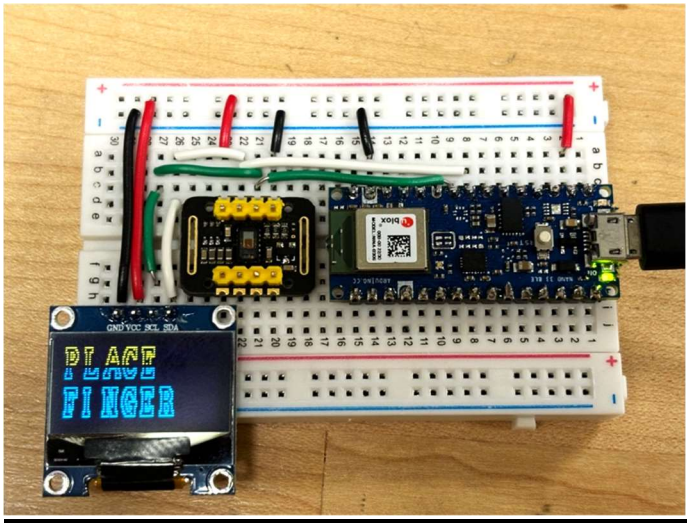
The Health Hero

ECE445 Final Project Report – Team 6

Fall 2023

Team Members: **Sam Bollman (CPE), Jack Curvey (EE), Jason Li (EE)**

Professor: **Dr. Zhen Qiu**



College of Engineering
MICHIGAN STATE UNIVERSITY

INTRODUCTION

In a tech-driven world, our goal is to revamp real-world biomedical systems and utilize developing technology to improve people's lives. We're on a mission to create a user-friendly wearable device that is easy to use while impactful by monitoring heart rates. This project bridges the knowledge that we gained in class to healthcare, envisioning wearables as part of daily life. In a world filled with technology, we're aiming to create something that not only fits into your daily life, but also helps you easily keep track on your heart health effortlessly. Our project is more than just a class assignment; we hope to reimage and recreate instruments that change people's lives.

SIGNIFICANCE AND IMPACT

With approximately 40% of the U.S. population being obese, the need for accessible and proactive health solutions has never been more critical (Faberman, 2023). Our project addresses this pressing issue by creating a wearable device for daily health monitoring, aiming to significantly impact public health awareness and preventive measures. Creating a wearable for daily health monitoring, our device stands at the forefront of health awareness, offering a convenient and non-intrusive means of daily health monitoring. We emphasize preventive health measures; our device empowers users to stay proactive about their well-being. By monitoring vital signs regularly, it becomes a reliable tool for the early detection of potential health issues. This proactive approach is crucial in a country where obesity rates are high as it allows individuals to take charge of their health before issues escalate.

Furthermore, creating an affordable solution for Widespread Health Awareness our device goes beyond being a novel gadget; it serves as an affordable solution for widespread health awareness. Cost-effective monitoring is a game-changer, breaking down financial barriers that often limit access to advanced health technologies. With Americans without health insurance in 2023 being record low of 7.7% in the first 3 months of 2023 (Tsai, 2023). Inclusivity is at the heart of our

impact. Regardless of geographical location or socioeconomic status, our device ensures that everyone, even in developing areas, can benefit from sophisticated health monitoring. This democratization of health care aligns with the urgent need to address health disparities and promote a holistic approach to well-being.

INNOVATION

In our project, we're taking a different route from the usual tech approach. Instead of creating a whole circuit that sweeps for frequency and filtering the noise, we're keeping things simple with microcontrollers. Microcontrollers offer rapid prototyping and are exceptionally suitable for hardware/software co-design. Our choice of a microcontroller-based design provides the flexibility to perform custom processing in parallel at high data rates, aligning with the demands of our project for heart rate monitoring. Importantly, microcontrollers allow us to implement upgrades and changes without the need for new hardware, a distinct advantage over application specific integrated circuits (ASICs) and complex programmable logic devices (CPLDs) that necessitate hardware replacements (Desai, 2012). A microcontroller-centric approach is not only cost-effective but also aligns seamlessly with our commitment to simplicity and accessibility in health technology. While our competitors employ multifunctional devices like the Apple Watch and Fitbit, our strategy revolves around simplicity and affordability. Rather than incorporating an array of functions that contribute to higher pricing, we prioritize a straightforward design using readily available and inexpensive components, making cardiovascular health monitoring accessible to a broader spectrum of consumers. Our innovation, aptly named The Health Hero, distinguishes itself by providing an affordable alternative for individuals seeking to monitor their cardiovascular health. By utilizing cheap and accessible components, we aim to break down financial barriers and promote inclusivity, ensuring that tracking and monitoring heart rate is not limited by financial constraints. Our overarching goal is to empower a diverse range of individuals, regardless of their financial limitations, to actively participate in promoting a healthier future through accessible cardiovascular

health monitoring.

RESEARCH APPROACH

Project Description:

The goal of this project is to create a wearable device that records vital information from the user and can display it onto a computer monitor. The specific vial information being recorded is the user's heart rate. There are a few design challenges that we must undertake when building this device. First and foremost, we must design a device that can fit comfortably on someone's wrist and is safe to wear while also not limiting the effectiveness and accuracy of the sensors recording the data. For it to be comfortable, the device must be relatively small which means our sensors, PCB, and additional components must be selected to be small and not cumbersome so the device can be worn during everyday tasks. For the device to be safe to wear, we must consider how to properly insulate the components while also making sure the sensors effectiveness remains uninhibited. Another challenge is assessing the best way to make the device portable. The best approach, we believe, is using a Bluetooth connection and having it connected to a computer monitor or mobile device to show our results in real time. The significance of our design will be that it will be created with the intent to be more affordable than its competitors, which usually have more complex functions resulting in a higher price.

The impact of our project will allow more people to be aware of their health daily, whether they are an athlete, an elderly individual, etc., without forcing them to pay a large amount of money to do so. The program we will use to do this will be the Arduino app. The data we expect to receive will be the average heart rate over a set period.

Methodology:

Over the course of the semester, we have the opportunity through our labs to be exposed to some of the technology we need to design and create our product. In one of our labs, we

experimented with checking our heart rates during various states of physical activity. Although our product will have some major design differences, the main one being that our product will be designed to be mobile unlike our equipment in the lab, these labs were crucial in helping us understand the circuitry and data needing to be collected to produce the results we want. Additionally, we looked at many products and websites for inspiration while researching our design. Our design must transmit the data to a portable LCD via minimal wired connections and transmit data to an app via Bluetooth to make our product more comfortable and easier to move with. When researching designs for heart rate monitor schematics, we found a good example by a user named Swagatam on Homemade Circuit Projects using operational amplifiers and capacitors (as well as various resistorsand diodes) to create a functioning circuit for the sensor. Other great sources we foundwhile researching can be credited to Instructible, Sourav Gupta (Circuit Digest), Electronics Hub, and Aman Malhotra (Electronics for You).

The business and commercialization of our project is focused on the affordability of our device. Wearable health devices are currently quite expensive with ones such as the apple watch starting at $250. The parts list for our device totals $30.65 which is significantly cheaper than anything similar on the market. With economies scale, our device could cut that cost even further. With such a low cost, our product will fill a gap in the market for affordable health devices. This will have the most impact on developing nations and underprivileged communities. To provide the best product, we will identify key target audiences, understand their needs, and align the device's features with those requirements.

Design Approaches:

In the development of our project, the primary focus was on the detailed design and development of a smartwatch aimed at efficiently gathering three vital healthdata points: heart rate, blood pressure, and body temperature. Our goal was to seamlessly integrate these features into a compact and user-friendly wearable device, akin to other smartwatches available in the market. To achieve this, we planned to utilize an Arduino Pro Mini as our main microcontroller and

Bluetooth chip. We planned to use an internal battery to power the device and output data to an SD card. Our sensors would be connected as shown in the initial schematic below.

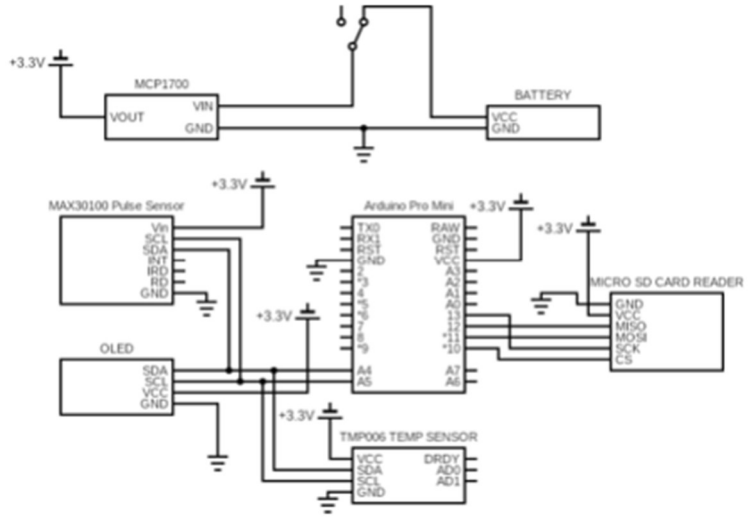


Figure 1: Initial schematic of the system.

These choices were later changed due to size and time constraints to just monitoring heart rate. We were also provided with parts from the school to make the simpler system.

Final Design:

The Arduino Nano 33 will serve as the central control unit, orchestrating the interaction between various components in our system (7). Key components include an LCD, a heart rate sensor for monitoring, a battery, and our protoboard. These sensors will be connected to the control board, ensuring accurate and reliable data collection. Power will be supplied by an external battery due to the Arduino getting power from USB only.

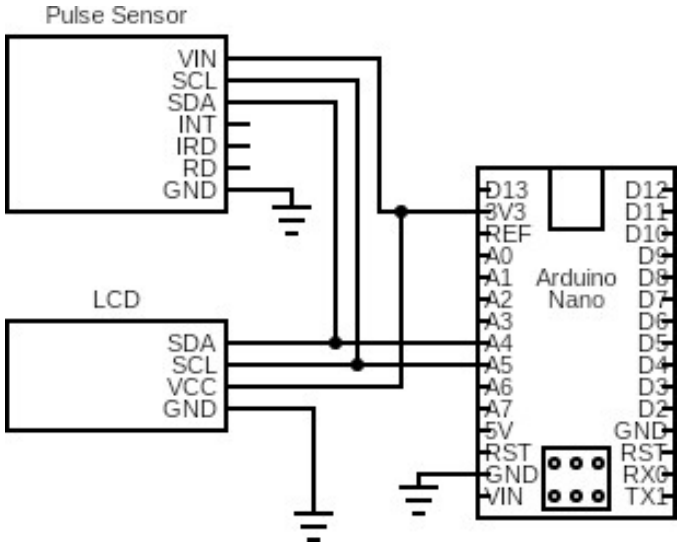


Figure 2: Final schematic of the system.

The operational workflow involves activating the watch, triggering the Arduino-generated code script. This script will consistently attempt to gather health data through the sensors. The collected information will be displayed on an LCD screen on the device, providing immediate feedback to the user. Additionally, the data will be transmitted and stored via Bluetooth, facilitating tracking and retrieval through a smartphone or computer interface. This comprehensive design ensures that our smartwatch not only effectively captures essential health metrics but also integrates seamlessly into the user's daily life, offeringboth real-time feedback and data accessibility through digital platforms.

EXPECTED RESULTS

Our expected results are to create a device that will accurately record the vital information of users and display it to a screen. Because we are using a Bluetooth connection to transmit our data, it will display the results in real time. The device will use its Bluetooth functionality to transmit the heart rate of the user to a phone. The results will show both a representation of both pieces of data being taken but also tell the user their heart rate per minute will also be displayed. These results recorded on the app allow the user to see over time how their heart rate changes

during a change in physical activity. During our presentation for our final demo, you will see the difference in these vitals when the user is sitting in a relaxed state, standing, and jogging.

Results and Analysis

Design Outcome:

After designing our device through diagrams and schematics we build the system in the lab. The final product turned out like what we expected but there were some limitations we realized throughout the build process. The biggest of these was the Bluetooth connection. Our Arduino device only supported Bluetooth Low Energy (BTE) which is a completely different standard connection not supported by most computers. To overcome this challenge, we downloaded a BLE app on our phone to connect to the device. This setup did not have a good user interface, but it did allow us to test the Bluetooth functionality.

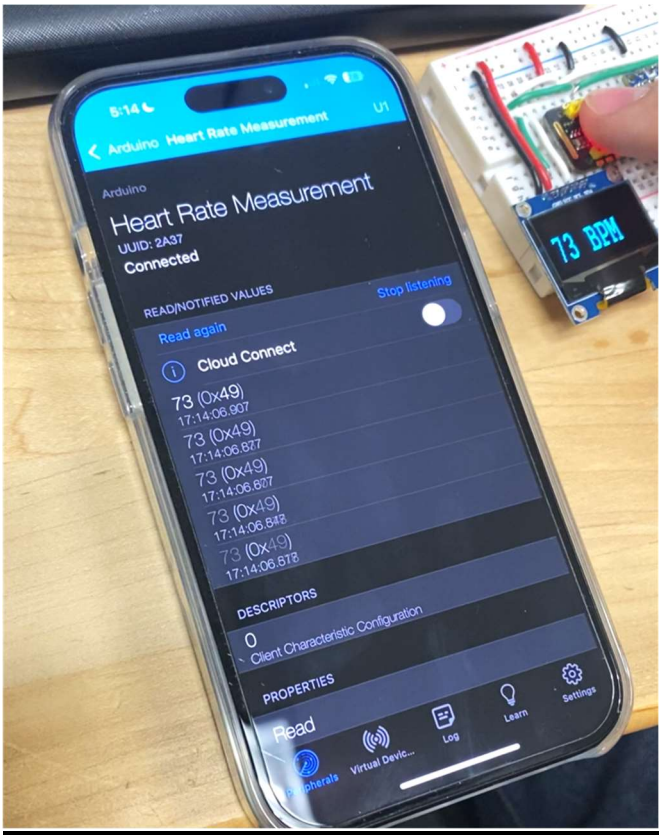


Figure 3: Photo showing BTE connection and continuous updating.

Another issue we came across in development was in implementing a waveform to show the heart rate on the LCD. This was a feature we hopped to add after our initial design, but we failed to implement it after multiple labs due to the way our heart calculated. Other than those two hiccups, we accomplished our goal in this project. We created a wireless system that can accurately measure and display the users heart rate via an LCD screen and Bluetooth. Our final system is shown in the figure below.

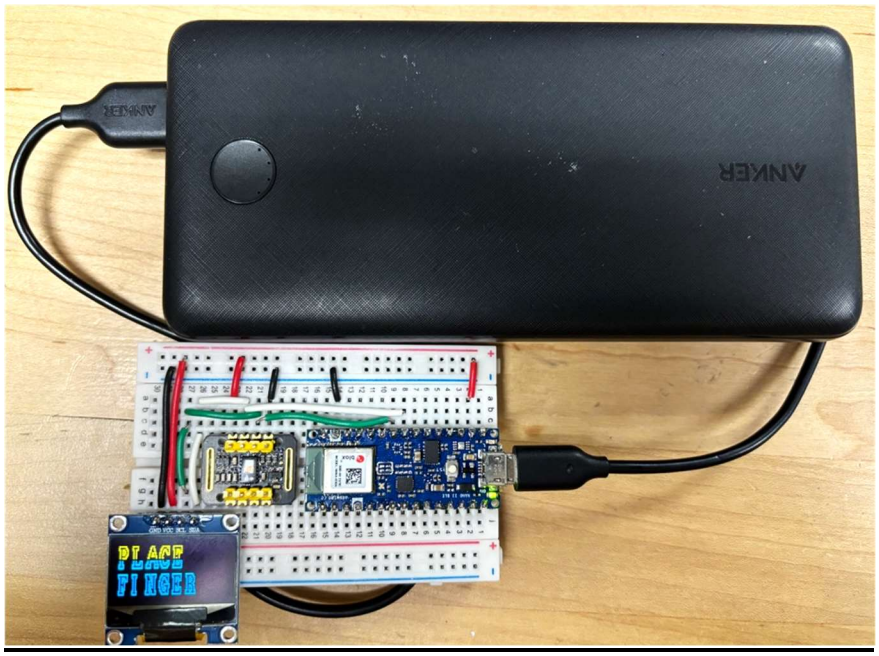


Figure 4: Photo showing full final system.

Analysis:

After our device was complete, we tested the accuracy. We compared its output to an apple watch to see if it was comparable to comparable devices currently on the market.

Table 1: Measured each exercising heart rate after one min of jogging in place.

Health Hero vs. Actual Resting Heart Rate				Health Hero vs. Actual Exercising Heart Rate			
Test number	Watch	Health Hero	Difference	Test number	Watch	Health Hero	Difference
test 1	81	79	2	test 1	117	118	1
test 2	76	80	4	test 2	115	113	2
test 3	80	74	6	test 3	121	123	2
test 4	81	82	1	test 4	118	112	6
test 5	78	82	4	test 5	123	120	3
Average	3.4			Average	2.8		
Std. Dev.	1.949358869			Std. Dev.	1.923538406		

After analyzing our testing results when compared to a more expensive device, it is clear we were able to achieve a very accurate and portable device using much cheaper means. As shown in figure 2, the test was conducted by comparing the health hero to the Apple Watch and seeing if the two devices gave similar readings when showing heart rate. The first set of tests were done while the user was relaxed. The second set of tests were conducted after the user jogged in place for 30 seconds. We knew this would be a good test to conduct after we did something very similar to this in a previous lab to test our heart rate. We also knew the Apple Watch generally gives very accurate readings, so directly comparing the two devices would give us good insight into the accuracy of our device. The results of the testing show the average difference in readings between the two devices as well as the standard deviation. During the resting period, the average difference was 3.4 bpm. While exercising, the difference was smaller at 2.8 bpm. The standard deviation was roughly the same at 1.95 for resting and 1.92 for exercising. There is a small margin for improvement, however the readings on the Health Hero are extremely close to that of the Apple Watch and thus extremely accurate.

SUMMARY

The implications of our device and testing show that if this product were to be created on a

large scale, many people who do not have access or the financial resources to heart rate monitors could receive the information and care they desire through our innovations. Not only with this product be influential in the United States, but we could see this being used by people in less wealthy countries as a cheap but effective solution to analyzing their health. This is the first iteration of our product and future innovations could focus on making the device even smaller while still maintaining its very low price point.

Overall, a cost effective and quality product like the one we have created could have lasting impacts on our society and communities all over the world. This project proved to be both challenging and informative and we are very happy with the result which we have achieved. The most difficult part of the process was creating a final code that made the microcontroller perform in the way in which we needed it to. This took many weeks and a good amount of trial and error. But in the end, we were able to get it to work.

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