Divide and Conquer (II)

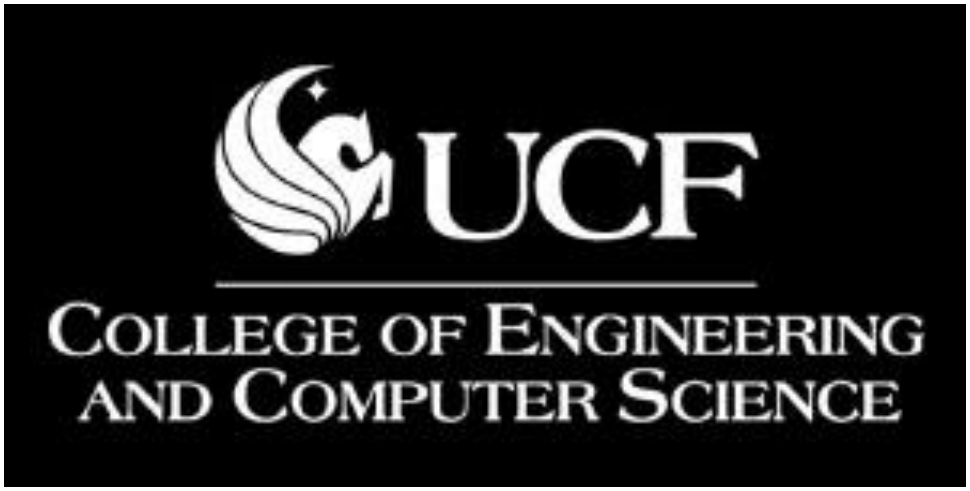
Senior Design 1 Spring 2019
Group 7

Members:

Makenson Jean (*EE*)
Annavay Kean (*CpE*)
Thien Nguyen (*CpE*)
Bonarine Ramjas (*EE*)

Customer:

Office Workers



1. Project Description

The project would be a smart chair to encourage 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 would include a 'pad' that would be placed onto an office chair with Velcro and would gather and interpret data on the user's sitting trends. The smart chair would monitor how long the user sits and remind them to get up at a regular interval. The device would also monitor the user's posture and provide feedback. The smart chair would pair with an application on the user's phone to provide feedback and reminders. The feedback will come from research related to common spine issues and simple techniques to provide relief. It would be beneficial for all people and offices because the smart chair will be powered by a low voltage power load and rechargeable. The battery itself will power all sensors, LEDs and Bluetooth detector. Due to the back pain by sitting too long in a chair, the smart chair will vibrate after a predetermined or user defined interval, and it will tell you how long you should get up and stretch or walk. The data being used to advise and correct the user's habits will primarily be collected using a grid of load or pressure based sensors. By using these, the design becomes more "plug and play" for existing office chairs.

1.1 Background

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.

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

How to determine if the office chair is adjusted correctly:

- User's elbows should be able to reach the keyboard and mouse while maintaining a 90 degree angle with the spine.
- Ensure that there is not too much pressure on the lower thigh by fitting two fingers between the seat and the user's thighs. If there is too much pressure on the thigh, correct with a footrest or raise the chair height.
- Check the chair back by ensuring a fist can fit between the end of the chair and the user's calf. If there is not sufficient room, adjust the back of the chair.
- The user's back should be pressed to the back of the chair such that the lower back support built-in to the chair pushes the lower

back slightly outward. This will protect against back pain and will encourage better posture.

- User's eye level should be level with the center of the monitor. Adjust monitor as necessary.
- Arm rests should be high enough to slightly lift user's shoulders. This will reduce pressure on spine.

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.

1.2 Competition

Current competition for devices that reduce office chair back pain or help to improve posture are few and far between.

There are ergonomic chairs designed to help with posture. These chairs cost between $100 to $200 dollars. These chairs encourage good posture by way of their design, but do not actively improve the user's posture and do not actively prevent back pain.

Ergonomic Office Chair

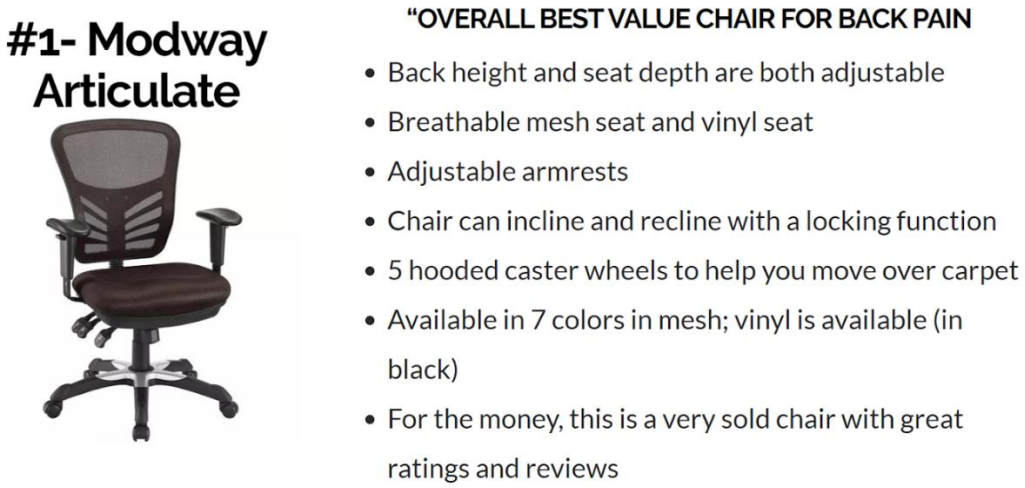


Fig.1

There are posture correcting devices like the one seen below. These devices do provide active feedback to correct posture, but require the user to stick pads to their back every morning or wear a harness-like device. Posture correcting devices sell for $30 to $100 dollars. Our product would provide a more convenient, set and forget, method of monitoring posture that would not require the user to put stickers on their back every morning.

Posture Correcting Device

Fig.2

Our product idea is unique to the market as a device that does not have to be applied and worn on the body, but does still provide active feedback on posture. Our product will not require continuous setup to maintain. It would also not require the user to replace their office chair. Posture-correcting chair add-ons are not currently for sale.

2. Requirements

2.1 Electronic Requirements

i. The device should update the sensor input readings every 30 seconds.
ii. The device should pair with a phone app and computer software.
iii. 5 day battery life, minimum.
iv. PCB not to exceed 230 cm squared.
v. Sensor array should be able to load a minimum of 100lbs (45.4kg).
vi. Vibrate module should operate between 200-400 Hz or rpm equivalent.
vii. LED notification lights should not exceed 1000 lumens (or equivalent rating)

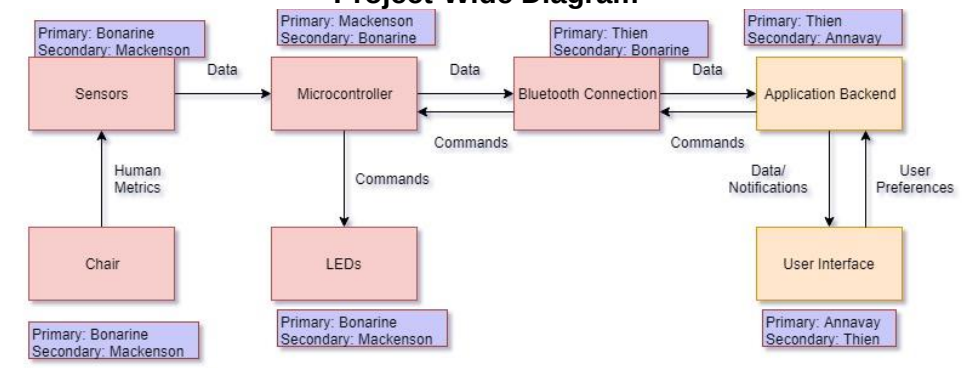
2.2 Application Requirements

i. The application should allow the user to log in.
ii. The application should save user data.
iii. The application should protect user privacy.
iv. The application should allow the user to set the time interval to be reminded to get up.
v. The application should have default settings according to scientific evidence available.
    a. Default time interval between walking reminders should be 30 minutes.

vi. The application should remind the user to get up after specified time interval.
vii. The application should gather user posture data.
viii. The application should provide feedback on the user's posture.
ix. The application should remind the user to get up after specified sitting interval.

3. Block Diagrams

Project-Wide Diagram



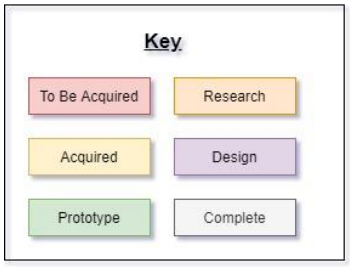


Fig.3

Hardware Diagram

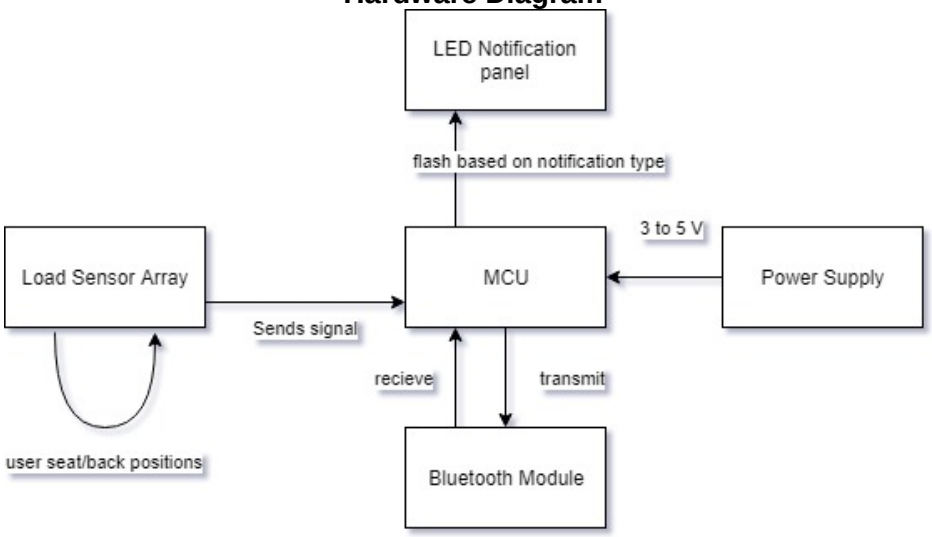


Fig.4

Application Diagram

Fig.5

User Interface Diagram

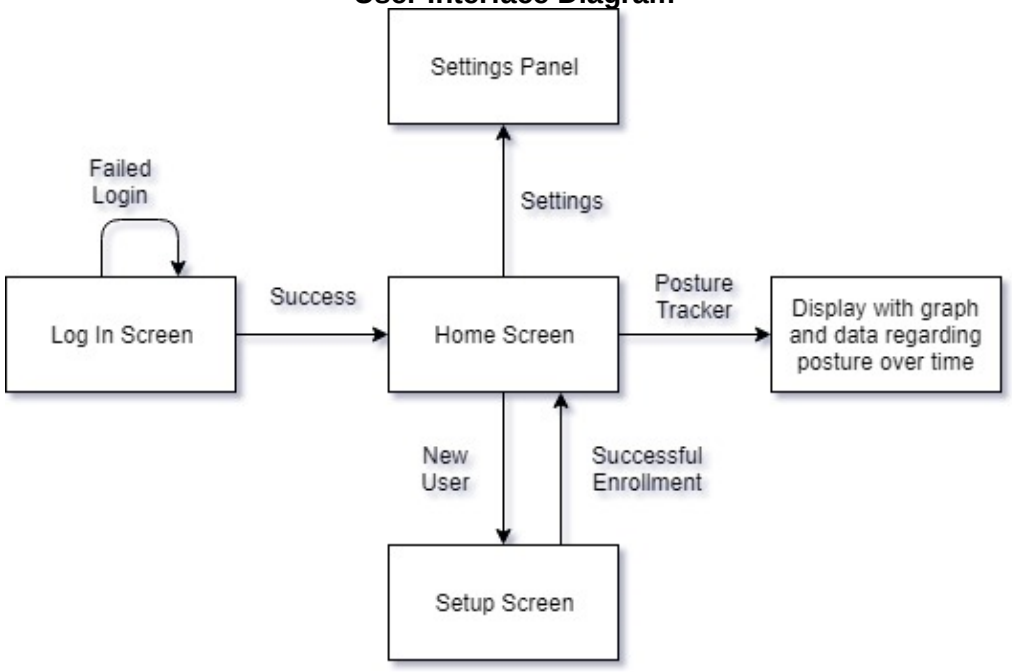


Fig.6

Annavay:
Annavay will be the lead for the user interface design due to her prior experience in the area. She will work with Thien on the application's backend to write the algorithm to interpret the incoming sensor data. She will also work with Thien to ensure proper communication between the application and the hardware.

Thien:
Thien will work along with Annavay on the user interface and backend algorithm to take in information from user and allowing them to customize a set amount for a timer and notification. Also help the integration process between software and hardware to communicate with the Bluetooth to synchronize with the application, allowing it to notify users and set guidelines.

Bonarine:
Bonarine will take point on the sensor, LED, & Bluetooth modules with respect to design and testing. This includes Mock ups and simulations. He will support Mackenson with PCB design, using it as an opportunity to learn eagle, and share responsibilities as stated below.

Mackenson:
Mackenson will take charge to design the PCB and make sure we have the perfect circuit that we need for the project, and work with Bonarine to implement the power that will be used for the sensor, Bluetooth and led systems. As a group, we will work together to integrate the software and hardware while testing proper functionality.

4. Budget and Financing

The project will be financed by the team members. The cost will be divided evenly among the 4 members.

Estimated Budget

Item (number)	Cost
PCB (3)	30.00
Microcontroller (1)	20.00-40.00
load cells	100.00-150.00
Bluetooth Module	25.00-50.00
Office Chair	55.00-100.00
Packaging and presentation	200.00
Compensated Total	800.00
Cost per member	200.00

Table 1

5. Milestones

5.1 Hardware

i. Circuit Design & software simulation including calculations and filter/gain stages
ii. breadboard simulation with test parts
iii. Design PCB & simulate
iv. Order final parts
v. Order PCBs
vi. Solder the parts on the PCB and reflow
vii. Test PCB

5.2 Software

i. Storyboard the user interface

ii. Learn how to create a mobile application for android and learn how to use local storage.
iii. Create skeleton UI and get interaction with backend.
iv. Algorithm to analyze the data from hardware and to recommend posture adjustments.
v. Communication with hardware to send commands to LEDs and receive sensor data.
vi. Finished version of UI.
vii. Fully functional application backend.

5.3 Integration

i. Send and receive data via Bluetooth
ii. User setting controls LED's
iii. Read sensor data from PCB's

6. Decision Matrix

Idea	Pros	Cons
Smart Chair (Primary)	• Not overdone • Not on the market • Cheaper project idea • More fault tolerant than smart mirror • Interesting project for team to work on. • Potential for patent	• Fewer guidelines since similar products do not exist.
Smart Mirror (Secondary)	• Lots of guidelines available to aid in project build. • Project could work to provide lower-cost design. • Kind of boring	• On the market • Expensive • Delicate, low fault tolerance • High chance of additional project cost due to glass failure.
Rotating Solar Tracker to optimize solar panels	• Potential sponsorship with Duke energy	• Moving Parts • Solar Panels are expensive and heavy to move • Low CpE workload unless expanded somehow

Table 2

7. House of Quality

	Technical Requirements	Battery Life	PCB size	Sensor Load	Vibration module frequency	Sensor reading	LED brightness	Bluetooth interface between chair and mobile application.	Push notifications	Database for user data.	Application click limit
Customer Requirements		V	V	V	^	^	V	^	^	V	^
Receive feedback on current posture	^				+	+	+		+		
Chair must maintain mobility similar to unmodified chair	V	-	-								
Comfort of chair must be similar to unmodified chair	V	-	-	-	-		-				
The chair should pair with a mobile application.	^					-		+	+	+	
The application should provide meaningful feedback.	^				+	+		+	+	+	+
The application should keep a history of user data.	V							-		+	+
The application should be simple to use.	^	-			-	-					+
	Specifications	≥5 days	≤230cm^2	100lbs	200-400Hz	every 30 sec	≤1000 lumens		5 minutes (for demo)		≤10 clicks for a task

Table 3

8. Links & References

https://www.startstanding.org/sitting-back-pain/best-office-chairs-back-pain/#list

https://www.amazon.com/Upright-Corrector-Strapless-Discrete-Confidence/dp/B0747YHYZF/ref=asc_df_B0747YHYZF/?tag=hyprod-

20&linkCode=df0&hvadid=309803898133&hvpos=1o1&hvnetw=g&hvrand=9975865465923443690&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9011795&hvtargid=pla-422762011569&psc=1

https://www.ninds.nih.gov/Disorders/Patient-Caregiver-Education/Fact-Sheets/Low-Back-Pain-Fact-Sheet

https://www.spine-health.com/wellness/ergonomics/office-chair-how-reduce-back-pain