# Smart Chair

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***Abstract* – The project is a smart chair that encourages healthy habits in an office job. One of the many issues facing office workers is back pain caused by long periods of time sitting coupled with poor posture. The product includes an array of sensors that are located on the seat of the office chair and gather data on the user's sitting trends. The smart chair monitors how long the user sits and reminds them to get up at a regular interval. The device also monitors the user's posture and provides feedback. The smart chair pairs with an application on the user's phone to provide feedback and reminders.**

***Index Terms* - Diseases, Internet of Things, Mobile Applications, Pressure Sensors, Web Services**

## I. Introduction

The National Institute of Neurological Disorders and Stroke claims that back pain is the most common job-related disability. Around 80% of adults will experience back pain during their lifetime and 25% of adults have experienced back pain recently.

According to Spine-health's website, sitting in office chairs involves a 'static posture' that can cause or worsen back pain. The increase in back pain is caused by over-stretching the spinal ligaments due to posture used when sitting in an office chair (slouching). A prolonged slouch posture can cause damage to the spine. It is advisable to maintain proper posture when sitting in an office chair to reduce the cause of this pain. Ergonomic chairs can assist in improving back support, but will not stop back pain unless the proper posture is used [1].

According to Spine-health, proper posture includes making sure your office chair is adjusted appropriately as well as your sitting posture.

Regular standing breaks can aid in reducing back pain induced by office chairs. Spine-health recommends getting up from an office chair at least once every half hour for at least one to two minutes.

While the market does offer products to aid in improving posture, those options are very limited and difficult to employ. The design team's goal was to develop a product that allowed the user to improve their posture without requiring an apparatus to be attached to their body. Our product offers a subtle and more comfortable option for users who want to improve their posture.

## II. Overview

The main goal of the project was to use pressure sensors to gather data on weight distribution and to analyze that data to help the user track trends and present the data to the user in a graphical format. In order to meet this objective, the design team elected to use pressure sensors and a modified center-of-gravity equation (with fixed-distance averaging) to determine if and in what direction the user was leaning. Once that value is calculated, the data is transmitted to storage in Firebase in the form of a Cartesian coordinate. The user can view this data in the form of an application with a scatter plot whose quadrants correspond to quadrants of the chair (front-left, front-right, rear-left, rear-right). In order to provide more immediate feedback for the user, a vibration feature was added to cause the chair to buzz if the user holds poor posture for a significant period of time.

The posture data is generated by an array of pressure sensors placed on the seat of the chair beneath the foam padding. The placement of these sensors was decided by determining the center of the chair and then identifying where the user's legs would rest relative to the center.

Storing the user's posture data is performed by visualizing the chair as a Cartesian grid and determining a variation on center of gravity from the center of the grid. If the user is leaning forward and left, the coordinate will have a negative horizontal (left-to-right) value and a positive vertical (front-to-back) value. Since it is very rare for an individual to sit perfectly dead-center on the chair, a tolerance threshold was introduced to increase the usability of the data.

The vibration feature reminds the user to correct posture by vibrating if the user has held poor posture for a set amount of time. If the user meets this condition, the vibrate modules will vibrate. As some users may find this feature undesirable, the developers added a toggle control to the mobile application to permit the user to turn off the feature.

Storage of the user's data was performed by way of Google's Firebase Realtime Database. The embedded software on the WiFi module uploads the Cartesian coordinates to the Firebase database. This data can be accessed via the mobile application.

The mobile application pulls the user's sensor data from Firebase and displays the coordinate points on a scatter plot. This allows the user to see their sitting trends referenced against the quadrants of the chair. The design team postulates that if the user can see how they are making posture errors, that it will be easier for the user to correct them.

## III. Power

A proper power supply is a key component of the design. In a design that requires mobility we considered multiple modes of power and ultimately decided on a dual supply, consisting of a 120v wall supply and rechargeable 9v battery.

### *A. Power Supply Standards*

This design utilizes national and international standards which exposes the product to a global market. A main objective was to have a safe design because using electrical components incorrectly can cause damage.

The team needed to chose a power supply that met international power standards. The power supply needed to have the proper conductor and insulator to protect the smart chair against electric shock and making sure it was safe to move around because the intended user may not stay seated in one place. There is also a battery power supply implemented in it. As you know, batteries are hazardous. It was important to use these standards to regulate the chair as there would be human interaction with the product. Batteries could cause severe burns and can explode when full of charge and being used under a volume of weight.

The power supply that we used in this project met the American and European standards to prevent the electric shock such as, fire, explosions, burns, and hot wires. We had to do calculations necessary to pick the power supply cords and the adapter systems needed to convert from AC to DC. The following table has standards that are use around the world for any projects that contain power supply specifically explosive stuff like batteries that can cause negative effects on humans being and materials.

The power standards listed in the following table are a few that were kept in mind throughout the design process. These standards provide broad market access and constraints to key features which helped to maintain a scope on the project.

| Standards | Description | Details |
|---|---|---|
| IEC 60950-1 | Safety of Information Technology Equipment. | Intended to prevent injury and damage such as electric shock, fire, dangerous temperature. |
| IEC 60065 | Safety of video, Audio, and similar electronic apparatus. | Intended to protect against fire, electric shock and injury, electronic equipment and communication. |
| IEC 62368-1 | Audio, Video, Information and communication technology equipment | Standards that currently govern companies marketing audio-visual products, computing and communications equipment in North America. |
| IEC 60601-1 | Safety of Medical electrical equipment. | Covers the basic safety and essential performance applicable to medical electric equipment including surgical, monitoring, hospital devices and been revised so many times. |
| IEC-61010-1 | Safety of measurement, Control and Laboratory equipment. | Requirements for measurement, control and laboratory equipment. It protects the electrical shock, fire and burns injury. |
| UL 1310 | Safety, Standards requirements for 2 class power units. | Covers indoors, outdoors that use 2 power supplies and batteries. Uses for residential and industrial. |
| UL 600799 | Standards that use for explosive atmospheres. | Covers electrical equipment that use for explosive atmosphere like construction, gas, combustible dust. |

Table: Power Supply Major Safety Standards

In the 19th century, electricity was a major problem in the world of technology. Thanks to some scientists in the 20th century that used their brain to beat the challenge by inventing electricity DC to AC and AC to DC, now we can use technology in our products with a low cost. The smart chair used a power AC source of 120V and 60 Hz for North America which designates that the alternating current 60 times per second in the substation where it comes from. As our design required DC current, we had to use a wall adapter that convert AC to DC to run power to our board. We had to stepdown the voltage that come from the wall then using a rectifier and a voltage regulator that kept the components running at a constant voltage so that the components will not be burned and explode due to unstable voltage rate.

First, the AC power in the wall is 120V. we used a stepdown transformer from 120V to 5V because the most of our components are using 3.3 to 5V. As you know the input voltage is not always perfect, we had a capacitor that connected in parallel to the load, regulator and a diode where the main function is to regulate the DC voltage from the transformation AC to DC so that the battery that used in the system can charge automatically and keep the charge for an amount of time because the smart chair is not connected to the wall consistently. To do so the battery that used is rechargeable and intended to supply about one week of use.

According to Wikipedia, using a rectifier in the project helps to take the alternating current and transform it to direct current to reach the amount of current that we are using on the load. As we learned in electronics classes, we have two types of rectifiers: half-wave rectifier and full-wave rectifier.

Instead of using a half-wave rectifier, the design team used a full wave rectifier. The full wave rectifier converts the full input waveform to one with a constant polarity. The advantages of using the full wave rectifier are that it is more effective and converts both polarities of the input to direct current and it produces the voltage higher than the half-wave, and it has a positive effect on the negative sinusoidal input where it provides a continuous power supply on the circuit. Due to the advantages of the full wave on the circuit, we used it to stabilize the direct current that we have in the smart chair. We accomplished the change from the alternate current to direct current which was the main purpose of the electrical supply to achieve the function of a full wave rectifier. We had to calculate and build the design by using diodes, capacitor and resistor to connect to the sensor.

Using a full-wave diode connection gave us the opportunity to accomplish the project because it had 4 diodes connected to get the transformation that we needed. One of the diode functions is helping to get the direct current in the right direction and have two pairs of diodes that conduct the direct current DC in one direction. Having four diodes in the rectifier is divided in two halfwave, one half wave for the positive direction and the other halfwave for the negative direction. Through we used a full wave, we had to add a capacitor in parallel with the load to regulate the current going to the load. The reason that we need the capacitor is to charge and discharge the alternating current input when they are switching. The battery is storing charge in case of main power supply loss where it provides a backup voltage to the load and prevents the components' loss of power.

### *B. Power Usage*

As we are using a rechargeable battery, it allows the user to replace the battery in case it has something wrong, without the assistance of a professional that will charge them a lot of money. One of our purpose in this project was using the printing circuit board to distribute the power in each electrical component. A 9V battery is powered the PCB and had 2 DC to DC converters because the board required a 5V to run and 3 to 4V to the rest of the component. We were using a step-down autotransformer with a combination of a rectifier to find the amount of voltages that allowed to power the PCB and the electrical component to get the accurate quantity of power at an unchanging rate. Selecting a 9V lithium battery gave the amount of voltage that each component needs at low cost.

## IV. PRINTED CIRCUIT BOARD

The PCB takes the breadboard test circuits and other prototype components of the design and provides a single, permanent location for them. This allows the core system of the smart chair to be concealed as to not impede with the regular functionality of an office chair. The final design of the PCB includes a dual power supply circuit which offers 5v and 3.3v regulators, 8 voltage dividers which utilize 8 ADC channels on our MCU, a crystal circuit and several GPIO pins for serial communication and other key components. Designing this PCB was done in Eagle which allowed for use of catalog part schematics provided by various manufacturers. From a cost perspective, we chose to utilize a Chinese vendor for manufacturing though, it results in a larger time delay, compared to U.S manufacturers.

### *A. Hardware Design*

As we know the PCB should be inside a box, we decided to design a 3D printing box that can fit for the printed circuit board PCB. We had a 3D wood printing that a dimension of 20 inches by 15 inches so that the PCB and all the other components can sit inside for safety because everything that has electricity flow on it should be protected to people. Smart Chair can move around and sell to world, we used SolidWorks to design the 3D wood board so that the dimension can be shape because plastic 3D printing costs too much. It is protected with the plastic cover because in electricity we used plastic as an isolate that means even there is water in the area, it should be protected. As we are doing this project out of pocket, we do not want to make it too expensive that's why we are using a 3D wood board to design the shape[2].

*B. Embedded code logic for operating sensors*

In order to have the capability to connect wirelessly, the device that is used is the NodeMCU using the Wi-Fi capabilities built into the development board. The NodeMCU is a System on Chip (SoC) which is a development board ready to be used along with an MCU to process data and commands, while being simple and easy to work, also inexpensive to acquire with enough pins that comes with analog and digital configurations. This board was impressive due to its capabilities, making the decision to choose it all the more worth while to be implemented for the project.

The NodeMCU is a device that allows Internet of Things platform functionality, such as connecting online via Wi-Fi. The specific module of choice from the NodeMCU lineup, is the ESP8266 that was developed by Espressif Systems that is based in Shanghai. The ESP8266 module itself has different types of variations ranging from the ESP-01 and ESP-12, while all the modules from this lineup has the same processor, what differentiates among them are the breakout board. Wi-Fi modules are important to connecting to the internet, although many equipment on its own are not able to connect to the internet, the capabilities to do so requires having a chip that enables that functionality [3].

**Pin Configurations:**

- **16 GPIO pins:** PWN pins
  - Control peripherals such as sensors, LEDs, switches, etc.
- **ADC (Analog-to-Digital Converter):** channel access through A0
- **SPI:** 4 pins (SCK, MISO, MOSI, CS)
  - Communication through UART
- **I2C:** accessible support in internal pins
  - Master-Slave device
- **UART:** 2 main interfaces
  - **RXD0 and TXD0:** uploading code into the module
  - **RXD1 and TXD1:** can be used either module or microcontroller

**Specifications:**

- **Operating Voltage:** 5V
- **Flash Memory:** 4Mb
- **Processor:** L106 32-bit
- **CPU Speed:** 80-160 MHz
- **RAM:** 32K + 80K
- **GPIO:** 16
- **ADC:** 1 and 10-bit

What makes the ESP8266 important for making the project, is that is allows serial communication between the ATmega2560 MCU to transfer and receive data. This method was proved to be beneficial in the progress of the project, because the data transmission allows being transmitted wirelessly to connect to a database. The database of choice used in the project is Firebase, a mobile and web application that was acquired by Google.

*B. Wireless Communication*

In order to access to the database online, the ESP8266 with its Wi-Fi capabilities has made this possible to have connection to the Firebase databaxse. This makes the process of receiving the data from the ATmega2560 MCU and transmitting sensor values to Firebase. Since the ESP8266 is a microcontroller, it allows compatibility of programs and functions similar to that of the ATmega2560 MCU.

Programming the NodeMCU is almost as simple as the ATmega2560 MCU, while requiring board management and downloading libraries from the manufacturer. The similar compatibility makes it accessible to the various components that can be used as a master and slave device. The transfer of data becomes more seamless thanks to the compatibilities with other MCU and transmitting incoming and outgoing data to the database online via Wi-Fi.

While the NodeMCU has multiple compatibilities with the ATmega MCU, but there are complexities that comes along while starting out. It requires libraries from the manufacturer before programming on a desired IDE. Once libraries have been installed on an IDE of choice, the usability of the NodeMCU development board becomes much more simple and can begin working and testing projects along with the capabilities of Wi-Fi.

*C. ATMega2560*

Core to the design is the microcontroller which executes the various calculations and communications. The ATMega2560-16AU specifications are summarized in the following table:

| **Parameter** | **Min** | **Typ.** | **Max** |
|---|---|---|---|
| Supply Voltage | 4.5v | 5v | 5.5v |
| Clock Frequency | | 16MHz | |
| Program Memory Size | | 256kB | |
| RAM Size | | 8kB | |
| FLASH Size | | 4kB | |
| GPIO Pins | | 86 | |
| PWM Channels | | | |
| ADC Channels | | 16 | |
| ADC Resolution | | 10 bit | |

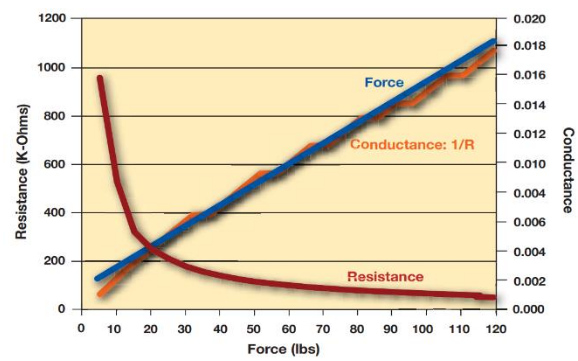
| | |
|---|---|
| Interface(s) | 2-wire, UART/USART, SPI |

Table: ATMEGA2560 Summary

The selection of MCU's from microchip technology is vasted with their acquired Atmel portfolio of ATMEGAxxx's. Specifically, the ATMEGA2560U16 offers a 16MHz frequency (internally clocked with an XO), This MCU allows for up to 256 KB of programmable flash which would allow for our project to be of relatively large file size. It contains 2 8-bit timers and 4 16-bit timers for a total of 6 isolated timers. It also offers a total of 86 I/O's, and 16 ADC channels [39]. These ADC channels are crucial to our design as we will have 10 sensors and may accommodate more should our measurements require a higher degree of accuracy, as defined in our engineering specifications. This MCU employs real-time clock. Another great feature is that it has six low power modes to ensure efficiency and power savings. The MCU allows for four external interrupts which is slightly less than the previously looked at MCU [39]. One of the benefits is that this MCU has a total of 86 general purpose I/O lines which means we will be able to connect several components onto the MCU without any issues. Another plus in this MCU is that it uses the highly favorable 16-bit computer architecture. The chip contains 4 UART, 5 SPI, and 1 I2C serial ports for digital communication [39]. This is by far one of the best options we have as it allows us to simultaneously communicate with the various components we have in our design. Additional requirements that are met with the selection of this microcontroller are the size constraints of our pcb as this is smaller than the TI equivalent. In terms of cost this controller does price higher than the ti at 12.04 per unit (under 25 units). This controller offers an operating voltage of 5 volts with a tolerance of ten percent (plus or minus), this is more ideal for the sensors being considered[4].

## V. PRESSURE SENSORS

Based on research and specifications of our project as it relates to sensing the user, the sensor type that met our constraints is the piezoresistive force sensor. A brief recap, the piezo sensor applies a known voltage across a variable resistance material. As pressure (or force) is applied to the material, the resistance will change. This change in resistance is not linear across the entire load range of the sensor, however when coupled with the right measuring setup, and tuned to a specific range, it can be accurate to within 5 percent. While the sensor cannot accurately determine where within its physical dimensions the pressure is applied, in an array it can very well offer data on weight distribution relative, to other sensors. Considerations made when determining sensor choice include cost, surface area, load range, drive voltage, and response delay. It is important to note that based on the sensor selected, the driving circuit will be constrained to what is best suited for said sensor. The driving circuit can be a number of choices including inverting/non inverting op amp or voltage divider. In our application, to meet pcb size constraint and cost, we chose the voltage divider setup which allowed for tuning to a range within average weight of a person in the United States. The following chart shows a typical response of resistance vs. force in a piezoresistive force sensor, provided by TEKSCAN [5].




***Resistance vs. force graph***

In order to verify the functionality of the force sensors, we devised a method to power them and define a reasonable response based on the following parameters: is the return signal amplified, what is the supply voltage, how much force is being applied (this must be some form of standardized weight for calibration. Referencing manufacturer provided test data, we should be able to determine with a high level of certainty, whether the sensors are operating within specification. After verifying functionality to manufacture spec, we confirmed our design theory that the sensors can be amplified using the MCU. We utilized circuit analysis and reference designs to aid in the integration of the crucial components.

In testing the sensors Tekscan recommended the sensor's be calibrated before initial use. According to their implementation guide, this is done by uniformly over loading the sensors several times; doing so allows sets a reference by which the sensor can be tuned. What is happening during this process is we are looking for a specific voltage output from the sensor based on a ten percent over load (110% loading). Whatever the deviation is from the desired output we can tune the sensor by supply voltage or, line resistor.

This line resistor acts as a voltage divider between the supply voltage and the sensor.

Due to the construction of the sensor, it is important that care is taken in mounting the devices. They are designed for point or distributed loading, not shear force measurements which means forces are exclusive to the z-plane we do not want lateral pulling or pushing on the sensor. however, as their name suggests the flexiforce sensor is somewhat malleable which will prove useful for the contours of our chairs seat. Again following the OEM’s recommendation, double stick adhesive tape is used to mount the sensors in place. By using tape versus a permanent adhesive we can ensure that the sensors don’t experience uneven or biased load distribution.

Referenced in the previous section is the concept of load distribution on the sensor. we can load the sensors in a few ways. One involves simply mounting them to the base wood of the chair and then applying the foam padding on top, allowing the foam to act as the buffer and distributor for us. Another method would be to “puck” the sensors; add a hard material onto the sensor’s readable area and let the foam rest upon that. In testing we find that either method is suitable, however since user comfort is important to us, the use of pucks may affect comfort for sensitive users. Based on the test results, we determined that the foam padding of the seat would be a sufficient barrier and provide optimal data, compared to an uncovered sensor in similar test conditions.

Below is a table that provides an overview of the conditions and locations of our sensors, in both a physical and digital format. This physical locations help in the calculations of our modified distance averaging equation, as we know what each individual sensor should read at, and can build in error detection functions around this.

| Sensor Location | ADC channel | Cartesian X value | Cartesian Y value |
|---|---|---|---|
| Front Left | A0 | - | + |
| Front Right | A1 | + | + |
| Rear Left | A2 | - | - |
| Rear Right | A3 | + | - |
| Small Front | A4 | 0 | + |
| Small Back | A5 | 0 | - |
| Small Left | A6 | - | 0 |
| Small Right | A7 | + | 0 |

*A. Embedded code logic for operating sensors*

Due A key design requirement is to provide the user with meaningful data. This is initiated in the embedded logic of our design. Overlaying a cartesian plane onto our chair’s base, we mapped the outline of our group members’ legs as they sit on the chair. This was combined with available data maps illustrating weight distribution of a seated person of average age and weight, as to not skew the data outside our target demographic. This was translated into an averaging equation from which we calculate an x and y coordinate. The load measured by each sensor scales the result in the corresponding region. Utilizing an interrupt service routine, we are able to define 4 demonstratable conditions that relate to poor seated posture. This interrupt is supported by several functions which allow us to translate the data and send to our database, which can then be retrieved by the user on their android application. The equation utilized follows this format, where n is the number of sensors, A is the known x or y value of that sensor and B is the known ADC output of that same. From this we derive two equations, one for x and one for y.

$$\sum_{i}^{n} \frac{A_i * B_i}{n}$$

VI. VIBRATION MODULE

In researching methods of notification commonplace in today’s technology we considered methods employed by smart phones. The vibrate style notification offers discretion and minimal distraction versus sound or light based notifications. Our design called for a small, low power device to be mounted within the chair. We came upon the DC coin vibrate module as a feasible solution. The model in use is the Dowonsol 2v-5v DC Coin Vibration Motor, also known as a pancake coin DC motor. This is small is size measuring at approximately 12mm diameter by 4 mm height. The motor is of a brushed type, and the z axis acceleration measures at approximately 0.8-1.2G. the device can be reflowed for surface mount applications, or can be ordered with an adhesive backing for non-SMT applications. In our design, the drive circuit consists of an NPN BJT, specifically the

N2222A. The supply voltage is set at 5v, with peak current consumption at 70mA. From the microcontroller this is controlled with a pulse width modulation (PWM) channel. Nested inside our aforementioned poor posture conditions are triggers for a vibrate sequence.

## VII. Transmission of Data

To have the ESP8266 function with the ATmega2560, Serial Communication is used to establish the connectivity and display the data. The Serial Communication is done so by connecting TX and RX pins as UART interface between both MCU. The starting end must use the TX pin which is connected to RX on the other end and vice versa between the development boards. Ideally the opposite pins must be connected from the boards, one end starts transmitting (TX) to the other board as the receiving end (RX) to establish the communication process.

## VIII. Data Storage

The development team decided to use the Firebase Realtime Database for data storage. Firebase is a NoSQL database that functions well with the mobile application framework. After data is transmitted to the database from the embedded software, it can be accessed by the mobile application. The data is organized into sets of posture measurements. Each posture measurement is composed of the x and y coordinates as well as a timestamp.

The database also holds a set of flags that are used to communicate settings between the front and back ends of the application. Fields such as 'notification' and 'vibration' are modified by the user to set user preferences. These flags are checked by both front and back ends to verify that vibrations and notifications should be served. The 'firePhoneNotif' field is used by the back end to communicate to the front end that the user is sitting with poor posture and a notification should be served if applicable. The 'getUp' field is also set by the back end to enable the front end to serve a reminder for the user to get up and take a walk after a set period of sitting.

The application and the backend rely on a system of pin codes to agree on where to read and write data. The pin is hard-coded into the embedded code and the user will received a pamphlet with the product that also encloses the pin. This system works to protect the user's privacy as user data is stored in a separate database from the account information.

Once a user has created an account, that pin is no longer available for anyone else to use. While the pins should not be duplicated, extra protection is added into the database to prevent writing over another user's data in the form of the 'usedPins' fields. Under the 'usedPins' Firebase child, there is a list of pins that have already been claimed by a user. When a user is signing up, if the pin is already claimed, the user is notified with an error message and the account is not created until a valid pin is entered.

## IX. Mobile Application

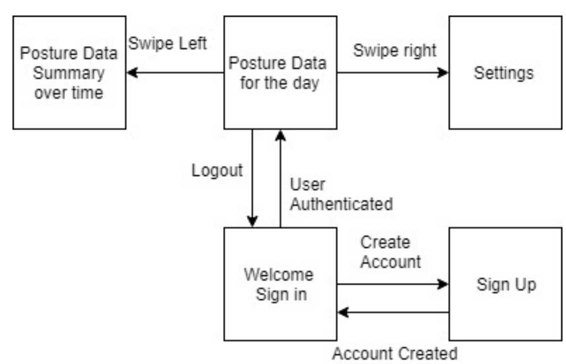
A mobile application was deemed the best method to provide meaningful feedback about the posture data to the user. Displaying the sensor data in a graphical format increases the readability and usability of the product.

The mobile application was developed with Google's Flutter framework in the Dart language. Flutter was selected as the framework for the application due to its reputation for speedy development and compatibility with Firebase.

The application makes use of Firebase's authentication system to handle user accounts and manage sessions.

The application is composed of 5 screens with distinct functions:

1. Sign In
2. Sign Up
3. Dashboard
4. Long Term Data
5. Settings




The sign in and sign up screens gather and process user input to manage accounts via Firebase. The password is salted and encrypted via Firebase authentication.

The dashboard screen is the landing page after the user is successfully authenticated. The dashboard screen displays posture data for the current day on a scatter plot. The dashboard also offers a 'I am currently experiencing backpain' button that offers the user a recommended stretch to attempt to help ease the ache. If the user swipes to the right, the long-term data page loads. If the user swipes left, the settings page loads.

The long-term data page offers a scatter plot with all of the user's data such that the user can use the two plots to track trends and watch their posture improve.

The settings page offers the user a portal to view and update their preferences. Here the user can toggle the ability of the chair to vibrate and the sending of phone notifications. The settings are saved as flag values within the Firebase Realtime Database.

## X. CONCLUSION

After completing the Smart Chair project, the design team reflected on the design and build process to consider future improvements. While the design was successful, the team noted areas where the design could have been improved and where the design decisions proved to be very helpful.

In regards to the sensors, the design team believes that the use of different sizes of sensors was unnecessary and would recommend future reproductions of this project to use one standard size for all sensors. The varying size did not allow for more detailed measurements.

Using the modified center of gravity equation proved to be very effective at determining how the user was leaning in the chair. The team recommends use of this equation if this project should be reproduced in the future.

Prior to the decision to use Wi-Fi to transfer the posture data to the database, the team explored using Bluetooth to transfer the data to the application and allowing the application to transfer the data to the database. This process was aborted due to limitations in the library compatibility. Using wifi proved to me much easier and a more reliable form of communication. Also, having the hardware push the data to the database and have the data retrieved by the application prevented data loss that could have occurred if the use closed the application or powered off their phone while the application was pushing data.

## XI. BIOGRAPHIES

Thien Nguyen is a senior at the University of Central Florida and will receive his Bachelor of Science in Computer Engineering in August 2019. He plans to pursue a career in the field of Embedded Systems. Developer for a startup company known as GratSee.

Annavay Kean is a senior in Computer Engineering at the University of Central Florida. She will be receiving her Bachelor of Science in Computer Engineering in August 2019. She will be working as a software engineer for Jacobs' after graduation.

Bonarine Ramjas, a senior at the University of Central Florida, will receive his Bachelor of Science in Electrical Engineering in August of 2019. His professional interests include RF engineering and Control Systems. Currently, he is an Applications Engineer for MtronPTI.

Mackenson Jean is a senior at University of Central Florida and will receive his Bachelor of Science in Electrical Engineering in August of 2019. He hopes to focus on power distribution and working for utility industries.

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