UCF Senior Design I

Title: U.P.R.I.G.H.T.
User Position Recognition Integrated Guiding Height Table

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Initial Project Document and Group Identification
Divide and Conquer

Group 11

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Chapter 1-Project Narrative
1.1 Background and Motivation

A study on musculoskeletal issues among office workers concluded that lower back pain is a common health problem among office workers with at least one-year experience, with an incidence rate ranging from 23% to 38% [1]. It is also the most common cause of work-related disability in people under the age of 45 [2]. This is a major concern that affects many individuals because, according to the United States Bureau Labor Statistics Occupational Requirements Survey, the average civilian worker dedicated 40.6 percent of their workday to sedentary activities. This number is even higher for certain occupations. For instance, computer programmers sat for 95.7 percent of the workday [3]. This paradigm underscores the pivotal role that the workstation plays in influencing our well-being, productivity, and overall job satisfaction.

In recognizing this connection between the nature of work and the physical environment, our senior design project seeks to address the challenges posed by static workspaces. The conventional desk, while serving as a staple in work and educational settings, may not fully align with the diverse needs of the modern workforce. The motivation to create a smarter, more adaptable workspace becomes evident in regard to the statistics on workplace musculoskeletal issues.

The conventional dichotomy of sitting and standing does not capture the nuanced requirements of today's work demands. The statistics provided by the Bureau of Labor Statistics highlight the need for a workspace that seamlessly transitions between various postures, promoting health, engagement, and performance. To address these issues, we propose a smart desk that will actively assist workers in maintaining an ergonomic work environment.

To address the ergonomic issues that plague the modern workforce, our design needs to go beyond a simple sit/stand desk. On the one hand, any effort the user needs to put into changing their desk orientation will discourage them from using the feature. Additionally, suddenly changing work styles can have adverse effects on the user [8]. To alleviate this, our design will implement smart tracking and reminders to encourage the user to switch between sitting and standing positions and thus avoid overcompensation. This smart tracking will keep track of the sitting to standing ratio and slowly increase the amount of standing so that the user is not adversely affected by the sudden increase of standing.

As we embark on the journey of designing a smart desk, our goal is to redefine the workspace paradigm by integrating intelligence, adaptability, and user-centric features. By leveraging insights into occupational dynamics, our smart desk aims to revolutionize the way individuals interact with their work environment, enhancing not only productivity but also fostering a holistic approach to well-being. The statistics serve as a compelling foundation, urging us to explore innovative solutions that go beyond the traditional confines of desk design and cater to the evolving needs of the modern workforce.

1.2 Features and Functionality

In the ever-evolving landscape of today's work environment, the combination of ergonomic design with cutting-edge technology plays a pivotal role in crafting spaces that enhance productivity while also supporting physical health. Our state-of-the-art electric smart standing desk stands as a testament to this combination, marking a major advancement in the realm of office furniture design. More than just a workstation, it embodies a holistic solution, catering to the complex requirements of modern professionals. Merging automated functionality with personalized user settings, this desk is designed to redefine ergonomic standards in the workplace by offering a transformative approach to how professionals interact with their workspaces.

The desk's defining characteristic is its automated height adjustment. This innovative functionality allows seamless transitioning between sitting and standing positions, eliminating the need for manual adjustment. At the core of this feature is a sophisticated detection system, which includes a camera and a weight-sensitive mat. These components work in unison to accurately discern the user's presence and their intent to either sit or stand. When the user stands, the desk recognizes this action and, after a brief, user-configurable delay (defaulted to 2 seconds), adjusts to a predetermined standing height. Conversely, when the user opts to sit, the desk responds by lowering to the saved sitting height, again after a short delay. For added safety measures we would include a collision detection system. This automated system is designed to prevent unintended desk movements, thus ensuring a seamless user experience.

User profile customization, facilitated through Bluetooth connectivity, adds another layer of personalization to the desk. Users can create and save individual profiles using a desktop/mobile application that communicates with the desk. The initial interaction with the desk involves a user-friendly calibration process. Here, users set their preferred sitting and standing heights. Once these preferences are saved, the desk automatically adjusts to these settings upon subsequent connections. The application is not just a tool for height adjustment; it also offers customized sit-stand reminders. These reminders are adaptable, with settings that cater to each user’s previous standing habits and ergonomic needs. Moreover, the application tracks and logs the duration of sitting and standing periods, offering valuable insights into the user’s ergonomic practices.

The desk's design incorporates a digital display, neatly mounted to the right underside of the desk which helpfully shows key information like the current desk height, the profile of the user currently utilizing the desk, and Bluetooth connectivity status. Adjacent to this display are manual controls. These controls offer users the ability to manually adjust the desk’s height, pair with Bluetooth devices, and toggle the automatic desk adjustment. Such manual options are vital for users who occasionally prefer traditional operation or need to override automatic adjustments for specific tasks.

As workplaces continue to evolve, the need for furniture that adapts to the changing demands of professionals becomes increasingly evident. Our electric standing desk is a response to this need. It represents a harmonious blend of technology and ergonomics, designed to foster a healthier, more dynamic work environment. This desk is more than just a piece of furniture; it is a tool for enhancing productivity and well-being in the workplace. With its innovative features and user-centered design, it is set to redefine the standards of office ergonomics, providing a tangible solution to the challenges of modern office life.

1.3 Goals and Objectives

The objective of our senior design project is to create a standing desk that will be able to adjust its height dynamically depending on whether the user is detected to be standing up or sitting down. The overarching goals of the project are listed below:

Goals and Objectives of the Overall Project

- Develop a reliable system capable of discerning whether the user is standing or seated utilizing an integrated camera for head tracking against a pre-calibrated reference and a weight-sensitive mat for accurate weight assessment.
    - A brief delay will precede any automatic height adjustment to minimize unintended activations of the desk's automatic feature. This delay is preset to three seconds but can be customized by the user via the accompanying app.
- Develop a mobile and desktop application for communicating with the desk via Bluetooth.
- Construct a desk from the ground up, incorporating linear actuators to facilitate its movement.

Objectives for the Mat

- Develop a sensing mat placed beneath the user's chair and feet, designed to accurately measure the user's weight against a calibrated reference.
    - By employing load cells, the mat distinguishes between two distinct scenarios: a lighter weight indicating the user is seated (as the chair's presence reduces the weight applied directly on the mat) and a heavier weight suggesting the user is standing directly on the mat. The load cells will be incorporated under the mat and attached to a custom-built frame. This arrangement facilitates precise weight measurement by evenly distributing the load.
    - A calibration phase will set a baseline for the user's standing weight during the initial set up in the app. Changes from this baseline will inform the system of the user's current position.
    - The dimensions of the mat will be 4x4 feet ensuring it can comfortably accommodate a chair while the user is seated. This size was chosen to balance the need for space with functional design requirements. In selecting the mat, particular attention was paid to its thickness and firmness; it must be robust enough to support everyday office chair use without hindering functionality, yet sufficiently thick—a desired ½ inch—to house the load

cells necessary for accurate weight measurement. This consideration ensures the mat remains unobtrusive in an office setting while fulfilling its critical role in our system.

Goals and Objectives for the Camera

- Develop a camera system within the desk, positioned underneath where the monitor is typically located, to provide an optimal vantage point for head tracking.
    - During the initial setup/calibration, users will define reference points for their head in both sitting and standing positions.
    - To conserve power and extend the camera's lifespan, a feature will be considered that requires a specific action (raising a flag) to activate the camera. This ensures the camera is only operational when necessary, reducing energy consumption.
    - The camera system will employ head tracking, outlined by a predetermined border based on the user's calibration, to ascertain changes in the user's position. If the user's face dips above or below a certain threshold relative to the reference line, the system interprets this as the user sitting down or standing up.

If the parameters for a change in position are met for both the mat and the camera, the desk will then change its position to the height set by the user during the initial calibration.

Additional Goals and Objectives

- Integrate an LCD screen to display information to the user. The screen will be positioned at the edge of the desk, specifically under the bottom right side, and angled upward for optimal visibility to the user.
    - Screen will display critical information, including the desk's current height, the user's posture (sitting or standing), the profile currently in use, and the status of the Bluetooth connection to the app.
- Incorporate a row of buttons in an enclosure positioned adjacent to the LCD screen for easy access.
    - There will be 4 distinct buttons, each assigned a specific function: manually raising or lowering the desk height, toggling the desk's automatic adjustment feature on or off, and initiating pairing with a Bluetooth-enabled device.
- Include collision avoidance system to enhance safety measures.
    - Hoping to include a pre-existing "plug and play" solution for collision detection used in current electric standing desks on the market. Further research is needed.

Mobile/Desktop application Objectives

- Develop applications for both mobile and desktop platforms to enable Bluetooth connectivity with the desk. These applications will enhance user interaction by providing a suit of customizable features and settings.

- Users can save their profile settings, including preferences for sitting and standing positions.
- Allows transmission of information to the desk’s LCD screen, facilitating real-time updates and notifications.
- Features an intuitive graphical user interface, which simplifies the calibration process, making it accessible for users to accurately set up their desk preferences.
- Includes customizable reminders prompting users to alternate between sitting and standing. Users can adjust the frequency and duration of these reminders, tailoring them to fit personal health goals and daily routines.
- Monitors and tracks the duration of time users spend in seated and standing positions. Will enable users to access and review their usage statistics, offering insights into both current and historical patterns.
- Feature predefined settings categorized into beginner, intermediate, and advanced levels, tailored to guide users in gradually adapting to standing while working.

Stretch Goals for Desk Operation

- A directional pad, integrated into the mat, offers users an innovative method to engage in physical activity while standing. This feature, coupled with app integration, leverages the mat's sensors to guide users through various activities. Inspired by exercises recommended for seated airplane passengers to enhance circulation, this functionality encourages movements that promote health and energy. To implement this, force sensing resistors will be placed within the mat to accurately track the user’s foot positions, enabling precise activity tracking and feedback. **(Credit to Dr. Zakhia Abichar)**
- An optional automatic monitor arm accessory can be added to the desk, leveraging the object detection technology utilized for head position tracking. This monitor arm is designed to pan and tilt, adjusting in real-time to maintain the user's optimal viewing angle of their computer screen. This feature ensures ergonomic viewing positions are maintained, enhancing user comfort and reducing strain during both standing and seated sessions.

1.4 Existing product

In the evolving market of ergonomic office solutions, our team initially conceived the idea of a Bluetooth-connected standing desk, believing it to be a novel concept. However, upon further research, we discovered the existence of similar products such as the UPLIFT Desk App combined with the separately sold UPLIFT Bluetooth Adapter [5] and the Autonomous SmartDesk Connect [4]. These products offer functionalities akin to our envisioned design, including movement reminders, daily standing goals, progress tracking, app-controlled height adjustment, and customizable memory settings for desk heights. The Autonomous SmartDesk Connect goes a step further by recommending various standing exercises like lunges and squats, enhancing the user's physical engagement.

Despite these similarities, our product distinguishes itself in several key areas. One of the most notable features setting our desk apart is the automatic transition between standing and sitting positions. This transition is seamless and intuitive, occurring automatically as the user stands or sits, without the need for manual interaction with a smartphone app. This feature is a significant advancement over the existing products, which require manual adjustments through an app for changing desk settings.

Moreover, our standing desk employs a sophisticated system comprising a built-in camera and a weight-sensing mat to accurately track actual usage times. This system is more precise in determining whether the user is actively standing or sitting at the desk, as opposed to the basic session tracking offered by other products, which may not accurately reflect real-time usage.

In addition, as a stretch goal, we aim to integrate sensors into the mat. These sensors would guide users through simple, low-profile exercises designed to promote blood circulation, such as calf raises, foot pumps, and knee lifts. This feature is particularly suited for office environments where more conspicuous activities like pushups or squats might be less appropriate. Our focus is on subtlety and discretion, ensuring that users can maintain a professional demeanor while still benefiting from physical activity.

Our standing desk is specifically tailored for office settings, balancing ergonomic benefits with the practicalities and decorum of a professional workplace. By combining advanced technology with user-friendly features, our product not only aligns with the current market trends but also introduces unique elements that enhance the overall experience of the user in an office environment.

Chapter 2-Project Requirements, Specifications and Diagrams

2.1 Requirements and Specifications

The table below illustrates key engineering specifications with quantitative measures for parts that will be used to construct the desk. In addition to the desired values, certain specifications have been highlighted in yellow to denote demonstrable specifications that will be demoed in a prototype at the end of the semester for Senior Design I.

Table 1: Specifications

Component(s)	Parameter	Specification
Linear Actuator	**Controllable Up/Down Action for Legs on the Desk**	**Travel Speed of 25mm/sec** **Maximum Load of 200 pounds (900N)** **Input Voltage of 12 VDC** **18-inch stroke length**
Relay Module	**Allows to Reverse Direction for Up/Down Action of Desk**	**Input Voltage of 5V** **4 Channel**
Raspberry Pi	**Enables for communication between the system and camera**	**Baud Rate of 9600** **2x USB 2.0**

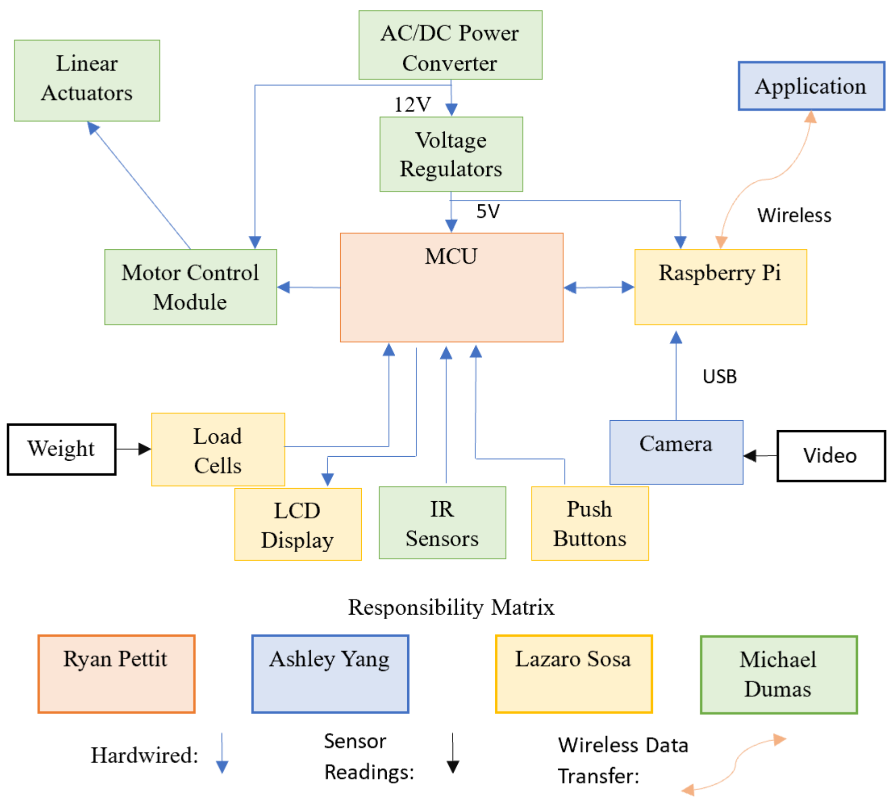
	Will be used for object detection to determine user's position	**SDRAM 2GB**
Microcontroller	**Will control the different points of operation excluding the camera Linear actuator/motor controller, LCD, load cell, push buttons, and Raspberry Pi communication**	**32 KB flash memory 1x UART 1x I2C 1x SPI 4x Analog/GPIO pins 10x Digital/GPIO pins 6 PWM pins**
Speed Controller	**Allows to Adjust the Speed of Up/Down Action of Legs of the Desk**	**Adjust Speed by a factor of 10% from the Base Speed From 22.5 mm/sec to 27.5 mm/sec**
Load Cells	**Used to Detect Whether User is Standing Up or Sitting Down**	**Able to Detect/Withstand within 10% accuracy between 500 – 1,000 Newtons (approximately 110 – 220 pounds)**
LCD Display	**Implemented to Provide User Interface**	**Able to Display Between 5 – 10 frames per second Resolution of 854x480 pixels**
Bluetooth Module	**Allows for Remote Communication with Wireless Enabled Devices**	**Up to 3 Mbps in Enhanced Data Rate Mode Up to 1 Mbps in Low Energy Mode**
Webcam	**Will be used for Object Detection in Conjunction With Pressure Sensing Resistors to Determine Whether User is Standing or Sitting Down**	**Resolution of 1920x1080 pixels Capable of Displaying 30 frames per second 180 degree viewing angle**
Face Tracking	**Used for tracking of the user's face to determine if the user is sitting or standing.**	**Accuracy of tracking between 80-90%**
Rubber Surface Mat	**Sensors Will be Incorporated Inside the Mat**	**½ inch thickness 4-foot x 4-foot**

2.2 Hardware Block Diagram

The hardware block diagram can be seen in Figure 1 below. It details the overall design implementing various features discussed in Section 1.2. A responsibility matrix is also provided that notes the obligation of each team member using color coordination with the individual blocks. Power will be supplied through any generic wall duplex outlet and converted down to 12V DC using a 10A power supply AC to DC power adapter. The 10A power supply is necessary to accommodate at least two linear actuators powerful enough to meet load requirements (Insert requirements). Voltage regulators will be installed to drop voltage to the correct input for the microcontroller unit or any other components.
The central processing needed for the PCB will be handled by the microcontroller unit (MCU), however, further research is still underway to determine the specific MCU to be utilized. Web cameras and load cells within the designed mat will send data to the MCU to determine whether the user is sitting or standing and when they make a transition to the other position. A Bluetooth module will be incorporated to send/receive data from the

MCU to a user connected device utilizing a customizable app. The MCU will use the data collected to determine the desired position of the desk and implement that location using a motor control module and the linear actuators. While the desk is moving, infrared sensors (IR sensors) are a possible solution to track any obstacles impeding movement to avoid collisions. Further research is necessary to implement the optimal system for collision avoidance. The relative position of the desk and the duration at the position will be tracked and shown with a built-in LCD display. Override buttons will be installed conveniently next to the LCD to enable manual control for the user and shut off automation.

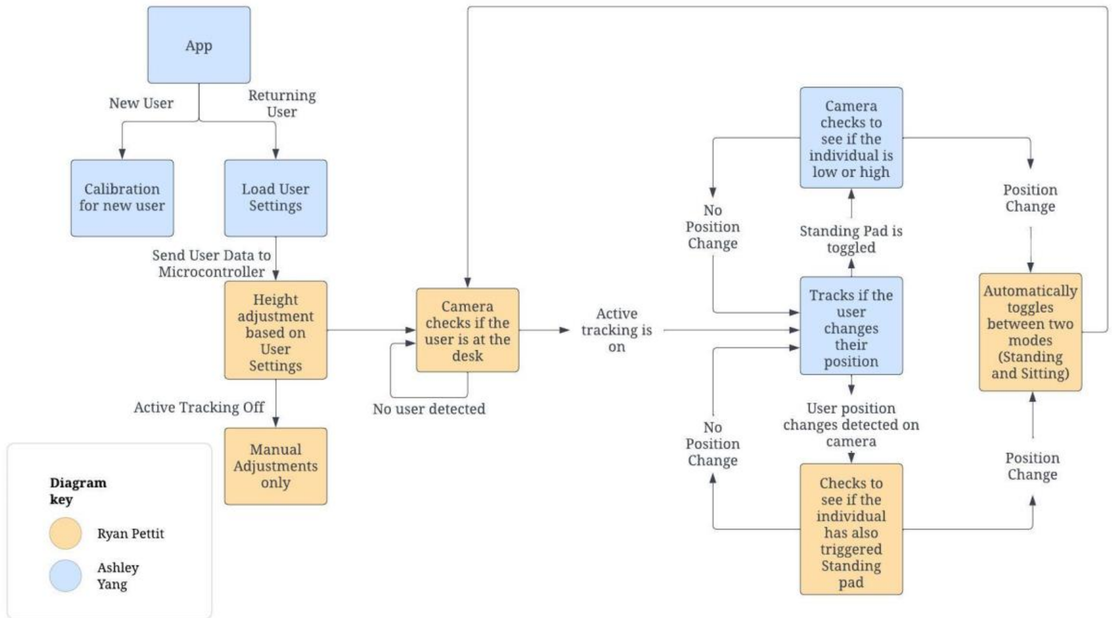
Figure 1 Hardware Block Diagram



2.3 Software Block Diagram

The diagram below details the software decision tree that will be implemented by the system. Flutter will be used to create the application for windows and android devices. The application will be used to save the user preferences and will provide instructions for the user during first time setup. This application will also be used for sending reminders to the user to either sit or stand-up. If the user is a returning user, it will send the saved profile settings to the embedded system through Bluetooth. Once it is determined that the user is at the desk, active tracking will be activated depending on the user's saved preferences. Then, if the user position changes, the desk will go through two checks before toggling between sitting and standing mode.

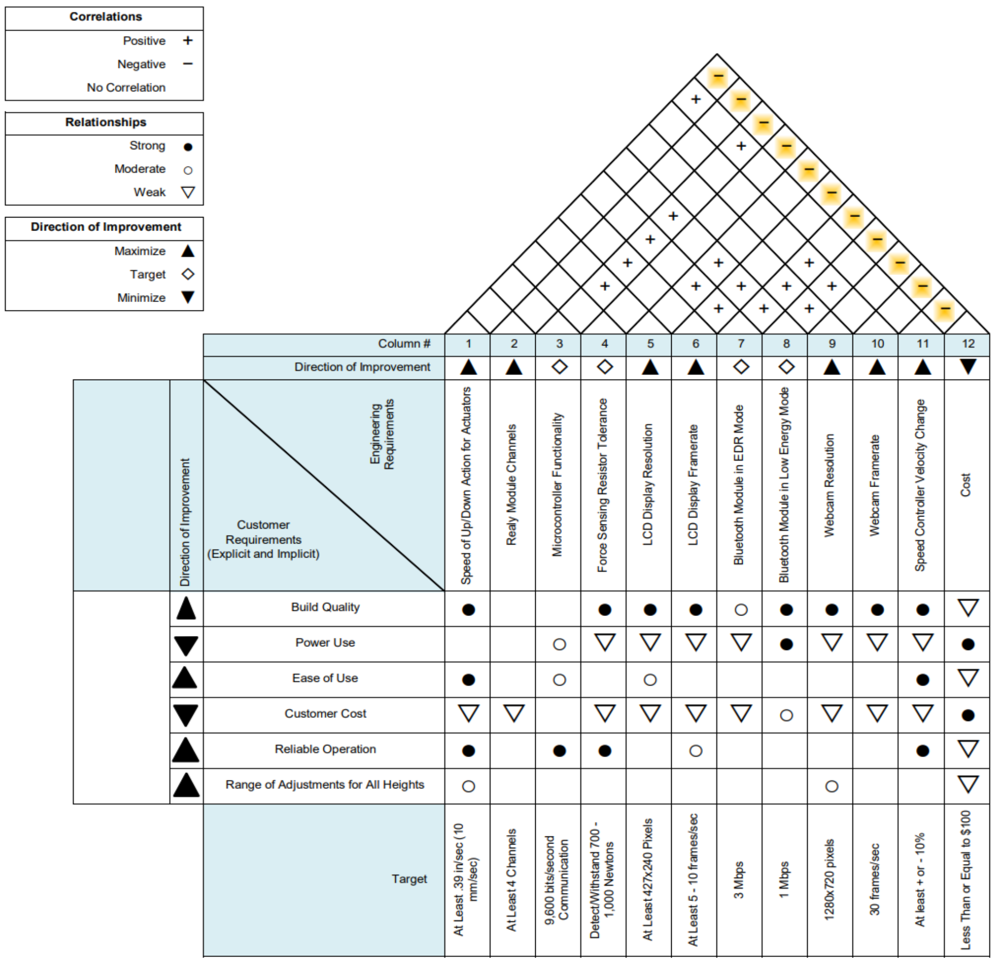
Figure 2 Software Block Diagram



2.4 House of Quality

The chart below shows the House of Quality diagram for our project for Senior Design. On the right side are the customer specifications. These are the aspects of the desk that a user would value when deciding whether to buy the product. On the top row are the engineering specifications. These are the relevant values and measurements required to get the desk to function. By plotting the desk characteristics in this way, it allows us to evaluate the relationships between the different components. For example, if we wanted to know what effect the build quality of the desk would have on the cost of the product, we could consult the House of Quality diagram to determine that they have an inverse relationship. This means that as the build quality of the desk goes up, the cost of the product goes up even though we desire to minimize the final price.

Figure 3 House of Quality Diagram



Chapter 3-Administrative Content

3.1 Budget

Budgeting is a crucial part of sustainability for the U.P.R.I.G.H.T, and the price of this desk will make or break its feasibility. One goal of this project is to create a product with a budget that can maximize market longevity. Our aim is to create a price point that matches the standard rates near the middle of the market. A quick search online shows a plethora of small, cheap desks priced right around $100.00, however none of these desks have any programmable or automated features. As discussed in section 1.4, desks from Uplift are installed with similar functionalities as those envisioned for this project, however they are also quite expensive. The base model starts at $569.00 and ranges up to and over $2,000. [6] Another similar example comes from Eureka Ergonomics' Ark Standing Desk line, offering their cheapest model at $2,000 as well. [7] Keeping this in mind, if the budget can achieve a price point on the lower end of these examples, the U.P.R.I.G.H.T should be able to have a few competitive advantages: not only will it include a sophisticated mat, but it would also include tracking functionality. However, all expenses for this project will be shared among the group members. To maximize these advantages, while not breaking the bank, the budget will be set at $800.00.

3.2 Bill of Materials

See Table 2 below for the estimated bill of material (BOM) needed to complete this project. The list is a general approximation of cost and will be updated as specific components are researched and selected. Also take note that some of the items included would not be in the final version of the U.P.R.I.G.H.T BOM. Duplicate items such as PCB and microcontrollers are included to ensure the capability for prototyping and demo throughout the design process. To guarantee that this project will operate under budget, these extra line items are included in the bill of material. The BOM shows a total price less than the budget set in the previous section.

Table 2: Bill of Materials

Item	Estimated Cost	Actual Cost
Materials for Desk	$200.00	TBD
Office Floor Mat	$50.00	TBD
Load Cells	$20.00	TBD
Housing design for Load Cells	$10.00	TBD
AC/DC Power Supply Convertor	$20.00	TBD
PCB(s)	$50.00	TBD
MCU	$5.00	TBD
Development Board and Raspberry Pi	$70.00	TBD
Motor Control Module	$20.00	TBD
Linear Actuators	$150.00	TBD
LCD Display	$30.00	TBD
Push Buttons	$5.00	TBD
Housing Design for user interface	$25.00	TBD
Web Camera	$25.00	TBD
Misc. items	$50.00	TBD
Total:	**$750.00**	TBD

3.3 Project Milestones

Team 11 formed at the beginning of Senior Design I in the spring of 2024 with plans to attend Senior Design II in the summer of 2024. The following tables have been created to reflect the milestones and goals for this schedule selection.

Table 3: Senior Design I Timeline Spring 2024

Task	Start Date	Anticipated End Date	Status
Project Idea Discussion	1/8/2024	1/17/2024	Complete
Project Selection and Committee Formed	1/17/2024	1/26/2024	Complete
Divide and Conquer Completion	1/22/2024	2/2/2024	Complete

30-Page Milestone	2/2/2024	2/23/2024	Current
Individual System Design	2/2/2024	2/23/2024	Current
60-Page Milestone	2/23/2024	3/22/2024	Not yet started
Individual System Testing	3/22/2024	4/5/2024	Not yet started
90-Page Milestone	3/22/2024	4/5/2024	Not yet started
Breadboard Prototyping	4/5/2024	4/19/2024	Not yet started
120-Page Milestone	4/5/2024	4/19/2024	Not yet started
Final Draft	4/19/2024	4/23/2024	Not yet started
Final PCB Design/Ordering	4/23/2024	4/30/2024	Not yet started

Table 4: Senior Design II Timeline Summer 2024

Task	Start Date	Anticipated End Date	Status
PCB Assembly and Testing	5/13/2024	5/24/2024	Not yet started
System Integration/Testing	5/24/2024	6/21/2024	Not yet started
Practice Project Demo	6/21/2024	7/5/2024	Not yet started
Finalize Documentation	7/5/2024	7/19/2024	Not yet started
Practice Final Presentation	7/19/2024	7/26/2024	Not yet started
Final Presentation	TBD	TBD	Not yet started

Declaration

We hereby declare that we have not copied more than 7 pages from the Large Language Model (LLM). We have utilized LLM for drafting, outlining, comparing, summarizing, and proofreading purposes.

References

[1] Janwantanakul P, Pensri P, Jiamjarasrangsri W, Sinsongsook T. Prevalence of self-reported musculoskeletal symptoms among office workers. Occup Med (Lond) 2008;58:436–8.doi:10.1093/occmed/kqn072. https://pubmed.ncbi.nlm.nih.gov/18544589/ (Accessed Jan 28, 2024)

[2] Andersson GBJ. Epidemiologic features of chronic low-back pain. Lancet. 1999;354:581–5.doi:10.1016/S0140-6736(99)01312-4. https://pubmed.ncbi.nlm.nih.gov/10470716/ (Accessed Jan 28, 2024)

[3] U.S Bureau of Labor Statistics, Occupational Requirements Survey, 2022 https://www.bls.gov/ors/factsheet/2018/sit-and-stand.htm#:~:text=On%20average%20civilian%20workers%20spend,59.4%20percent%20standing%20or%20walking. (Accessed Jan. 27, 2024)

[4] Autonomous. "SmartDesk Connect App Guide: Connect & Control Features." Autonomous.ai, https://www.autonomous.ai/ourblog/smartdesk-connect-app-guide-connect-control-features. (Accessed Jan. 26, 2024)

[5] UPLIFT Desk. "UPLIFT Desk App." UPLIFT Desk, https://www.upliftdesk.com/uplift-desk-app/. (Accessed Jan. 26, 2024)

[6] Uplift Desk. Uplift V2 Standing Desk - V2 or V2 Commercial. Uplift Desk. https://www.upliftdesk.com/uplift-v2-standing-desk-v2-or-v2-commercial/ (Accessed Jan. 30, 2024)

[7] Eureka Ergonomic. ARK Standing Desk Collection. Eureka Ergonomic. https://eurekaergonomic.com/collections/ark-standing-desk (Accessed Jan. 30, 2024)

[8] Harvard Health. “The truth behind standing desks”. Robert H. Shmerling, MD. https://www.health.harvard.edu/blog/the-truth-behind-standing-desks-2016092310264 (Accessed Feb. 1, 2024)