetrate tissues well whereas blue, green, yellow, and far-IR light are significantly absorbed by non-vascular tissues and water.3 O2Hb absorbs greater amounts of IR light and lower amounts of red light than does HHb”*

We performed numerous characterizations on the sensor as we worked on the project. We used the I2C protocol to communicate with the sensor. We used pull up resistors to pull two of the lines up to our supply voltage of 5v. Despite the datasheet recommending a maximum of 3.3v for the supply voltage, we found that the sensor was not stable and our next available regulated voltage was 5 volts. We still were experiencing rather peculiar readings from the sensor, and we therefore began tweaking two of the registers on the IC. The first register we began editing was the MAX30100_REG_LED_CONFIGURATION register. This register controlled the maximum current that the LED was supplied with, and it had a noticeable effect on brightness. We determined that the best setting was 27.1 mA as this was the lowest setting where the sensor was reliably operating.



CURRENT EXPERIMENT 3/30/2019

Current mA	PASS/FAIL	Improvements / Feedback.
0	FAILS	DON'T WORK
4.4	FAILS	
7.6	FAILS	
11	PASS	gave normal readings.
14.2	FAILS but WORKS	doesn't work great
17.4	PASS	gave normal readings.
20.8	FAILS	doesn't work properly
24		
27.1	PASS	gave normal readings
30.6		

We also edited the pulse width of the LEDs. We tested all 4 options and settled on 400us. These choices needed to be balanced against concerns for the temperature of the package. As noted in the datasheet, at a high duty cycle additional LED current can lead to significant temperature changes.

Table 14. Red LED Current Settings vs. LED Temperature Rise

RED LED CURRENT SETTING	RED LED DUTY CYCLE (% OF LED PULSE WIDTH TO SAMPLE TIME)	ESTIMATED TEMPERATURE RISE (ADD TO TEMPERATURE SENSOR MEASUREMENT) (°C)
0001 (3.1mA)	8	0.1
1111 (35mA)	8	2
0001 (3.1mA)	16	0.3
1111 (35mA)	16	4
0001 (3.1mA)	32	0.6
1111 (35mA)	32	8

The sensor was polled in the code and it yielded two float values: a pulse measurement and a oxygenation measurement. We converted this to a string and transmitted using the HC-05. The sensor used a software serial library. The transmission was received by a phone and used to display on our app.

The HS311 was used a servo to rotate a pill dispensing tray. It is controlled by the arduino. The servo library however, appears to interrupt the sensor's polling and cause a crash.

We also used an op-amp to drive an LED. This op-amp had its inverting and noninverting input connected to the supply voltage and a reference voltage respectively. The result was that a low battery voltage would trigger an LED to turn on.

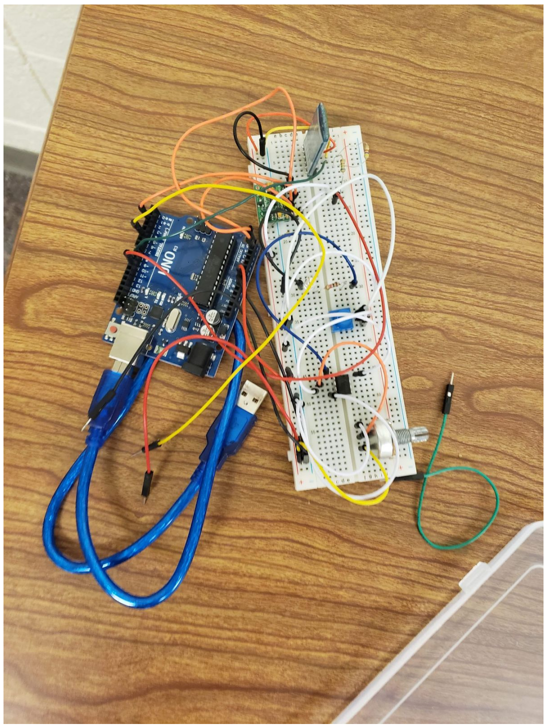
Design Description

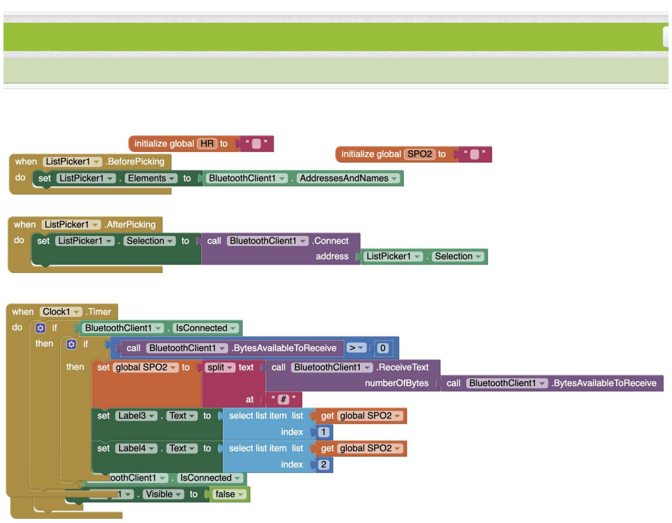
The design of our project involved the main sensor system to collect the users pulse, an app that was used by the user to read the sensor values and the pill dispensary which if detected a higher pulse than a set value dispensed the required pill.

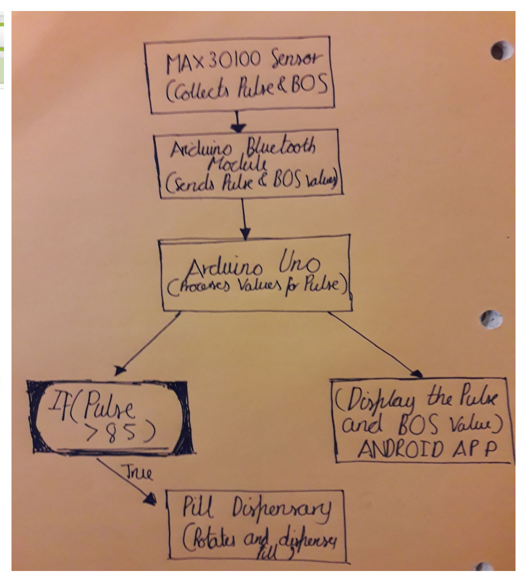
The main system utilised an MAX30100 sensor to read the users pulse and their blood oxygen saturation. The sensor collected the pulse and oxygen saturation values sending them to the Arduino through the help of an Arduino bluetooth module. The Arduino was used to detect whether the pulse values were higher than an offset pulse value that we set previously to 85 beats/minute .

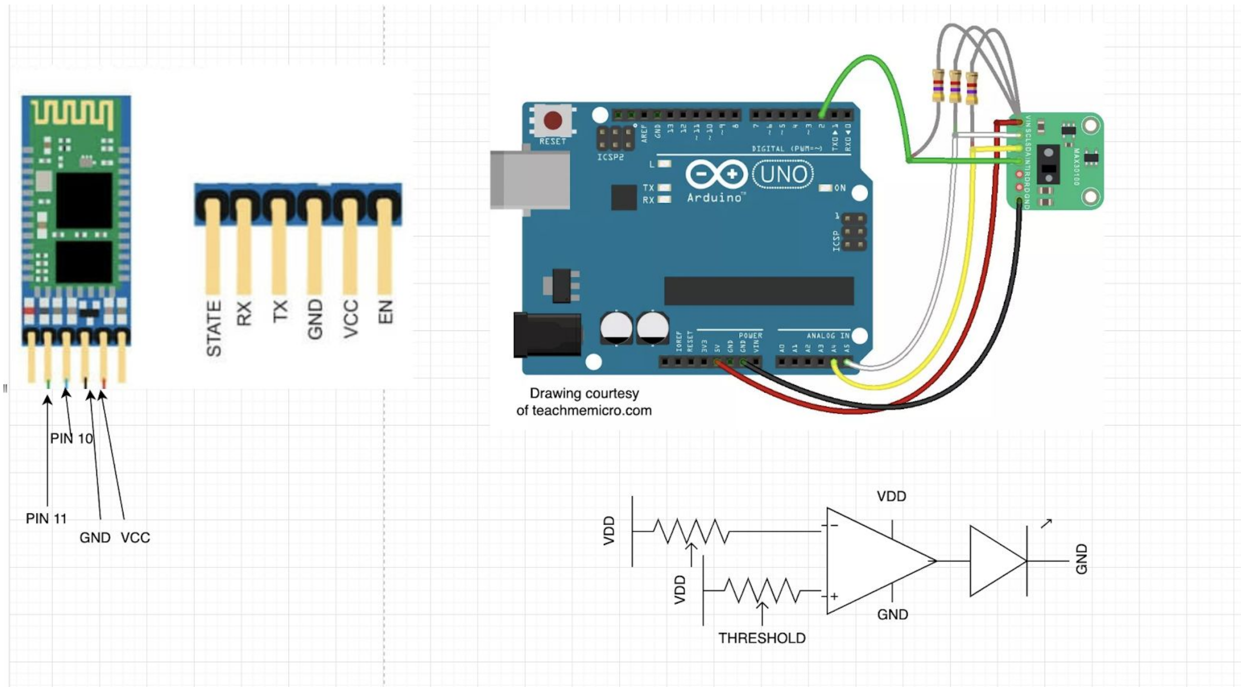
The Arduino then sent those pulse values to the Android App through which the user could read them. We constructed the Android App using Android Studio in a way so that it could communicate with the Arduino in real time.

The design of the pill dispensary was supposed to comprise of two parts - a stationary circular plate with one quarter missing and a second rotating cylindrical wheel with separate compartments to hold different kinds of pills. If the pulse values crossed the offset value the bottom cylindrical part (which we CADed and 3D printed using SolidWorks) would rotate 180 degrees or less because of the HS-311 Servo motor connected to it . The cylinder was supposed to move to the location in the circular disk which was open and could be used to pick the pill.









Conclusions:

Throughout the design of this project there were a few obstacles that came up. One to note was in the MAX3100 sensor. This sensor was prone to crashing, and did so at many intervals. Occasionally, the sensor would crash and freeze, and we had to press the reset button on multiple occasions. Another problem with the sensor was that it would not work properly after the servo had completed a turn. After the servo turned, the sensor would keep outputting the same data, despite there being no finger present (and thus no heart beat detection) on the sensor. When this happened, we also had to press the reset button on our Arduino. Another problem that happened was that we could not figure out how to get a bluetooth module to act as a master and a slave at the same time. We wanted to use two bluetooth modules originally to connect the phone to the pill dispensary and another Arduino, but this did not come to fruition.

In terms of what we listed in the introduction, our design was able to perform some things we specified but not able to do other things. We were successful in getting the servo to turn based on the minimum threshold needed to the servo. Additionally, we could not get our device to repeat this multiple times due the sensor crashing.In term of our pill dispensary, this is the area in which we had the least success. Our pill dispensary, ultimately was not successful in its job. We we able to get the servo working, and we were able to 3D print the plate used for the dispensary, but ultimately we were not able to make the actual structure of it. This is best left to a future revision and implementation of this project.

WORKS CITED

Chan, Edward. “Pulse Oximetry: Understanding Its Basic Principles Facilitates Appreciation of Its Limitations.” Respiratory Medicine, W.B. Saunders, 13 Mar. 2013, www.sciencedirect.com/science/article/pii/S095461111300053X.

The link to the datasheet of the MAX30100:
https://datasheets.maximintegrated.com/en/ds/MAX30100.pdf