Electronic Drawer Organization System Proposal

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Introduction

Problem Statement

One of the most important factors in productivity is the level of organization a person has in their workspace. The quickness and ease with which someone can find the tools or paperwork they need to do a job has a meaningful impact on the time the actual job takes. Currently, this is an area of the workplace that needs improvement, as 28% of office workers say they would save an hour every day if their workspace was more organized [1].

Perhaps the most common method of office organization involves drawers or cabinets of some kind. The issue with this method occurs when people forget which drawer they put a certain item in. Then, when they need to find it again, the best case scenario is that they have to open multiple drawers to find the one item they are looking for. The worst case scenario is that they don't find the item at all. This could very easily occur in someone's dresser or nightstand, but it becomes even more of an issue when in an environment with many tools or files stored in a large number of drawers, such as a restaurant kitchen or a big file cabinet.

Solution Proposal

The proposed solution allows a user to automatically 'open' the drawer containing the item they wish to find. This is done by using a smartphone app as a user interface where the desired item can be selected. Once the user chooses an item on the app, the smartphone communicates this choice with a microcontroller via Bluetooth. This microcontroller stores each drawer item with its corresponding drawer pair, and once it receives the item selection, it will optionally flash an LED on, open, or unlock the desired drawer. In this way, the user is always able to find the drawer containing their item with minimal rummaging and searching.

Some more specifics for the functionality of the drawer system might help make the system a little more clear. The drawer will be opened by controlling a linear motor that will push the drawer open. The locking mechanism for the drawer will be a solenoid that will drive a metal pin into a slot in the drawer to lock, and retract to unlock. The LED will be mounted on the front of the drawer system for maximum visibility.

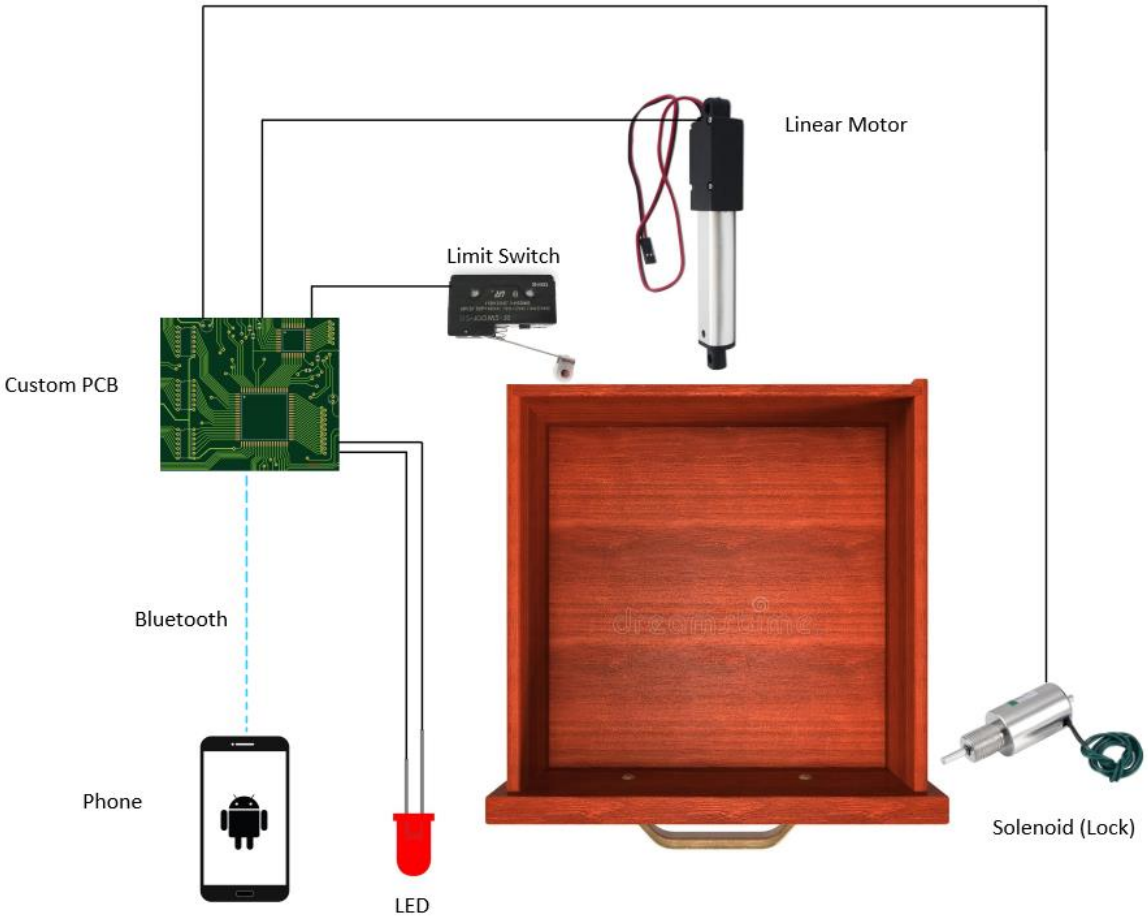
High Level Requirements List

- The interaction between the microcontroller and the physical mechanisms on the drawer should produce the desired result. For example, if the microcontroller sends a signal to the linear motor to push the drawer open, the linear motor should push the drawer open. If the pressure switch on the back of the drawer is

depressed to indicate that the drawer is closed, then the microcontroller should register the drawer as closed. Similar requirements would be needed for the LED at the front of the drawer and the solenoid locking mechanism at the side of the drawer.

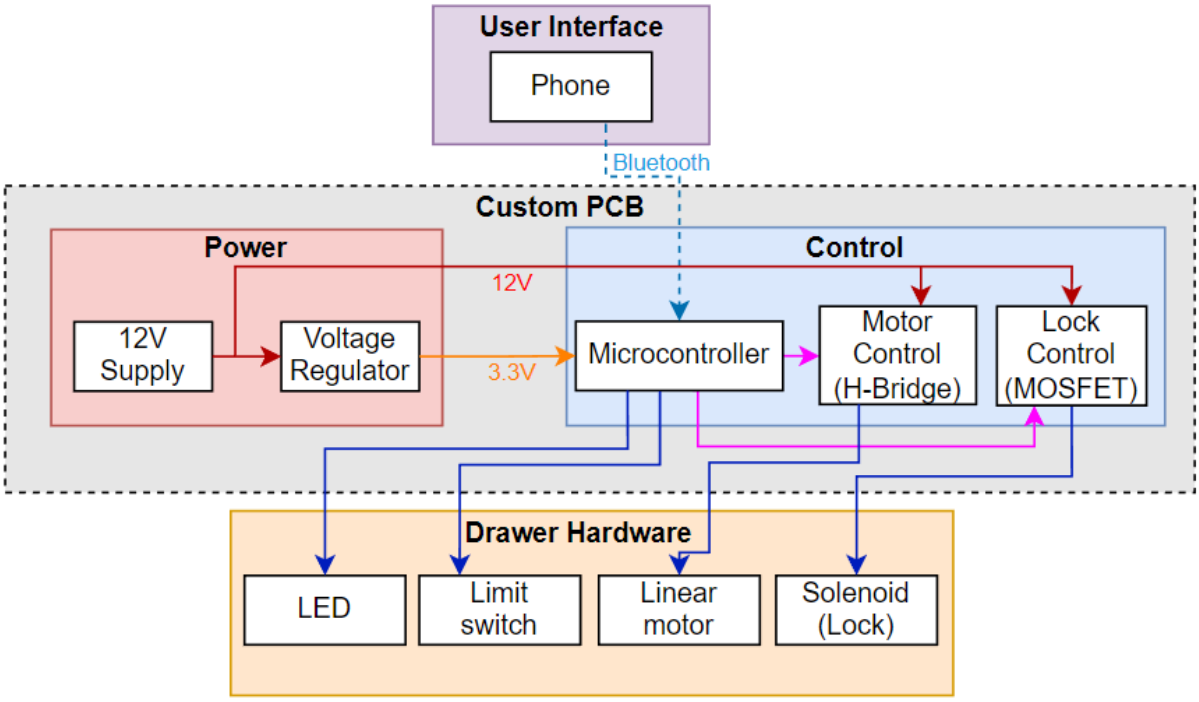
- The microcontroller must be able to interact with a smartphone app via bluetooth. This means that all requests sent to the microcontroller must come from a smartphone.
- The bluetooth connection between the smartphone and the microcontroller must have a range at least the size of an average room. The size of an average room is 14x16 feet [2]. If this room is a rectangle, that means the farthest distance within the room between the microcontroller and phone is 21.26 feet. Thus, the bluetooth connection needs to be present at a maximum distance of at least 21.26 feet.

Visual Aid



Design and Requirements

Block Diagram



Subsystems

Power

Overview

The power subsystem performs necessary functions on the standard outlet voltage of 120V, 60Hz so that the voltage can be used by various other devices within the project. The first step in this process is to rectify the outlet voltage into a more manageable 12V DC supply. This is necessary since, although the voltages needed by other devices within the project vary considerably, they all require voltages significantly less than 120V. The actual components used by the power unit will be almost exclusively regulators. The power subsystem must provide a regulated DC voltage to the microcontroller, the solenoid locking mechanism, and the linear motors.

Requirements

- The power subsystem must provide regulated 12V +/- 8% to the linear motors and solenoid [3].
- The power subsystem must provide an extremely well regulated 3.3V +/- 9% to the ESP32 microcontroller. This voltage must not exceed 3.6V, or the microcontroller will be damaged [4].

Control

Overview

The control module mainly consists of an ESP32 microcontroller. This microcontroller was chosen for its Bluetooth capability, as being able to interface with a smartphone via Bluetooth is one of the key functionalities of the control subsystem. The other reason that the ESP32 was chosen was its sizable RAM. ESP32 has 520KB of RAM, and this will be used to store the various pairings between the user string inputted on a smartphone and the drawer corresponding to the item the string represents [4]. The microcontroller will take as an input the Bluetooth data coming from the smartphone, as well as input from the switches at the back of the drawers that indicate whether the drawers are closed. From this information, the MCU will be programmed to send a signal to the motor control unit using its PWM generating capabilities, as well as the lock control unit. The output pins will be connected to the linear motors that open the drawers, the LED indicators at the front of the drawers, and the solenoid locking mechanism. In this way, the control module will interpret the user input and correctly operate the drawer mechanisms to perform the desired action.

Requirements

- GPIO pins must be configured to supply/accept the correct input and output voltage to/from the drawer mechanism peripherals.
- The MCU must be able to send and receive data from a smartphone via Bluetooth.
- PWM functionality on the MCU must be realized to control DC motor speed effectively.

User Interface

Overview

The User Interface is a smartphone application that will be connected via Bluetooth to the Control subsystem. This application will be on an Android phone, since app development in the Android environment is considerably easier than iOS. Extending app functionality to iOS is a possible direction the project could take after the completion of the semester. The application will allow the user to see all of the drawers in their currently connected drawer system, as well as all of the items currently stored in each drawer. Through the app interface, the user will be able to add items to each drawer, which is necessary to initially configure the drawer/item pairs. By searching an item and clicking on it in the app, the smartphone will send a Bluetooth signal to the microcontroller. The microcontroller will check the status of the corresponding drawer and, if possible, perform the desired action on it. The microcontroller will send a signal back to the smartphone indicating which action has been taken, or send an error message if the action could not be performed. Then, on the app, the user will be able to

see a text representation of the action/lack of action that has been done. The app will have a search function so that the user does not have to manually scroll through a list of currently stored items. It will also have a settings section, where preferences for drawer behavior can be set. This means that the app settings will determine whether or not a drawer opens or lights the LED when an item is chosen, as well as whether a drawer will lock or unlock with the use of a digital passcode inputted through the app interface.

Requirements

- The smartphone must be able to send and receive data to/from the microcontroller via Bluetooth.
- The app must have the capability to add an item/drawer pairing as well as search through previous item/drawer pairs.
- The settings section of the app allows for configurability of LED/drawer-opening functionality as well as locking capability with a passcode.

Physical Drawer Sensors and Mechanics

Overview

The drawer sensors and mechanics subsystem is used to physically open and lock the drawer, as well as sense whether or not the drawer is closed. The components included in this subsystem are the linear motors to push open the drawers, LEDs to light up and visually indicate a drawer, a solenoid to to push/retract a pin into a drawer slot to lock the drawer, and a pressure switch at the back of the drawer to determine whether or not the drawer is closed. All of these mechanical components receive their control signals from the MCU in the control unit. The switch and motor will send their status information back to the MCU so that the MCU can stay updated as to whether the drawer is locked and/or open.

Requirements

- Mechanical components work as expected. The linear motor should be able to push out the drawer, the LED should light when the signal is sent from the MCU, the solenoid should extend and retract the locking pin when it is commanded to do so, and the switch should depress when the drawer is closed.
- Physical components should not impede drawer movement. It should be built in such a way so that the drawer functions as normal if the user manually opens and closes it.
- PWM modulation from the control unit should be able to control the speed of the linear motors so that our design can have a tunable drawer speed.

Tolerance Analysis

One of the most critical systems is the Physical Drawer Sensors and Mechanics subsystem. In particular, the motor mechanical force requires tolerance analysis to ensure that the drawer can open properly. The force that the motor needs to overcome is the force of static friction, and therefore we merely need to ensure that our linear motor can push with a force greater than that of the static friction of the drawer itself. In particular,

$$F_{motor} = u_s mg$$

Obviously, the coefficient of static friction will be bigger than kinetic friction. However, since we can only estimate static friction, we may as well use it for our energy and power calculations. We can multiply our force by the speed at which we wish to open it to calculate the power needed for the motor to open the drawer. In equation speak that is,

$$P_{motor} = u_s mg v_{drawer}$$

For example, apply this formula to a typical kitchen drawer's weight capacity of 50 lbs [5]. We can estimate our coefficient of friction is 0.5, that is we need to push with 25lbs of force or about 111.26N. At a rate of 1cm/s, a fairly reasonable frequency to safely open a drawer, we require a motor power of 1.1126W. This gives us an idea that our power supply should be able to supply at least 5W exclusively to the motors at any given time to ensure mechanical operation. Note this is more than 3 times as much as needed to move one drawer in this manner, since there are three motors, plus a little extra power to account for any losses. Obviously, this only approximates the power since our force will need to be somewhat greater than that of static friction and will need to increase until kinetic friction matches it at the speed of our motor. However, this is a good approximation since we won't be moving our drawer very fast so the amount of force needed to apply will be nearly that of the force required to overcome static friction. Overall, it is very feasible to supply this amount of power to the mechanical system and push a drawer with this much force, as even this estimated amount of force is fairly trivial for most linear motors to produce.

Ethics and Safety

In order to have a successful product at the end of the senior design process, creating the project in a safe and ethical manner will be paramount.

First and foremost, safety concerns that might be potential issues with the project must be addressed (IEEE Code of Ethics I.1) [6]. Because the project in question is a drawer system, there are not many inherent safety risks, although some still are present. One concern that exists is a possibility of electrical shock or fire due to poor wiring of circuits or incorrect regulation of current and voltage. This can be remedied by making sure that the wires used in the project are in working order, and making sure to check that our currents and voltages don't surpass the maximum rating values for any of our components. Another safety concern is the possibility of injury if a motorized opening drawer is pushed open into a person. This cannot be completely mitigated in the design process, as the user of the product has some responsibility to not put themselves in harm's way. However, by having the linear motor operate at a relatively low speed, the risk of injury from such an event can be minimized.

Ethical concerns for the project must be addressed to ensure that the design process is completed in a manner compliant with IEEE standards. The main concern with ethics with regards to this specific project involves plagiarism (IEEE Code of Ethics II.5) [6]. It is extremely likely, if not certain, that this project will require its designers to perform research on different components and design methods. To make sure that credit is given to the correct people, it is imperative that every effort is put forth to make sure the proper sources are cited in the proper manner.

Citations and References

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[3] D. Olson, “How to choose the right power supply for your 12V DC linear actuator - venturemfgco blog,” *Venture Mfg. Co.*, 10-Feb-2022. [Online]. Available: https://www.venturemfgco.com/blog/learn-how-to-choose-the-right-power-supply-for-your-12v-dc-linear-actuator/. [Accessed: 12-Sep-2022].

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[5] T. Felder, “How much weight can kitchen drawers hold?,” *Kitchen Seer*, 12-Aug-2021. [Online]. Available: https://kitchenseer.com/weight-kitchen-drawers-can-hold/. [Accessed: 12-Sep-2022].

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