Perfect Posture

Team 38 - Julianna Gecsey, Apoorva Josyula, Rohan Kanianchalil
ECE 445 Project Proposal -- Spring 2021
TA: Daniel Vargas

1. Introduction

1.1 Objective

During the pandemic many people have been sitting more frequently than they would have been in the past. While sitting for long periods of time may not seem to cause great threat to one's back, through extended sitting one's posture may significantly worsen and hit a point in which their "hunch" will lead to extreme back pain. As hard working students we recognize the issues that follow poor posture and are eager to diligently come up with a solution to poor posture -- perfect posture. Through ECE 445 we are creating a wearable device that when attached to a user's back will accurately assess their posture and alert users of potential necessary adjustments, preventing future and helping current back problems.

1.2 Background

Back problems are typically excluded to being thought of as issues with lower back angles which neglects solving all posture issues since posture follows through with the neck. While the lower back is important the upper lordosis and cervical spine connect to form an important C-shape that is proportional in all humans. While an action like sitting in an office chair may not have many negative effects on the lower back, it is very common for people to position themselves into the "head forward" position in which this C-shape is no longer maintained [1]. Although this position does not cause many issues in the beginning, over time this causes kyphosis, muscle dystrophy, and is linked to future lower back issues. In order to determine the severity of one's head forward position doctors measure a patient's craniovertebral angle which is between the tragus of the ear and the C7 vertebrae of the spine [2]. As a group of ECE students we want to fix this problem.

Although similar back reminder concepts exist, they are expensive and do not focus as heavily on the upper back region in which we know as a main problem area.

1.3 Physical Diagram

The diagram below shows a visual representation on how the device will be worn on a person's back. All our sensors and other devices will be encased in a plastic case. With the back of the plastic case having a skin safe adhesive to be able to stick onto a person's back. The wires connecting these components will be put through a fabric so be gentler on a person's back.

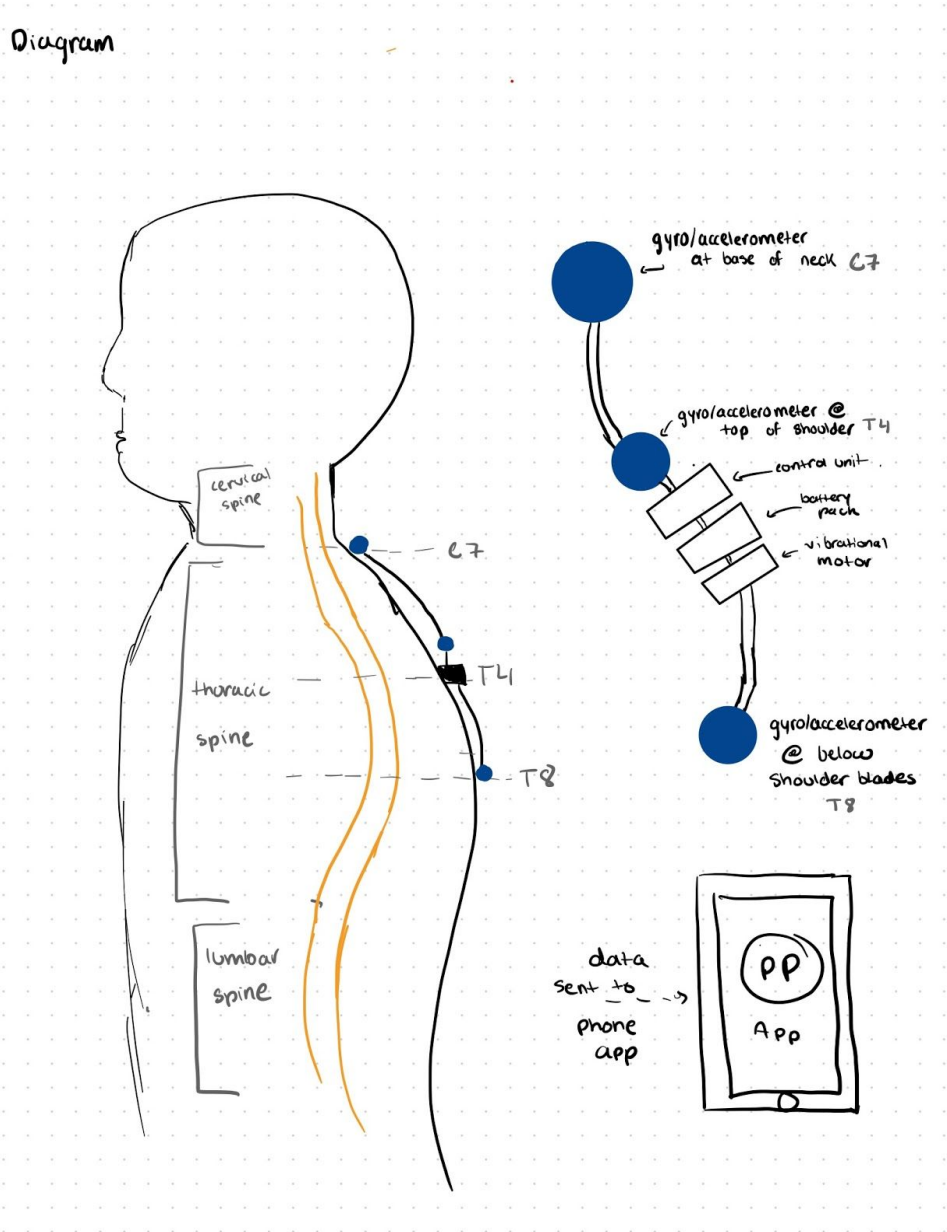

Figure 1: A diagram to show how the device will be worn

1.4 High Level Requirements

1.4.1 Use the accelerometer and gyroscope to calculate the change in degree from the ideal C-Shape of the spine.

1.4.2 Data taken from the Microprocessor via bluetooth will be interpreted visually through an app on an individual preferred device.

1.4.3 Through push notifications on the preferred device and a vibrational motor within our physical device, will notify the user over a 10 second interval whether their posture is off the ideal degree.

2. Design

2.1 Block

2.1.1 Block Diagram Description

In order to build out this device we will be required to work out the following block diagram. As you can see our block diagram consists of four main subsystems: sensor/feedback system, control unit, app interface, and power system. Each subsystem is described in greater detail below.

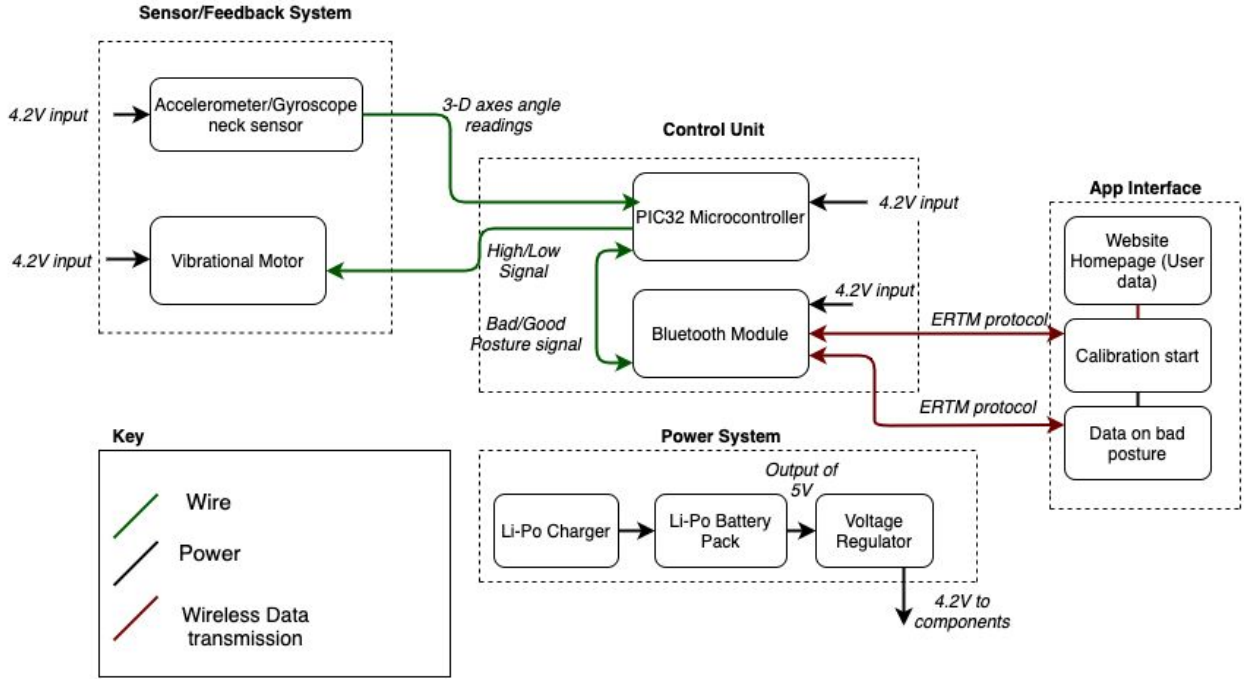

Figure 2: Block Diagram for Perfect Posture product

2.2 Functional Overview

2.2.1 Power Supply

The power subsystem consists of a Li-Po Charger, Li-Po Battery Pack, and a Voltage regulator all connected to one another through wires, and eventually attached to the feedback subsystem. This subsystem ensures that necessary power is delivered to each component meanwhile regulates the voltage delivered to provide user safety. These processes are able to occur through the nature of how each component is designed to work.

2.2.2 Control Unit

Our control unit consists of a microcontroller that will acquire raw angular data from our sensor system that connects through a data bus and convert them into readable angle values. It will relay the information to our bluetooth module whenever there is significant deviance from each data reading.

The bluetooth module will then return to our app interface when the app has decided to either start the calibration process or just want data to send to users about current posture data. The bluetooth module will also receive information back from our app interface whenever the angles are deviated from the calibrated position which will then send that signal back to the microcontroller.

At that point the microcontroller will start a timer and after a given time interval will send a signal to the vibrational motor, sending more vibrations as the interval time in the bad posture increases.

2.2.3 Sensor/Feedback Unit

Our sensor subsystem will consist of a gyroscope and an accelerometer. The combination of these two sensors will give us a raw data value of the x,y,z plane position of where the sensors are at. Three sensor units will be placed along the spine to ensure we can read an accurate picture of how a person's "C-shaped" upper spine position looks like. The sensors will relay their positional data to the microcontroller, where it will store the changes of values when there is significant movement.

The feedback system will be our vibrational motor. The vibrational motor will be in charge of alerting the user whenever their posture is off for a significant amount of time. It will receive either a High signal (indicating the posture is off so turn on motor) or Low signal (posture is fine for now so stop motor). The vibrational motor will be set off again whenever the time spent in the bad posture continues to increase.

2.2.4 App Interface

Our App interface will be in charge of the algorithms used to measure the spine. The first algorithm will be the one that will help start the calibration process of what that person's initial back posture is. When the calibration process is started the app will send back the calibrated angles to the control unit so the control unit will have in memory where the user's position should be. The app interface will also be keeping track of the deiviances of the user's spinal position. Since we care about maintaining the "C-shape" of the spine there will be an algorithm that will take in the new angle data readings from the control unit and determine if the shape of the spine is remaining in the correct curvature. It will send a signal back to the control unit when the algorithm detects that the shape has actually been compromised.

2.3 Block Requirements

2.3.1 Power Supply

The system must be able to supply 4.2V +/- 0.1 to the different components in the device.

Voltage regulator must take in the output voltage given by the Li-Po batteries and regulate the appropriate amount to be given out to the different components to the devices.

Li-Po charger should appropriately charge the batteries to 5V +/- 0.2.

2.3.2 Control Unit

The microcontroller will poll information from the sensors through I²C data bus. It should also convert the raw x,y,z angular data from the sensors into readable angle values. The Microcontroller will have memory space to hold in calibrated angle values of a person's back and send angular data values to the bluetooth module.

The Bluetooth module will receive information from the microcontroller regarding angular data and send it to the app interface. The Bluetooth module will also receive signals from the app interface regarding whether to start the calibration process or not and whether the sensors are out of the correct position.

The Microcontroller must also receive a signal from the bluetooth module when sensors are out of position. It must then send an initial signal to the feedback system alerting the user the position is off. After the initial signal it must wait an interval of 5 minutes before sending another signal.

2.3.3 Sensor/Feedback System

Gyroscopes will record rotational values in the x, y, and z plane of a person's back. It will have a steady output of readings that doesn't deviate more than 2 degrees when in a stable position for more than 2 seconds. Accelerometer will do the same as a gyroscope but will record the acceleration values in the x,y, and z plane.

The sensors will be placed at the C7, T4, and T8 positions of the spinal vertebrae to measure the C shape of the upper spine.

Vibrational motor will turn on when receiving the high signal from the microcontroller. When the High signal is received, the vibrational motor will be turned on for 10 seconds.

2.3.4 App Interface

App interface receives angular data reading from the sensors via Bluetooth.

App interface will include a calibration start button that will let the control unit know that the current readings from the sensors are a person's upright position. It should calibrate for 30 seconds to read steady input. Calibration should read angles received and compare to our default angle measurements of the C7, T4, and T8 to make sure no more than a 2 degree variation is being read.

As readings come in from the bluetooth module it will go through an algorithm that will determine if the change in position is significant enough to indicate bad curvature posture, change in C-shape.

The algorithm should measure change in C-shape by reading individual sensor readings from each different position and measuring if the difference of the angles have changed from the calibration positions.

2.4 Risk Analysis

The Control Unit poses the biggest risk to the completion of the project. The control unit will have to consist of receiving and sending multiple signals while also carrying memory of the appropriate calibration angles. Translation from the app interface and control unit might not be completely synchronized or could have the potential of the data being corrupted. The control unit will also have to be relatively small in size in order to not bear down weight onto a user's spine.

3. Safety and Ethics

When creating our project, we have to consider a few safety issues as well as some ethical as well.

Starting with the issues that could possibly occur during the development of the project is the usage of 3 accelerometers and gyroscopes. With that many being in use, if we are not careful

with how things are wired and powered, it may cause a malfunction in our project. Continuing on, with the usage of a microcontroller and a bluetooth module, if we miscode the microcontroller, we may cause an adverse effect in our project.

Regarding the physical issues with the device in regards to the user, we have to consider many factors. We must consider the voltage of the battery when designing our implementation so that it may not cause harm to the user. We must also consider how the accelerometer and gyroscope may affect the wearer and the rpm of the vibrational motor so that it doesn't hurt the user. Finally a factor to consider is the type of adhesive used when placing the device on the user.

There are few ethical codes that we must worry about when we design our project. Because our implementation is physically being put on a person, we have to make sure that we follow code 1.2 of the ACM Code of Ethics: Avoid Harm [3]. We must make sure the adhesive and the components of our invention that are being placed on a person will not harm them in any way and cannot be used in such a way that it negatively impacts the user.

With our project including an app interface, we have to also consider code 1.6 of the ACM Code of Ethics: Respecting Privacy [3]. Our project constantly monitors an individual's posture as well as many calibrational factors, such as weight, height, age, etc. , so we must keep the users information confidential as those factors are private to oneself.

One more ethical issue that we should highlight and make sure to follow is the IEEE code of ethics 7.8 subsection 10: to support colleagues and co-workers in following this code of ethics, to strive to ensure the code is upheld, and to not retaliate against individuals reporting a violation. [4]. This is a code that we have to uphold because we are making something from scratch , which entails 100's of hours of potential work. We must make sure that although we must put that amount of effort into our project, that each individual in our group is making sure that they are both physically and emotionally well and ensure that there is a balance between the work needed for this project as well as a healthy off-work life.

Reference:

[1] spine-health.com, “How to Measure and Fix Head Posture”, 2018. [Online]. Available: https://www.spine-health.com/conditions/neck-pain/how-measure-and-fix-forward-head-posture.com [Accessed 18-Feb-2021]

[2] spine-heath.com, “Forward Head Posture’s Effect on the Cervical Spine”, 2018. [Online]. Available: https://www.spine-health.com/conditions/neck-pain/forward-head-postures-effect-cervical-spine.com [Accessed 18-Feb-2021]

[3] acm.org, "ACM Code of Ethics", 2018. [Online]. Available: https://www.acm.org/code-of-ethics. [Accessed: 18- Feb- 2021].

[4] Ieee.org"IEEE Code of Ethics", 2016. [Online]. Available: http://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 18- Feb- 2021].