ECE 445

Project Proposal:
Automated Closet

Shania Arora, Nikhil Parmar, William Doherty

Fall 2019

1. Introduction

1.1 Objective

Choosing what to wear is an unavoidable part of everyone's routine and as of today, there is no real "automation" to this process. Moreover, many people spend a lot of time in the mornings deciding on what clothes to wear. In Illinois especially, the weather varies drastically every day and many people always have to consult weather apps to judge what they should wear for the day. This is a hassle and takes away precious minutes of sleep in the morning. According to a study done in 2016, women spend as much as 17 minutes choosing their outfit every morning, while men can take up to 13 minutes [1].

We propose an automated closet system that can select an outfit for the user based on the type of clothes, weather, color, and other metrics. The user will have to insert data about the clothes when the first time the closet system is set up. For every article of clothing, a database would store details about each clothing piece such as color, size, type of clothing, sleeve length, fit, etc..

1.2 Background

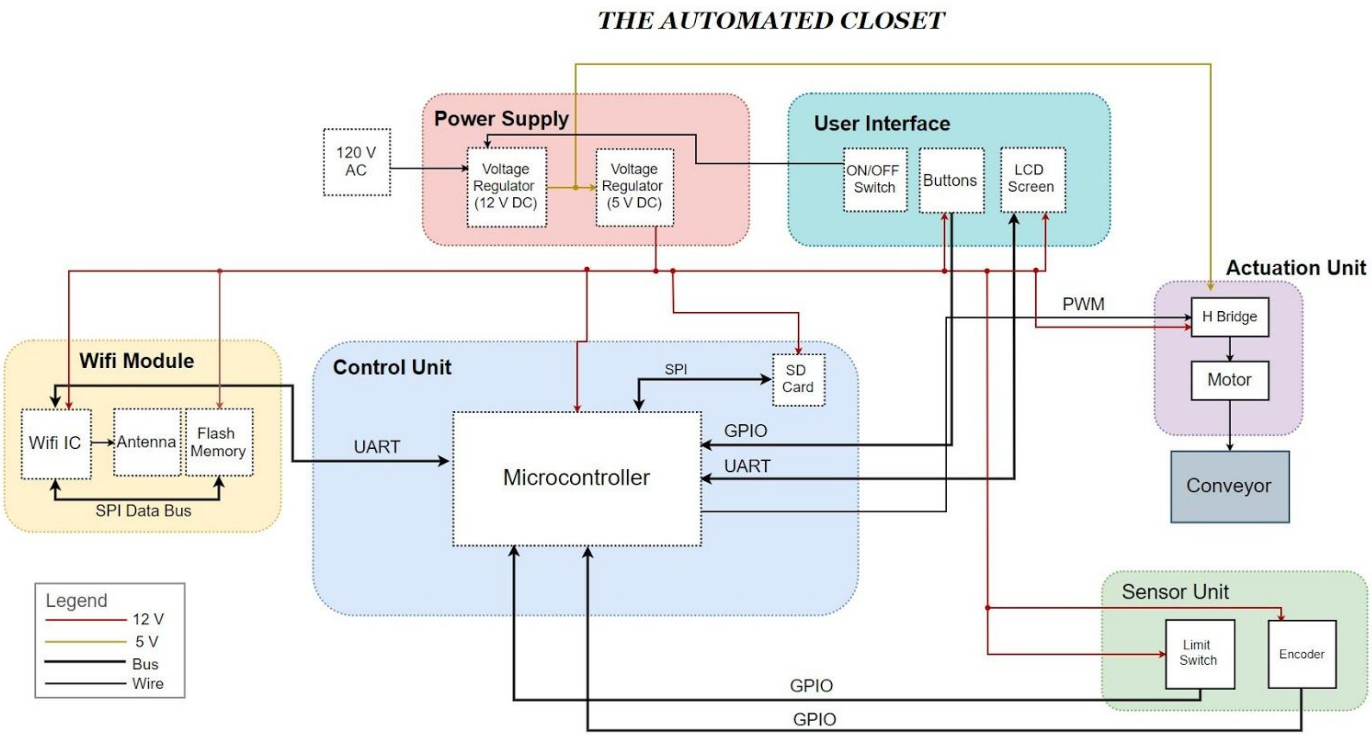
Although motorized closet systems exist, they don't have the decision making capabilities needed to optimize their functionality. Most solutions are similar to the Closet Carousel, which simply has a foot pedal to control movement [2]. This solves the problem of increasing usable closet space, but there is clear room for innovation in lightening the decision making load on the user. Additionally, these solutions can require significant effort to install, reaching weights upwards of 135 lbs with an exorbitant price tag of $3000 or more to match [3]. Our solution will provide this additional functionality in an easy-to-use package.

1.3 High-Level Requirements

- The closet spins with all the clothes in the system
- The closet suggests an outfit to the user
- The closet is able to support articles of clothing that are manually inputted into the system

2. Design

2.1 Block Diagram



2.2 Block Requirements

2.2.1 Power Supply

The power supply will provide the power necessary to operate our motor as well as our microcontroller and connected devices. The power for both of these tasks will be provided by a wall outlet.

2.2.1.1 120VAC to 12VDC Voltage Regulator

Our motor requires 12V to perform as expected, so this regulator will provide a steady 12V to be used by the motor. The 12V will also be used as an input to a second regulator which will power the microcontroller. As this regulator will supply current to both the motor and second regulator, it must be able to handle enough current for both. We expect this load to be between 5A and 10A, depending on motor load.

Requirement 1: Regulate 120VAC from wall to 12VDC.
Requirement 2: Provide up to 10A of continuous current.

2.2.1.2 120VAC to 12VDC Voltage Regulator

This second regulator will step down the 12V used for motor power to 5V used for microcontroller logic and power for components that connect to the microcontroller. This must be able to supply a peak current similar to that required by an Arduino Mega, around 1A.

Requirement 1: Regulate 12VDC from output of the first voltage regulator to 5VDC.
Requirement 2: Must be able to handle current draws of 1A.

2.2.2 Control Unit

The control unit will process user input from the UI module, track the position of the conveyor using sensor input, control the motor speed and direction through PWM, and send API requests to online databases to query weather and closet data.

2.2.2.1 Microcontroller

Our microcontroller will be doing all of our decision making, both for clothes selection and motor speed. In order to accomplish this, it must be capable of handling communication with multiple devices at the same time, and have enough available channels for single device communication protocols such as UART.

Requirement 1: Must be able to read hardware interrupts on at least 2 GPIO pins
Requirement 2: Must be able to output a PWM signal using either native hardware or properly timed software implementations
Requirement 3: Must maintain SPI and multiple UART communications concurrently.

2.2.2.2 SD Card

The SD card will store information about the closet state locally, so decisions can be made in the absence of an internet connection.

Requirement 1: Have Read/Write capabilities accessible by the microcontroller

2.2.3 Actuation Unit

The actuation unit uses PWM input from the microcontroller to control the bidirectional DC motor used on the conveyor system.

2.2.3.1 H-Bridge

The H-Bridge is responsible for using the PWM signal from the microcontroller to control the magnitude of the output voltage. To supply enough current to safely run the motor, we may need multiple devices in parallel depending on the models available.

Requirement 1: Produce a (-12)VDC - 12VDC output for the motor
Requirement 2: Supply at least 6A

2.2.3.2 Motor

The motor is responsible for moving all of the weight loaded on the conveyor. For safety reasons, we will be limiting its speed so that clothes move at 6 inches per second.

Requirement 1: Move a load of 20 lbs at 6 in/sec

2.2.4 Sensor Unit

The sensor unit produces signals for the microcontroller to handle, indicating rotational speed and position of the conveyor.

2.2.4.1 Limit Switch

The limit switch will send a digital signal to the microcontroller whenever it is pressed, helping to count hanger sections as they pass by.

Requirement 1: Send a digital signal every time a hanger location passes by.

2.2.4.2 Encoder

The quadrature encoder will track the more detailed movement of the conveyor between hangers, helping the microcontroller to adjust motor speed as it approaches the target position. It will operate at the microcontroller logic level and send at least 16 counts per revolution over its two digital pins.

Requirement 1: Send a signal that indicates movement magnitude and direction to the microcontroller, using two GPIO pins.

2.2.5 UI Module

The UI module interacts with the user to display outfit information and process the user's decision. To do this, we will use an LCD screen and push buttons.

2.2.5.1 LCD screen

The LCD screen will display prompts and messages to the user. To do this, the screen will need to have enough pixels to make distinguishable words on the screen, as well as be able to communicate via UART with the microcontroller.

Requirement 1: Display distinguishable words on the screen.
Requirement 2: Communicate with the microcontroller via UART

2.2.5.2 Button Interface

The user will have a set of 2 buttons that will answer prompts and indicate decisions. These buttons must have stable output to the microcontroller to ensure behavior at all times.

Requirement 1: Buttons will be debounced to stabilize behavior

2.2.5.3 On/Of Button

An on/off button will allow the user to begin a controlled shutdown of the closet system, cutting power to motors and minimizing microcontroller activity.

Requirement 1: Button will turn on and off closet system in a controlled manner that does not damage the physical system or any data being written at shutdown time.

2.2.6 Wi-Fi Module

The Wi-Fi module connects the controller to the internet so it can make API requests from online databases, which we will use to get information about the weather and closet.

2.2.6.1 Wi-Fi IC

The Wi-Fi IC sends data to and from the microcontroller while providing an interface to the antenna system and processing the input. The IC must be capable of using 802.11 b/g/n networks to maximize compatibility in any environment.

Requirement 1: Must communicate to microcontroller through UART.
Requirement 2: Ability to connect to 802.11 b/g/n networks.

2.2.6.2 Antenna

The antenna will interface with the Wi-Fi networks in the vicinity of the system, enabling 2.4GHz connections. To ensure reliable performance, the signal strength must be uniform in all directions.

Requirement 1: Connect to 2.4GHz networks.
Requirement 2: Uniform signal strength in all directions.

2.2.6.3 Flash

The flash will hold program memory for the Wi-Fi IC and will hold at least 1MB, which is in line with common commercial modules.

Requirement 1: Have at least 1MB of storage

2.3 Risk Analysis

The Wi-Fi module poses the most significant risk to the successful completion of this project. Not only does this module have to talk to the microcontroller, but it also must be able to make API calls to weather websites as a part of our clothing-decision process. If we can't access the internet, our clothing-decision process will not work. We also plan on storing information about each piece of clothing on an external database and making API calls to that database. Similarly, we will not be able to get information about the types of clothing in the closet if we cannot access the internet.

Our decision to use Wi-Fi comes with many potential issues. Not being able to see a network and dropped network connections are among many of the problems we may face. To circumvent this issue, we plan on having an access point nearby to address any intermittent signal issues. For a worst-case scenario, we will swap out this module with an ethernet module instead.

3. Ethics & Safety

There are a few potential safety concerns with our project. Since the automated closet will have moving parts that are driven by a motor and the user will be interacting directly with them, the moving parts pose a safety hazard. We will extensively test all the moving parts. Every moving part of the system will be individually tested to make sure its behavior is safe and predictable. Preventative safety measures will be taken to ensure there are no risks for the user with regard to the moving parts.

In addition, another potential hazard is exposed mechanical parts. Since the technology we develop will be integrated directly into the closet, it will be exposed to users of the automated closet. We will ensure that we encase all parts of the closet in some material so the user doesn't accidentally touch something they shouldn't, such as moving parts. Moreover, we will make sure that all edges are smooth and polished to mitigate the risk of injury.

The input to our power supply module is 120V AC from the wall. Voltages in this range can cause serious bodily harm if handled improperly. We will take precautions when working with the voltage regulator. Namely, we will not touch the power supply module when it is powered. For the end users, we will cover the power supply module so people do not accidentally touch live wires and risk electrical shock.

We are designing the automated closet because we wish to alleviate people's lives by automating the task of choosing clothes. According to number 5 on IEEE's code of ethics, it is our responsibility to brief others on the capabilities of new technology [4]. We hope our product will be helpful for people and we plan on educating others about our product. Number 1 on IEEE's code of ethics states that the safety of the public is most important and that any potential concerns are addressed and appropriately handled [4]. We acknowledge all the possible safety issues and will make sure to take preventative measures to ensure our product is safe for the public.

4. References

[1] The Daily Mail Online. (2016). *Women spend SIX MONTHS of their working lives deciding what to wear*. [online] Available at: https://www.dailymail.co.uk/femail/article-3626069/Women-spend-SIX-MONTHS-working-lives-deciding-wear.html [Accessed 19 Sep. 2019].

[2] The Closet Carousel. (2019). [video] Available at: http://vimeo.com/162454530 [Accessed 19 Sep. 2019].

[3] Rotating Closets. (2019). *All Products | The Closet Carousel*. [online] Available at: https://rotatingclosets.com/pages/all-products [Accessed 19 Sep. 2019].

[4] Ieee.org, "IEEE IEEE Code of Ethics", 2016. [Online]. Available at: http://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed 19 Sep. 2019].