**Project Title:** Automatic Door

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**GitHub Page:** [**https://github.com/cbyrneatu/internet-of-things-project**](https://github.com/cbyrneatu/internet-of-things-project)

**Trello Page:** [**https://trello.com/b/jdyRRwGD/door**](https://trello.com/b/jdyRRwGD/door)

**Links to data:**

1. A document which explores more complex automatic doors, which can detect the speed of people going through the door: <https://ieeexplore.ieee.org/abstract/document/6907799>
2. A door system using a heat sensor to control the amount of people entering a room: <https://ieeexplore.ieee.org/abstract/document/9596388>

**Problem to be solved:**

With most doors, people who have certain medical conditions, like being unable to walk properly, or having reduced strength, are unable to open doors which have handles or buttons. They require someone else to open the door for them, which can make them feel less independent.

In situations like COVID, we tried to have as little contact with surfaces as possible to prevent it spreading. Unfortunately, this was unavoidable with most doors, as they were heavy and required force for a few seconds to open. In these cases, if someone was contagious with COVID and used the door, it could live on the surface (for example steel or metal, which is often used for door handles) for up to 72 hours if not cleaned in the meantime. (Health Library Ireland, n.d.)

In both cases, there is a common issue to be solved, people may not be able to open a door, or they may not want to touch a door to open it to prevent infection.

With current semi-automatic doors, they require the pressing of a button to open the door, however this can be impractical to those who are wheelchair bound, suffer from paralysis and other such ailments. Current motion sensor doors are big, bulky and expensive, however our take on the automatic door would require little setting up making it a cheaper and effective option over other pre-existing automatic doors.

In conclusion, our project tries to make a cheap and effective automatic door that would be accessible to anyone and everyone who needs it.

*References:*

* Health Library Ireland (n.d.) *How long can the COVID-19 virus exist on surfaces? What role do contaminated surfaces play in the chain of transmission? What infection control precautions should be implemented?*, available: <https://hselibrary.ie/how-long-can-the-covid-19-virus-exist-on-surfaces-what-role-do-contaminated-surfaces-play-in-the-chain-of-transmission-what-infection-control-precautions-should-be-implemented/> [accessed 10 Mar 2024]

**Summary of the Project Solution:**

Our project solves the problem of people with certain disabilities not being able to access the door. It’s a simple contactless door, which also has the bonus of preventing the spread of germs. The door itself would be cheaper than other automatic doors. It’s smaller in size and can be easily installed into an existing door configuration.

The door will automatically open once a laser tripwire installed at the base of the door has been broken. This makes it so that the door can be opened by anyone, regardless of age, height and medical condition. The door itself is programmed to keep the door open for 10 seconds, allowing people plenty of time to enter the room. If someone goes across the door within this 10 second period, it will reset, meaning that the door won’t accidentally close on anybody.

A diagram of a sensor

Description automatically generated

This door design makes the process of entering and exiting rooms contactless. During the pandemic 4 years ago, it was imperative that all surfaces remained clean to prevent spreading COVID. Our system allows the opening of a door without even touching it, thus preventing the spread of diseases. As well as this, the contactless door allows people who are carrying stuff or pushing trolleys to open the door, without having to stop what they’re doing.

This concept would also help people who aren’t able to open doors without another person enter or exit the room. We believe that this would help extremely with boosting self-esteem, as some people may feel embarrassed to have other people open or hold doors for them.

Finally, our project is both cheap and effective. The laser tripwire can be set up effortlessly on a door frame. Right now, our implementation doesn’t go in depth about how the motor would be attached to the door itself.

Hypothetically, a motor or some other system would be fitted to the door, allowing it to be controlled by the Arduino. The laser, light sensor, and motor are then connected to an Arduino, which can be installed into a wall. We also explored the idea of using a wireless signal to connect the Arduino to the motor, but our motor for this prototype didn’t allow that.

This simple set up is easy and cost efficient as it would not require a professional to set up, as well as only requiring some basic, cheap parts. It was even trivial to add a webserver to this project. This serves a HTML page which allows the owner of it to track the usage of the door, and see if it’s currently opened or closed.

**List of Project Requirements:**

1. To detect when the connection between the laser pointer and the light sensor has broken, this indicates that someone is at the door.
2. To use a motor to open the door after the laser connection has broken.
3. To close the door after 10 seconds of it being open, if someone else hasn’t walked up to it in that time.
4. To count the amount of people entering the room.
5. Have a way to lock the door through a web interface.
6. Have statistics about how many times the door was opened in a day.

**Initial Design**

Our design requires an Arduino, a motor controller, a motor, a light sensor, a laser pointer and several connection cables.

The light sensor would be connected to digital port 2. The motor controller would be connected to pins 8, 9, 10 and 11, as well as having 5V and ground. This controller is responsible for talking to the motor. The Arduino itself would be connected to a power source, supplying power to everything.

Our hardware design is very simple, and could scale quite easily, as parts like the light sensor and motor can be changed, if they are compatible with our code.

**A diagram of a motor

Description automatically generated**

Attached to the motor would be the door itself. For this device, we will be using a small-scale door to prove the concept, however the code is easily scaled for use with a bigger door.

**Implementation Plan**

As mentioned in the initial design, our design requires an Arduino, a motor controller, a motor, a light sensor, a laser pointer and several connection cables.

To make configuring the system easy, the main behaviour is controllable by setting the value of constants at the top of our project file.

A black text with a blue and white background

Description automatically generated

This allows the user to control the number of seconds (50 = 5 seconds) before the door will close, how many steps the motor takes for a full revolution, and which digital port the light sensor is connected to.

The code architecture is quite simple, we use the Stepper library for controlling the stepper motor, and the Bridge set of libraries for establishing our webserver.

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Description automatically generated

In the doorLoop method, we perform the following tasks:

In the beginning, we check the state set at the end of the last loop:

* Check if the door should open, if so, we rotate the door 90 degrees.
* Check if the door should close, if so, we rotate the door backwards 90 degrees.

After checking the state, we read a value from the sensor to see what should be done at the start of the next loop:

* If the sensor doesn’t detect light, we indicate that the door should open on the start of the next loop
* If the sensor does detect light:
  + Increment a variable called openTicks.
  + If this variable is above a certain amount (e.g. 5, defined as SECONDS\_BEFORE\_CLOSING) multiplied by 10, we indicate that the door should close on the start of the next loop.

A screen shot of a computer code

Description automatically generated

We have a separate method called serverLoop, which will check if there’s an incoming connection, and if so, will send back a basic HTML page showing statistics of the door.

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The main loop method calls both server and door loop, keeping these parts of the code in separate methods allows them to be worked on individually and keeps our code clean.

Finally at the end of the loop method (not doorLoop!), we delay for 100ms, the average human classifies as 200ms for something to happen to be fast, so if we check every 100ms, the door will still feel responsive, while running our checks a lot less, this reduces the amount of stress on the Arduino hardware.

**Testing Approach**

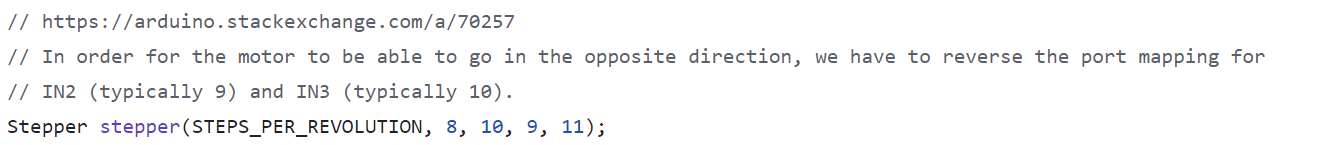
To test the system, we decided to split it into smaller parts to ensure that they were all working on their own before putting it all together for a final test.

At the start, we decided to just test the sensitivity of the light sensor. We did this very simply by connecting an LED to the Arduino, and setting the LED to turn on when it detects light and turn off when it doesn’t.

A circuit board with wires

Description automatically generatedThen, we disconnected the light sensor, and just connected the motor, so we could see how it worked and ensure that it would do what we needed to do.

This brought an issue to light that we had with the motor: it was unable to move backwards in its default configuration, which is quite important for our design, since we don’t want the door to go through a wall.

After some research, we found that swapping two pins in our code allowed the door to go backwards, which was quite weird, but it was good to find that issue early, before we ran into it with all the other parts connected and trying to figure out if something else was the problem. 

Finally, we connected all the parts together, and spent a while trying to break it, fortunately, everything seemed to work, even when trying to trick the light sensor.

**Security Analysis**

Fortunately, our initial implementation of this design does not have many security loopholes:

* The webserver doesn’t allow any sort of data modification at the moment (see future improvements planned section for more details), meaning that the door cannot be controlled remotely at all.
* All parts (motor, light sensor, etc.) are connected directly to the Arduino and don’t send data to each other over the network, this prevents remote attackers from being able to pretend to be a motor or light sensor, and causing the door to do unwanted actions.

**Future Improvements Planned**

* Our initial implementation only included a basic webserver, which did not allow for permanently locking or manually opening the door. This would be something that we would implement in the future, but we need to consider how to store the password in a way that is safe, as if an attacker managed to gain access to the device, they may be able to extract the password.
* We would also like this functionality to be disabled by default, and manually enabled when the user wants it, as leaving it on by default could cause some people to be unaware of it and misconfigure the system to allow anybody to control the door.