1

Poor to Proper Posture

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***Abstract*—The modern world is almost entirely dominated by electronics and many people today find themselves stationary for hours at a time, whether it be sitting behind a monitor at an office or behind a steering wheel. While being stationary, many individuals inherently suffer from poor posture which can cause many long lasting negative effects for overall health, being detrimental both mentally and physically. To solve this epidemic problem, our group has designed a wearable system that will detect when a user hunches and then notify them through a small, continuous vibration that will stop once the user goes back to proper posture. As a result, the user is able to target their posture habits directly. Our product will be entirely battery powered and last at least 20 hours as well as have wirelessly charging, and users will be able to connect with the device over bluetooth to view progress.**

I. Introduction

About half of the American population are concerned about their posture. As a technological driven society we spend more and more time on our devices. As more office jobs become more prevalent, back and posture issues start to arise.

A. Problem

When sitting at non optimal desk for user's height, people tend to slouch which can cause a series of issues [2]. Being misaligned puts a lot of stress on your body and your body will compensate for those changes such as rounding of the shoulder or having your head positioned forward. These stresses can add unnecessary pounds to your body. Other than the obvious effects of poor posture, there are other side effects such as headaches, heaving breathing, fatigue and multitudes of issues that can arise from poor posture [1].

B. Existing Products

Many products have been invented to fulfill the same role as ours, though they mainly consists strap-on braces that forcefully correct user's back. There have been positive results where it has helped people fix their back issues. However there have been negative reviews and results with the back braces. One of the issues of wearing a back brace is that it is not a permanent fix and people cannot wear it for too long because the user's body will get adjusted to it and it will defeat the purpose of the product trying to correct user's posture [4]. Other issues are that it is not a one size fix-all which means that some back braces are not meant to fit for your body type because the way how our spine curves and everyone's spine curves differently. In addition, not everyone is at the same stages with their slouching issues. With our product, it will be a device that can be put on and off on different clothings that will also be comfortable and non-forceful. Along with comfortability, people can adjust the threshold of curvature that the device monitor and notify the user to stand up straight when threshold is passed. That way people can slowly work your way up to a proper posture than rush the process that may cause other issues for your back.

The other product is an electronic device that can measure the posture of your back. The device can measure the angle that your back is at and has a buzzer that reminds the user to stand up straight. The sensors that the product uses are accelerometers and gyroscopes [5]. Some issues with using these sensors that in certain cases it may not work because of the limitations on the sensors. For example, if the user were to be on a rollercoaster while wearing the device, the gyroscope will most likely be going off constantly or if user is playing a sport that involves a lot of jumping that may also affect the gyroscope and accelerometer readings. Even though there have been many positive reviews with these devices on Amazon [6]. The product still comes with bad reviews and issues that can occur from using the device. One of the biggest issues is putting the device on the user's back which is one of the crucial parts of the design. People have complained that the adhesive does not stick the device and the user's back together and sometimes the device falls off or needs to be readjusted. Also the user will need to buy new packs of adhesive every time they run out. With our product the user will not need to buy new packs of adhesive packs nor need to stick something directly onto their backs. They will have the device be connected to an undergarment such as a T-shirt. Since we will be using a curvature sensor, limitations that come from a gyroscope will not be an issue for our product. In addition we will be focusing on the lower back which the other device does not consider. We will have two sensors that will be measuring the lower back and the upper back to help the user have proper posture.

C. Societal Impacts

The people who will benefit from our back posture product are people with poor back postures and people who have back issues. Our product will help them build healthy habits that support proper posture in a non forceful way. There will be a setting that allows different levels of hunching which will help ease people with severe back problems to a better back. Since we want this system to be convenient and user friendly, we added the functionality of changing the levels of hunching before the device reminds the user. In addition, add a tracker of how many times the user has hunched on that day to create a reward system so the user is more inclined to stand up straight throughout the day.

D. Requirements Analysis and Specifications

We want our product to vibrate every time the user is hunching and be able to function for a whole day without

1

recharging. Also there will be bluetooth that will interface between the posture device and a smartphone so the user can calibrate proper posture, hunching and the level of hunching that is acceptable. As we can see in Table 1. we have our system specifications and requirements. We want our system to be light and power efficient which can last for about 20 hours, which is more than enough for an average working day. In addition, we want the battery to be conveniently charged without a usb but instead with an inductive coil. Once the system detects hunching it will vibrate a motor within 5 seconds, giving the user a 5 second leeway before it vibrates because the user may be picking up an object off the floor which can trigger the system. To prevent the system from short circuiting from sweat or rain water we will make it have an IPX grade 4.

Requirement	Specification	Value
portable	weight	<.5lbs
	size	<10cm2
	battery powered	<lasts 20 hours
	inductive Charging	<charges in 5 hours
responsive	latency	<every .5 sec sample
safety	sweatproof	IPX 4

Table 1: Requirements and Specifications

II. Design

A. Overview

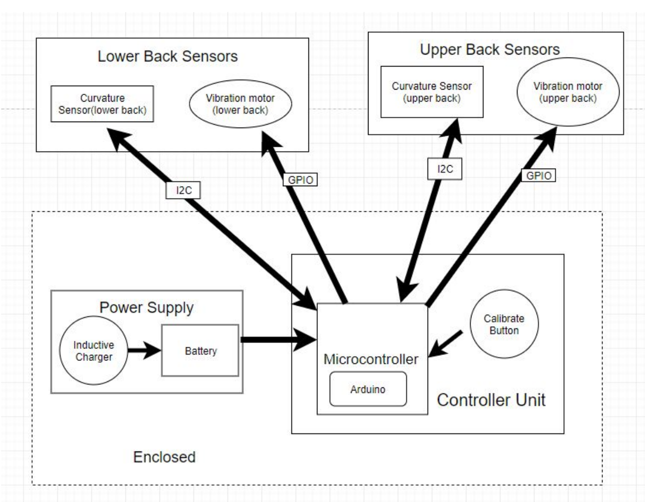

Figure 1: Block Diagram of our device. It has two curvature sensors, power supply, and microcontroller.

We will develop a product that uses vibration to notify the user when he is in a bad posture. We are going to use Capacitive curvature sensor, small vibration motor, and power efficient microcontroller. See the block diagram in Figure 1. The Capacitive curverture sensor is very accurate, the error is half a degree in curvature[10]. We need the precision because the curvature sensor is only about 10cm long and the curve on the back in 10cm is very small. With a sensor that's less precise, we wouldn't be able to notify the user hunching in a timely manner. We also considered resistive curvature sensor. See Appendix A for details.

The curvature sensor needs to measure the curvature accurately, we have conducted tests to guarantee that. See Appendix B for detailed test procedure. The whole system relies on battery for power, we will collect data on the system current and use that to calculate the battery life and ensure that it lasts 20 hours.

B. Embedded System

The brain of the whole system is the microprocessor that dealing with the sensor data and trigger the vibration motor at the correct time. At first, we used Arduino UNO as the microcontroller. The reason is that the manufacturer of the curvature sensor has wrote a driver targeting Arduino. It makes it very easy to set up and have the prototype working. We just need to make the correct pin connection and upload the program. But Arduino consumes a lot of power, so we carefully chose the low power variant of the 8 bit microprocessor - ATTINY 416 as the microprocessor used on the demo. Using Atmel Studio Integrated Development Environment, we programmed it to communicate with the curvature sensor using I2C protocol. The chip has I2C hardware built in, so we need to read the datasheet and use different registers to control the I2C component. The curvature sensor has a driver code written for Arduino Platform using the wire library. Since there is no wire library for ATTINY 416, we wrote our own I2C communication code. There are still problems with the code as it requires manual reset to reestablish connection. We will keep working on improving the code during the next semester.

C. Power and Charging

As a portable system our product will be powered by a small rechargeable lithium ion battery. After power consumption was tested to be 30mA@4V while passive and 72.5mA@4V while active a 1000mAh 4V Li-Ion battery was chosen. This battery fulfills the requirement for a 20hr use with overhead. With a battery powered device we introduced a to charge it. Due to the desire to create a completely enclosed, water resistant device, Inductive charging was implemented. The inductive charger we chooses uses 2 coils with inner diameter 29.9mm outer diameter 38.7mm in conjunction with a rectifier and oscillator to transmit power wirelessly. This induction charger provides 5V DC with a maximum of 500mA current draw, dependent on coil distance. In our design the coils will be 2-3mms apart with 200mA draw. To charge the battery from the inductive charger we are using a board that keeps the battery topped off by dynamically changing the current based on the batteries current capacity.

As the battery gets closer to capacity the current is reduced till it is trickle charging to keep the battery topped off. Using skills learned in our electronics class and lab we must test this circuit to determine many of its parameters. To determine proper charge time we must test their current draw of circuit from the output of the charging circuit at carrying induction coil distances. In testing the efficiency of the inductive charger we tested the output current at the rectifier against varying input currents.

D. Curvature Sensor

The most important and most expensive part of our product is the curvature sensor. Since the data from the sensor needs to be accurate, precise, and reliable, we decided on using the Bend Labs single axis flex sensor. According to Bend Labs, the single axis sensor has very low power consumption (78 uA active run current), zero drift, and a repeatability of 0.18°. Not only this, but it is also water and weather resistant, made with a flexible silicon elastomer which allows for unrestricted bending and stretching. As something that needs to be strapped up along a user's spine, the qualities of the Bend Labs sensor lead us to pick it over other less accurate sensors.

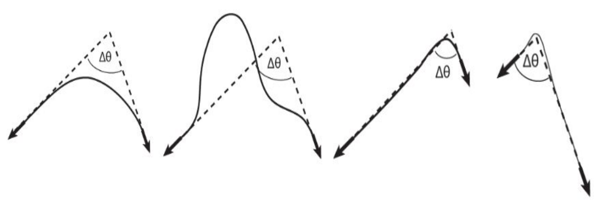

Figure 2: Path independence demonstration of flex sensor

Observing Figure 2 above shows one of the unique properties of the sensor, in which regardless of the path the sensor takes, the angular displacement is independent, thus all four paths of the figure above will theoretically yield the same result. As all humans have different curves to their spines, this path independence quality of the flex sensor is an important part of our product and will allow it to be used on nearly every person. To correctly make use of the single axis sensor, we must use data and signal processing techniques from our Hardware and Signals and Systems classes to manipulate the I2C protocol that the sensor is based off of. Since we aim to use multiple sensors in parallel, we must also learn how to manipulate the parallel I2C bus to get accurate and noiseless data from each sensor. To test out the accuracy of the sensor we will conduct various angular measurements to simulate the precision of the sensor at various set angles, making sure to power cycle the sensor as to simulate its on and off states. This test will demonstrate the precision of the sensor as well as the repeatability of our product as a whole.

III. Project Management

MDR Deliverables:

1. Be able to read the curvature sensor data
2. User will be able to recalibrate the curvature sensor based on their correct posture
3. When a certain angle is reached an LED will light up with the vibration motor running
4. The battery will be inductively charged.

We have successfully completed the MDR deliverables for point 1, 2 and 3. The status for the 4th deliverable has been has not been finished yet because we cannot run the system with the current battery because it is a 4V battery while the system requires at least 5 volts to run optimally. However, we have gotten the inductive charging to work for the battery. We have made the system portable by attaching it to a 5V battery but that cannot be inductively charged. In table 2 it is the group contribution to MDR. After MDR is table 2 which describes the team's work for CDR.

Table 2: Gantt chart for MDR

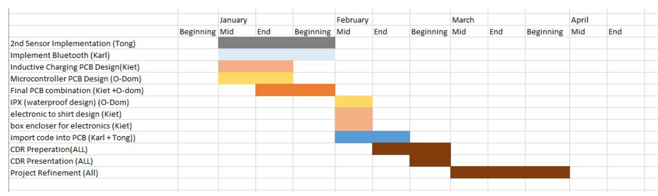

Table 3: Gantt chart for CDR

IV. Conclusion

In this semester with the effort of the whole team, we create two prototypes, one uses Arduino and the other one uses ATTINY 416. We have gained experience in working with the capacitive curvature sensor and I2C protocol. We were able to charge the whole system with inductive charging.

In the next semester we are going to put all the components on PCB. Our goal is to make it less than 100 square centimeters. We are also planning to waterproof the whole product using silicon. Both PCB and enclose in Silicon are new to us, so we have to learn as we go.

Acknowledgment

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Appendix

A. *Design Alternatives*

We could have used resistive curvature sensor, but the capacitive sensor is more accurate and doesn't have any drift in measurement data[10].

We have considered different Microprocessors and ATTINY416 seems to be the most power efficient and reliable one.

B. *Testing Methods*

So far our group has only executed precision testing for the curvature sensor to demonstrate its repeatability. For this test our sensor was set up to simulate 0 degrees and 90 degrees, in which we measured with a protractor to make sure we were as accurate as we could be. Since we had the baseline for what was theoretically 90 degrees, we then proceeded to take the sensor reading at 90 degrees, resetting the sensor back to 0 degrees after taking the reading. We took 40 samples in total following this procedure and plotted each iteration.

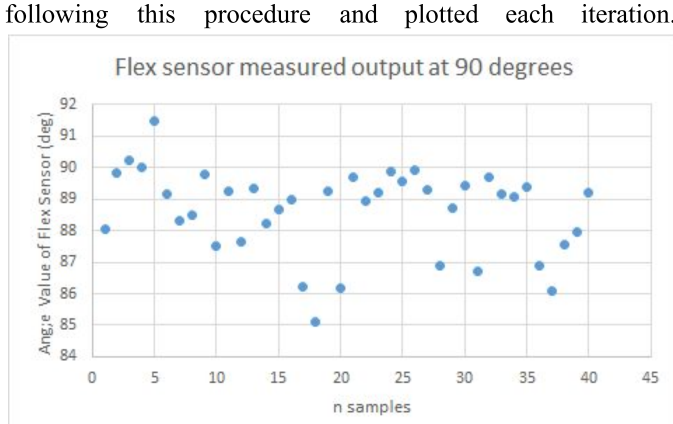

Figure 3: Sensor readings of 90 degrees conducted with 40 samples to demonstrate accuracy and precision

Observing Figure 3, the flex sensor output generally comes short of 90 degrees, with a sample mean of 88.6 degrees and a standard deviation of 1.335. By assuming that the sensor output was purely Gaussian, we were able to conclude with 95% confidence that the true mean of our output is 88.6265 ∓ 0.413661 degrees. This data shows the flex sensor to be very reliable and repeatable regardless of what state the sensor is in.

Although this test shows the precision and accuracy of the flex sensor, we only conducted it at 90 degrees. Since the change in angle of the back when someone hunches versus when they have good posture is small, we need to be able to demonstrate that the sensor is able to discern smaller angles as well as smaller changes in angles.

To meet our design specification of a battery lasting at least 20 hours, we would need to take various current draw measurements for each of the blocks of our product. Since the flex sensor has extremely low current draw, the only component that will determine how big of a battery we need is the microprocessor. To meet our design specifications of users being notified of their hunch within 5 seconds, we would need to take various measurements to see how long it takes our system to respond.

C. Team Organization

We divided our work and each member of the team was given work that matches his expertise. Kiet worked on hardware, in particular the soldering, battery and inductive charging. O-Dom worked on hardware, on curvature sensor, making sure it works and soldering the curvature sensor circuit. Karl worked on the Arduino prototype which we then used to measure the accuracy of the curvature sensor. Tong worked on ATTINY 416 prototype which we used to put on a shirt as the demo. Each lead work in their corresponding fields through starting discussions, problem solving when a bug arrose, or assigning parts to team members.

At the night before the MDR demo, we worked together to create and debug the prototype and test the prototype. After 4 hours of debugging and testing, we finally found the solution to stabilize the sensor output - decrease the sampling rate of the sensor.

Throughout the semester, we increased workflow and productivity by assigning team members to their appropriate field of study within the project and separating tasks to individuals or small groups. The team coordinated two or more full team meetings throughout the week as well as several small team meetings spread intermittently. This provided an optimal progression of ideas. During large team meetings discussions were held for basic ideas and goals to be bounced around and analyzed. Once completed, each goal was assigned to a small team or individual. Each individual would then conduct their own research and meet with their small team to discuss more in depth on planning and ordering parts. Once parts were purchased, small teams would complete their components and then it would all be combined and tested in the large team meetings. This process insured everyone had a job at a given time and contributing towards completing project as a whole. Everyone worked in parallel and making sure their component function properly. Then the whole system were combined and the whole team test and troubleshoot together.

D. Beyond the Classroom

In the project, we have to develop effective communication skills to fully utilize the expertise of each team member. Also the skills to read datasheet of Microprocessor and curvature sensor and website development. Researching online has helped us solve certain problems with some of our code and hardware. Those skills are invaluable to our future work in the industry.