Back to Healthy Posture

1. **Introduction**
    - **Objective:**

        i. Many people do not sit correctly and have bad posture. This can lead to back problems, pains, and potentially cause a medical issue. There should be a way to monitor one's posture and have feedback for their sitting position over the course of a work or study day. There are many components of good posture, such as lack of movement, kyphosed, slouching and imbalanced sitting posture [1] [4].

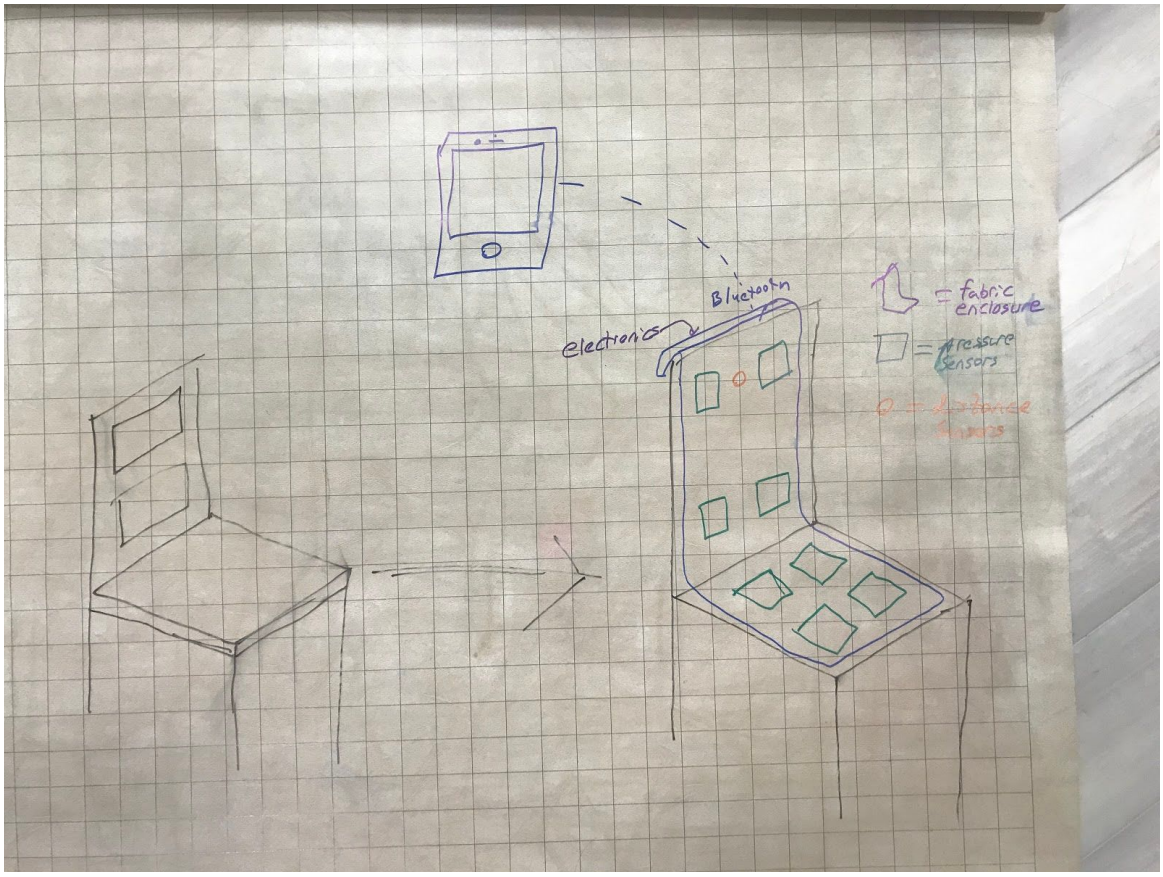
        ii. The system will consist of 8 or more pressure sensors, 1 distance sensor, and an app that the user can download. This apparatus will be draped over the seat where the user sits. It will measure the force applied to the backrest of the chair and to the seat to see if proper and even pressure is applied by the seating posture.

    - **Background:**

        i. Back issues can lead to less mobility as moving around too much can be painful. Additionally, there are high medical costs associated with back surgeries and even just when a medical professional has to work around the back issue for something unrelated. Finally, chronic back pain has been shown to lead to an increase of negative and downhearted daily feelings [2].

        ii. Similar to the SP15 COMPACT SLOUCH DETECTOR and SP18 ORTHOPEDIC CHAIR, we plan on monitoring the sitting position of the user and telling them how they could improve their posture. Our proposal is a combination of the two mentioned projects that covers both the sitting and back posture, and would use a phone app component for checking if the posture is good and providing feedback. This feature, plus that our design is a cushion instead of an entire chair, makes our design portable and could be placed on any seat that one would be sitting on, minimizing the inconvenience caused by the user having to always use a fixed chair or put on a wearable device, which is the case with the previous projects.

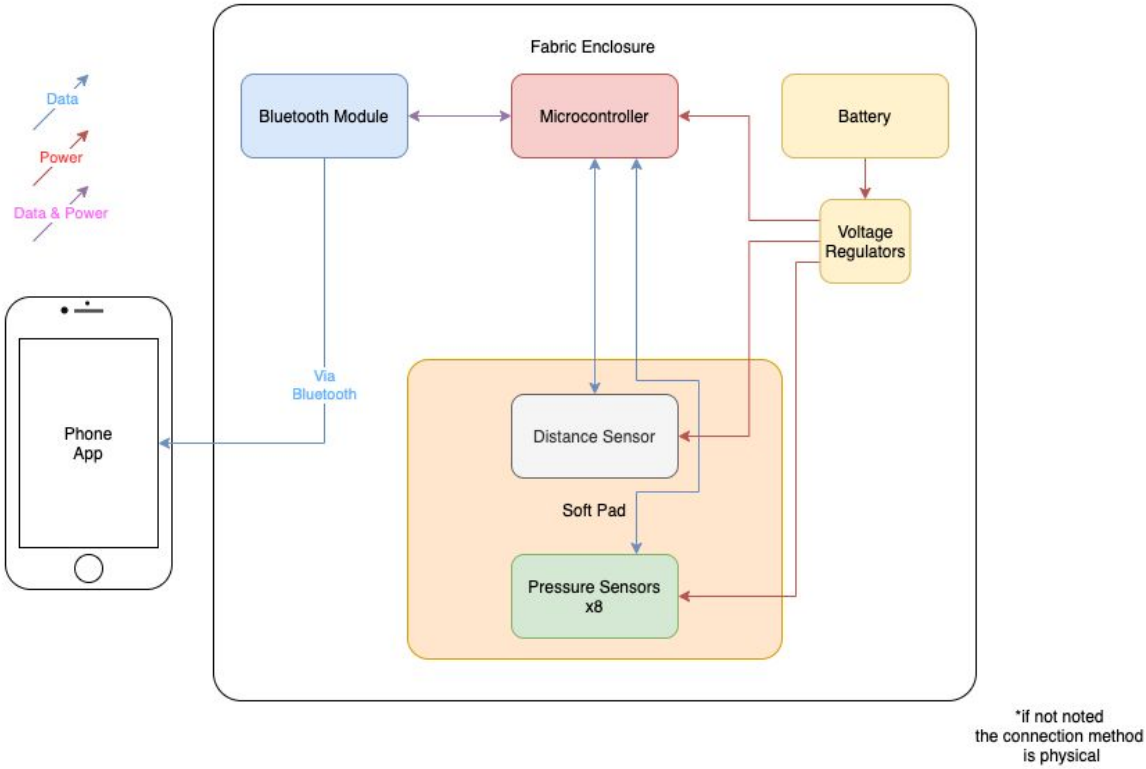
- **Physical Design:**



- **High-level requirements list:**

  i. The user needs to be able to check **pressure** data calculated by the system in real time with an accuracy of 0.5 kilogram.
  ii. The user needs to be able to check **distance** data calculated by the system in real time with an accuracy of 1 centimeter.
  iii. The user needs to be able to adjust parameters to fit their personal data and check their feedback using a phone application as interface.

2. **Design**
    - **Block Diagram:**



After the battery voltage is regulated the microcontroller reads the data from the eight pressure sensors and one distance sensor and packages the data to be sent off via the bluetooth module. The module then sends the data to the phone application. The phone application takes the raw data and converts it into a display for the user to actively monitor their seating position.

- **Functional Overview:**

    i. Pressure Sensors - These devices measure what force the user is applying to cushion and send the data to the microcontroller. They are powered from the voltage regulators. They nominally have a very large resistance (manufacturer says “approximately infinite”), but when depressed they change to a lower resistance. Using a voltage divider, one can calculate the resistance and convert that to a pressure amount.

    ii. Battery - This supplies power to the device. The voltage is nominally 7.4 volts from the battery, but it can range from 6-8.8 volts. The decision was made to use a lithium polymer (LiPo) battery due to the longevity of the charge from a LiPo battery. The voltage is a bit too high for the devices and so the power is first passed through the voltage regulator.

    iii. Voltage Regulators - These convert the battery voltage to the correct level for each component. For battery safety reasons the circuitry will shut off the system if there is too low of a voltage (UVLO). The voltage we will run on will be 5 volts for the pressure sensors, microcontroller and distance sensors and they are all sensitive to variations in voltage so the 7.4 volts must be converted. For safety reasons, multiple voltage regulators will be used because the sensors will be in direct contact with the user and we would like to limit the maximum current through. On the other hand, we would like to limit the current to the microcontroller to a lesser degree.

    iv. Microcontroller - Interprets data from pressure sensors and distance sensors and sends the raw data to the phone application via a bluetooth module. The structure of the microcontroller will be an Arduino Mega chip and using their design suggestions.

    v. Bluetooth Module - The bluetooth module should transmit data between the microcontroller and the phone app. The module we have selected supports up to Bluetooth 4.0 which is sufficient for our needs.

    vi. Phone App - The phone app serves as a user interface. It should allow input and storage of baseline data from the microcontroller for postures the user considers as healthy. It will also evaluate data sent from the microcontroller via bluetooth and warn the user of bad postures in real time. This will determine what is a good posture when the user goes through the process of setting up the application each sitting session. This is to account for individuals who deviate from the “normal” sitting position (due to an amputation, bone defect, etc.).

    vii. Distance sensor(s) - This device is mounted towards where the upper back of the user rests. It measures the distance of the upper back and

helps determine if the user is in a compromising position. The device uses ultrasonic sound waves and measures the return wave timing in order to determine distance.

viii. Soft Pad - Simply a swapable pad that the user can remove. The user can adjust the firmness of the device by swapping to a different pad. Additionally this allows the user to remove an element of the device for hygienic reasons.

ix. Fabric Enclosure - A more durable fabric sleeve that holds all the components in place and in the right position. This is how the user will physically interact with the device.

- **Block Requirements:**

Pressure Sensors - These devices measure what force the user is applying to cushion and send the data to the microcontroller.	The pressure sensor must be able to differentiate to a degree of at least ½ a kilogram.
Battery - Supplies power to the device.	Supply current equal to at least 2.0 A for all the components.
Voltage Regulators - These/this converts the battery voltage to the correct level for each component.	Should supply 5 volts ± 0.1 volts. Should be able to supply 2.0 A ± 0.1 A for the microcontroller and 10 mA ± 1 mA
Microcontroller - Interprets data from pressure sensors and distance sensors and sends the raw data to the phone application via a bluetooth module.	This should send the data to the bluetooth module at least 4 times a second.
Bluetooth Module - The bluetooth module should transmit data between the microcontroller and the phone app.	This should be able to send off the data from the microcontroller at least 4 times a second.
Phone App - The phone app serves as a user interface. It should allow input and storage of baseline data from the microcontroller for postures the user considers as healthy. It will also evaluate data sent from the microcontroller via bluetooth and warn the user of bad postures in real time.	1. The app should detect if it is run on a compatible platform in terms of hardware, operating system, and library support. 2. It should provide the user with an “Set Default” mode that allows input and storage of a set of baseline data. 3. It should be able to process all the incoming data and give a visual feedback to the user. This should all happen and update 4 times a second.

Distance sensor - This device is mounted towards where the upper back of the user rests. It measures the distance of the upper back and helps determine if the user is in a compromising position.	This device must be accurate to within 1cm.

2. **Risk Analysis:** If the voltage regulator is not able to keep the voltage within our tolerance of voltage then the devices could become damaged or (in the case of the pressure sensors) give very varying results. We can possibly mitigate the issue with the pressure sensor if we were to measure the voltage digitally with the microcontroller.

3. **Ethics and Safety**
    - Due to the fact that a human will literally be sitting on an electrical system strong care must be taken to ensure maximum safety.

      The main way this problem is tackled is by separating the user from the electrical components with a layer of insulating fabric and an insulating foam pad (in addition to its qualities in making the apparatus more comfortable). The wiring should be contained as much as possible within the fabric sleeve to distance the user.

      Luckily, the main parts that the user will physically interact with are the pressure sensors and the distance sensor, as the remaining components drape behind the seat or are based on a phone. The two sensors will require very little power, but they will have up to 5 volts across so we will attempt to limit the current able to be supplied by tuning the voltage regulator related to the sensors to only about 10 mA. This is still a dangerous current amount but the lower we are able to tune the system the better.

      These precautions should comply with the IEEE Code of Ethics #1 which states that we will agree “to hold paramount the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, and to disclose promptly factors that might endanger the public or the environment” [3]. In fact our product may even increase the health of the public as back problems are very detrimental to our health for more than one reason [2].

      We cannot say, though, that our product is guaranteed to help the health of the user. This is because good posture will not *absolutely* help one’s back and we cannot ensure that the user will use the product to the extent one might need. We do not guarantee this statement because we try to adhere to IEEE Code of Ethics #3 which states that we agree “to be honest and realistic

in stating claims or estimates based on available data” [3]. We do state that proper use of our product will help a sizable margin of the moderate or less severe posture cases, but not all cases.

Our application setup requires the user to sit in a position that they determine to be “proper” posture. This is because each person is unique in their sitting pattern and potentially what weight distribution they possess. This complies with IEEE Code of Ethics #8 that says “to treat fairly all persons and to not engage in acts of discrimination based on race, religion, gender, disability, age, national origin, sexual orientation, gender identity, or gender expression” [3]. We do not intend to discriminate if the user has a weight distribution that does not align with our original testing or code for whatever that reason may be.

4. References

[1] “Chronic Back Pain,” *Health Policy Institute*. [Online]. Available: https://hpi.georgetown.edu/backpain/. [Accessed: 04-Apr-2020].

[2] J. Huizen, “Tips for Sitting Posture at a Computer,” *Medical News Today*, 21-May-2018. .

[3] “IEEE Code of Ethics,” *IEEE*. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 04-Apr-2020].

[4] “UNITED STATES DEPARTMENT OF LABOR,” *eTools | Computer Workstations eTool - Good Working Positions | Occupational Safety and Health Administration*. [Online]. Available: https://www.osha.gov/SLTC/etools/computerworkstations/positions.html. [Accessed: 04-Apr-2020].