Self-Cleaning Locker

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1 Introduction

1.1 Objective

Sanitation means everything, especially in a pandemic. We must make sure that ourselves and our belongings are clean in order to help mitigate the spread of COVID. Especially with more companies, buildings, restaurants, and gyms opening up, it's becoming easier for the disease to spread. Particularly with gyms, people are constantly sharing lockers with others, which can easily spread germs due to the storage of their sweaty belongings and clothes.

To combat the spread of COVID, and germs in general, we are proposing a self-cleaning locker. When the locker detects that nothing is inside, it will automatically disinfect the inside of the locker using disinfectant sprays. An LED display on the outside of the locker door will display the status of whether or not it is cleaned, and if there is still disinfectant in the locker.

In addition, we will be building an app that will monitor the status of the locker. For gym owners, the app will allow them to keep track of all their self-cleaning lockers in their locker rooms and make sure that every locker is properly maintained for the safety of their employees and individuals using the gym's lockers.

1.2 Background

We are trying to solve the issue of germs spreading between uses at gym lockers. The gym locker is the main area to hold someone's belongings while using the gym, and everyone throws their belongings in there. However, no one knows who has used that particular locker before them, and if that person has been in contact with other people who have had COVID. Since the locker room is a shared space, an individual really has no choice where else to put their belongings, and whether or not the locker they choose is COVID, or germ free in general.

The gym is one of the easiest places where bacteria can spread. Many different parts of the building and locker room have a multitude of germs. For example, the gym faucet handle has 545,312 CFU (colony forming units), which has eight times as many bacteria than a school cafeteria water fountain spigot. Gym benches have 8,241 CFU, which has six times more bacteria than an animal cage [1]. Contact with these objects can easily lead to the spread of germs. In addition, research shows COVID can last up to two days on fabric, and even up to nine days on certain surfaces [2], [3].

This is where our project comes in. The main problem we are trying to solve is allowing users to have that ease of mind by not worrying about who has used the locker before them, and whether or not it's clean to put their belongings in by eliminating bacteria that could be spread from surface to clothing, and ultimately an individual.

1.3 Physical Design

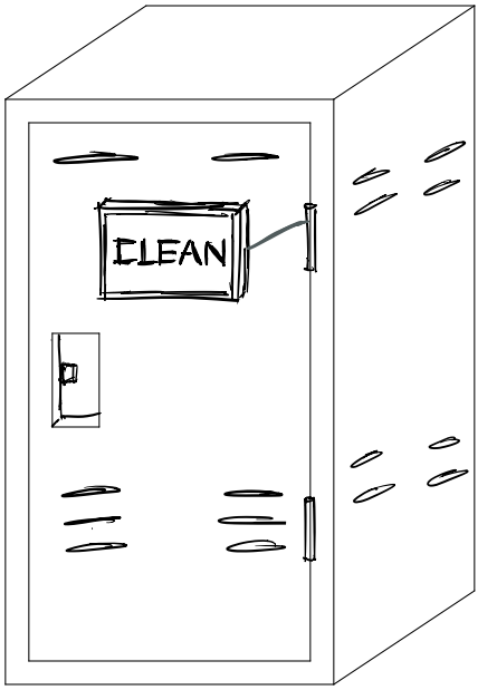

Figure 1: Sketch of locker exterior

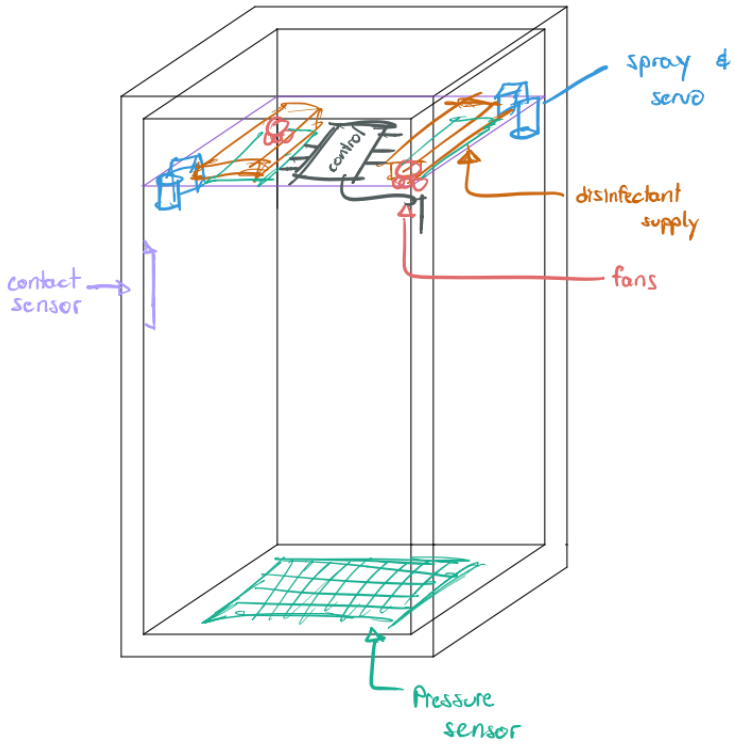

Figure 2: Sketch of locker interior with subsystems

1.4 High Level Requirements

- Weight sensors correctly detect when items weighing at least 5 grams are on top of them with an error range of roughly 10%.
- Spray correctly cleans the inside of the locker when it is empty and closed, covering at least 90% of each surface on the interior.
- Project correctly detects disinfectant supply levels with an error range of around 10%.
- Android application that communicates with the locker to get the status to display to the user. We will need a Bluetooth sensor capable of transmitting between 20 and 30 feet.

2 Design

The three main subsystem modules we will be using for our project will consist of a control unit, disinfectant unit, and monitoring unit. We will go into each module into further detail.

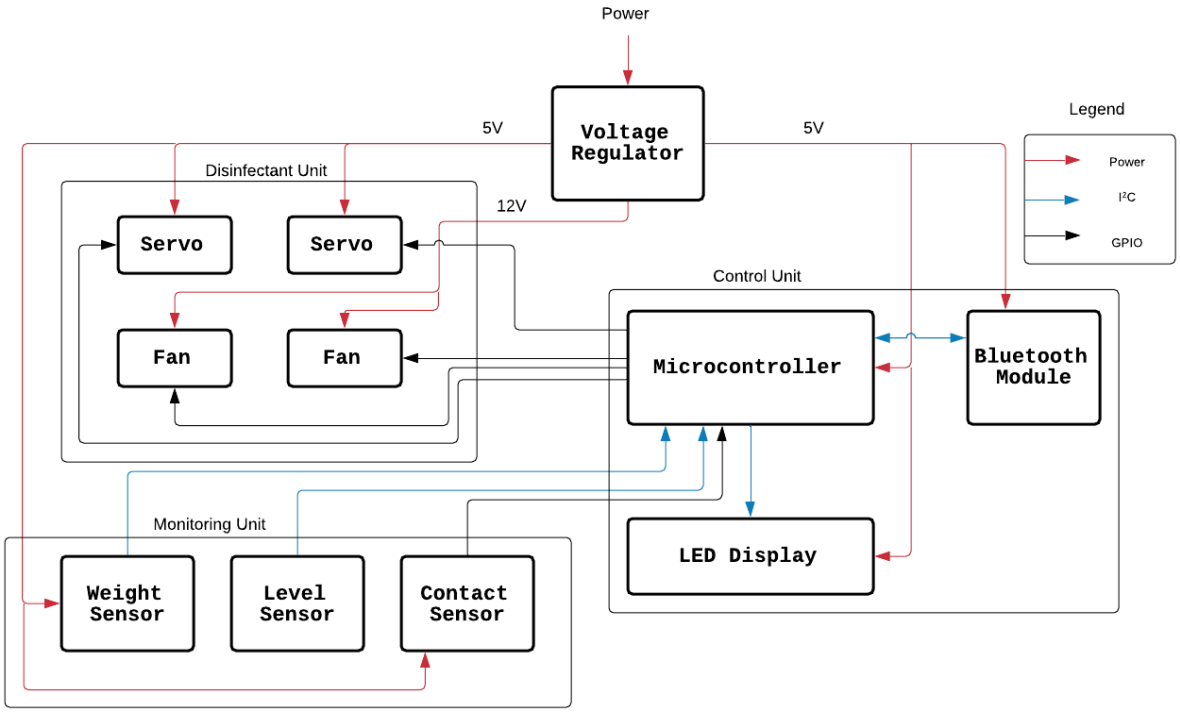

Figure 3: Block Diagram

2.1 Power Supply

Our locker will be plugged into a wall outlet but will make use of a voltage regulator to fine tune how much voltage we want to supply to certain components in our design. We will be using a power supply with two voltage rails. The first will be a 5V rail that will go to every device but the fans. We decided that we needed to have powerful fans to be able to quickly dry the locker after cleaning. Thus, we wanted to use bigger 12V fans optimized for airflow rather than tiny 5V fans that cannot really push much air.

2.1.1 Voltage Regulator

The voltage regulator will allow us to choose how much power to supply to each of our subsystems.

Requirement: Have the voltage regulator be able to correctly send 5V or 12V to the correct subsystems within our locker.

2.2 Control Unit

Our control unit allows for all our subsystems to communicate with one another on which actions to perform depending on the conditions met within our locker.

2.2.1 Microcontroller

The MCU we are using is the ATMEGA32. This will be used to program our LED display.

Requirement: Correctly have the LED correctly output the wanted messages on its display, either "CLEAN" or "LOW SUPPLY," depending on the condition of the locker disinfectant supply from our Monitoring Unit.

2.2.2 Bluetooth Module

The Bluetooth module will be used to communicate the level of disinfectant supply within our locker to our Android application.

Requirement: This needs to communicate with the MCU with SPI and send status to our central application. This should have a range of 20 to 30 feet.

2.2.3 LED Display

The LED should communicate with our microcontroller on what the display should show on the outside of the locker.

Requirement 1: The LED should communicate with our Disinfectant Unit on whether the sanitizing process has initiated, and display "CLEAN" if so.

Requirement 2: The LED should communicate with our Monitoring Unit on whether there is a low supply of disinfectant, and display "LOW SUPPLY" if so.

Requirement 3: The LED display should use around 5 Volts [4].

2.3 Disinfectant Unit

The disinfectant unit will be used to sanitize the interior of our locker when no items are inside the locker. Fans will be used to help dry the interior after we spray disinfectant on the surfaces of the inside.

2.3.1 Servo Motors

The servo motors should be able to initiate the spraying mechanism to sanitize the interior of the locker.

Requirement: The motor should communicate with the weight and contact sensors in our Monitoring Unit to know when it is okay to sanitize the locker. This should use around 5 to 6 Volts [5].

2.3.2 Fans

The fans will be used to air out the inside of the locker after the spray sanitizes the inside of the locker. The locker door should be closed when the fans operate as well.

Requirement: The fans should activate when the spray has finished spraying and when the locker door is closed. They will need to be 12V, as we wanted more powerful fans capable of moving air as quickly as possible.

2.4 Monitoring Unit

The monitoring unit will be used to monitor whether there are items inside the locker and will communicate with our disinfecting unit on whether to initialize or not. This unit will also monitor the amount of disinfectant supply within the locker and will communicate with our LED display and an Android app about certain locker information, such as supply level, and whether it is in use.

2.4.1 Weight Sensor

This weight sensor will be located at the bottom of the inside of the locker to detect if there are any objects on top of it to communicate whether to start the sanitation process.

Requirement: The sensor must detect items that weigh at least 5 grams and communicate with our MCU with roughly a 10% error range. Depending on the sensor used, this can use anywhere from 2 to 12 Volts [6].

2.4.2 Level Sensor (Weight Sensor)

This second weight sensor will be used to measure how much disinfectant there is left in our locker in order to clean it.

Requirement: The weight sensor should correctly output the amount of disinfectant supply to our MCU controlling our LED, as well as our Bluetooth module for our application. This should have roughly about a 10% error range. Depending on the sensor used, this can use anywhere from 2 to 12 Volts [6].

2.4.3 Contact Sensor

The contact sensor will be attached to the inside of the locker door to check whether the door is closed or not.

Requirement: The contact sensor must correctly communicate with our MCU whether the locker door is closed.

2.4.4 Application

The application will act as a central monitoring system for all connected lockers. Each locker will have its status listed for an employee to check on the locker room. This will be created using Android Studio.

Requirement: The application needs to communicate with the Bluetooth module to show whether or not the locker is in use and what the disinfectant level for that locker is.

3 Ethics and Safety

We are responsible for keeping the public's safety, health, and welfare in mind when designing this project. This refers to the IEEE Code of Ethics, #1, stating "to hold paramount the safety, health, and welfare of the public" [7]. We must be sure that our locker does not pose any safety concerns for people when using our device. We will go into how we would implement the required safety restrictions in our project later in this section.

Another ethical concern that is out of our control would be the discrimination of use with our product. This refers to the IEEE Code of Ethics #7, stating "to treat all persons fairly and with respect, and to not engage in discrimination based on characteristics such as race, religion, gender, disability, age, national origin, sexual orientation, gender identity, or gender expression" [7]. While we will never discriminate the use of our product based on the characteristics of a person such as race and gender, in a real-world application of our product where it is readily available in public gyms, certain establishments may discriminate against certain people on the use of the lockers. We do not have a solution for this, as it is out of our control as to how someone else may allow others to use our locker. The best thing we can do is to investigate whether or not a buyer has a good record of respecting an individual's race, gender, religion, etc., if we were to sell this product.

In terms of safety for our self-cleaning locker, we must make sure that our pressure sensor is accurate in detecting whether there are items, even small ones, in our locker. We have to make sure that no one's belongings get wet on accident by our sensor not detecting that they are there. Another safety issue that can come up is the issue of wiring in our project. We want to make sure that our wires do not short and cause damage to anything. We will address this by covering our wires with electrical tape whenever possible.

Going along with the issue of wiring in our project, we are going with a plastic build for our locker. Although most gym lockers are made up of metal, if anything were to go wrong with our circuit, and have that touch our locker, it could send an electrical current through the locker, injuring people who are in contact with the locker. We decided to use a plastic locker frame to avoid this potential safety hazard.

References

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