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Development of Self-Sanitizing Door Handle Automation

Chan Yu Xuan[1], Lim Kian Ann[1], Loh Ee Herng[1], Ahmad Alabqari Ma'Radzi[1]*

[1]Department of Electrical Engineering, Centre for Diploma Studies,
Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub,
84600 Pagoh, Johor, MALAYSIA

*Corresponding Author Designation

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Abstract : Lately, sanitising hands is required for people before entering a building but due to manual hand sanitiser, not all the customers will sanitise their hands before entering a building. Thus, the development of a system self-sanitising door handle allows people to open the door while keeping their hands and the surface of the door handle clean where the self-sanitising door handle can operate manually or automatically. This thesis covers the details of the theory and working principles of the self-sanitising door handle. This thesis explains and discusses the methods of developing a self-sanitising door handle using Tinkercad Simulation and Arduino Uno. Furthermore, the operation of the self-sanitising door handle is presented in this thesis. The experimental data and simulation results are all provided and discussed. Both self-sanitising door handle prototype experimental results and simulation in Tinkercad results have been recorded and compared. In conclusion, the theoretical results are supported by the experimental and simulation results.

Keywords: Hand Sanitiser, Door Handle, Self-sanitising door handle, Arduino UNO

1. Introduction

In late December 2019, a previously unidentified coronavirus known as the 2019 novel Coronavirus emerged from Wuhan, China and caused a massive outbreak across China to other countries, including Malaysia. This disease is officially named as Coronavirus Disease-2019 (COVID-19) [1]. The Huanan Seafood Wholesale Market in Wuhan, Hubei, China, is the first to experience an outbreak of strange pneumonia characterised by fever, dry cough, fatigue and occasional gastrointestinal symptoms in late December of 2019[2]. The first Malaysian was confirmed with COVID-19 on February 4, 2020, is a 41-year-old man who had recently returned to Malaysia from Singapore when he started to have a fever and a cough. He was quarantined at Sungai Buloh Hospital, Selangor [3]. Covid-19 rapidly spread to other countries, including South Korea, Taiwan, Thailand, Singapore, Japan, Italy, Iran, Spain, the United States and the United Kingdom. The World Health Organisation (WHO) declared a pandemic on March 12, 2020. As of December 10, 2021, there have

*Corresponding author: abqari@uthm.edu.my

been a total of 269,470,277 Covid-19 cases reported worldwide, with 5,312,606 deaths and 242,389,485 recovered cases [4]. The United States has the highest number of Covid-19 cases (50,705,257) and death cases (817,326) [4]. In Malaysia, 5,058 new cases and 54 new deaths were reported on December 10 2021[5]. The number of cases has increased exponentially in USA, UK, Germany, France and South Africa [4].

For the modes of transmission of COVID-19 virus, respiratory infections can be transmitted through droplets of various sizes when the droplet particles are larger than 5-10 μm in diameter they are referred to as respiratory droplets while when the particles are smaller than 5μm in diameter are referred to droplet nuclei [6]. Droplet transmission occurs when a person is in close contact with someone (within 1 m) who has respiratory symptoms like coughing and sneezing; therefore, someone will have the risk of having his/her mucosae or conjunctiva exposed to potentially infective respiration droplets [7]. In addition, the transmission may also occur through fomites (surface) in the immediate environment around the infected person. As a result, the COVID-19 can be transmitted through direct contact with infected people and indirectly contact surfaces in the immediate environment or with objects used on the infected person, for example, like thermometer and door handle [8]. According to research, COVID-19 spread between persons by contacting surfaces where an infected person has just coughed or sneezed and then touching the mouth, nose, or eyes directly [9].

To prevent the virus from spreading, a few steps have been taken by the government. Government has stated and launched the Standard Operation Procedure (SOP) and one of it is to wear mask at the public places such as, hypermarket, hotel, hospital and public toilets. The owners of the public places also are asked to place the sanitizers at the entries in order to allow the customers to sanitize their hands before entering. However, due to the manual hand sanitizer, the customers feel troublesome for them to press the sanitizer as they are holding something on their hands. Therefore, they prevent not to use the sanitizer. Not only that, by pressing the sanitizer themselves will cause the wasting of sanitizer as they press a lot but did not clean and sanitize their hands nicely and completely. When they press it, the sanitizer will flow out in a large quantity. However, the customers do not rub the sanitizer all over their hands but their palms only. They are not using the sanitizer optimistically as some of the sanitizer will be wasted. If the sanitizer keeps on run out in a short period of time, the supply of sanitizer maybe stop as it has become a burden for some small business owner.

This product is to develop a system self-sanitizing door handle that keeps the users hands and the surface of the door handle clean and well-sanitized. After that, this product is aimed to control the sanitizing process to ensure the cleanliness of the door handle at the optimum level with sufficient sanitizer. At the same time, to minimize the design of the microcontroller by using Arduino UNO board. To achieve these objectives, infrared sensor has been use to detect the present of the users' hands while the ultrasonic sensor is used to detect the close open of the door. 12V DC bettery is act as an electrical supply for the 12V DC motor pump which is use to pump the sanitizer from the sanitizer tank and spray it out through the mist nozzle. Also, the ultraviolet (UV) light is use to kill and eliminate the bacteria and viruses on the door handle. All of this components are connect to the Arduino UNO through the mini breadboard.

2. Materials and Methods

2.1 Block Diagram and Flowcart

From **Figure 1**, the block diagram shown that the inputs are IR Sensor and Ultrasonic Sensor. The process is control by the Arduino UNO as the microncontroller and the output is the Motor Pump and UV LED.

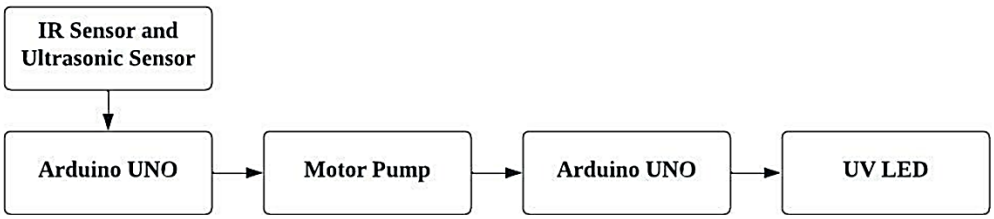


Figure 1: Block diagram of the system

Figure 2 shows the flowchart of the overall operation process. The program starts with steady-state where both infrared and ultrasonic sensor is in detecting condition. When both sensors detects the user's hand and the door is opened, motor pump will be activated for 5 seconds. Otherwise, it remains in steady-state. After 5 seconds, the motor pump deactivated and Arduino's timer starts counting. If the door is not used within 2 minutes, the UV LED will be activated for 1 minute. After 1 minute, the program will end or back to the steady-state. Using the door within the 2 minutes will activate the motor pump and reset the timer counting. Using the door while the UV LED is activated also will de-activate the UV LED, activate the motor pump and reset the timer counting.

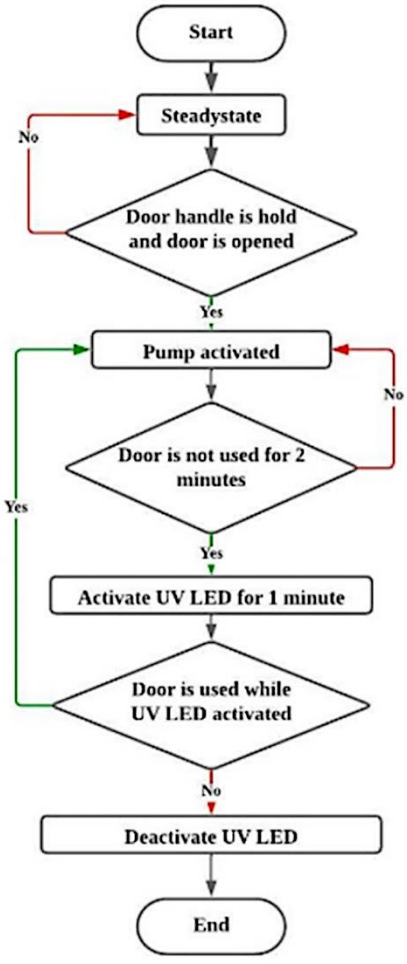


Figure 1: Flowchart of the overall operation process

2.2 Preliminary Sketch

Figure 3 shows the preliminary sketch of the hardware which consist of the parts of the self-sanitizing door handle and the views (front view, side view and plan view) of the self sanitizing door handle. The function of each parts of the self-sanitizing door is explained and shown in **Table 1**.

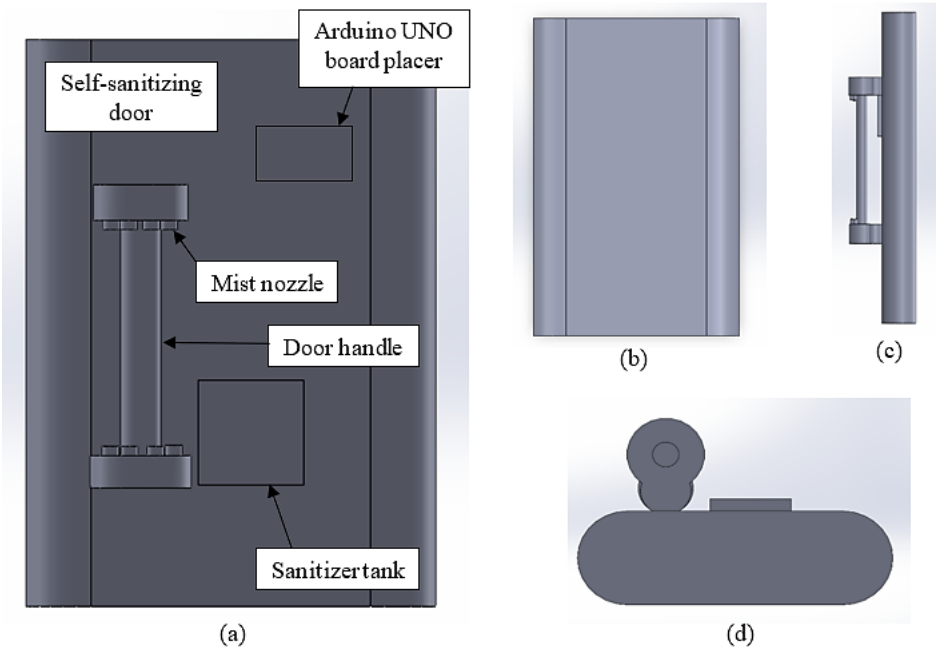


Figure 3: Preliminary sketch of the hardware consist of (a) parts of the self-sanitizing door. (b) front view on the self-sanitizing door. (c) side view of the self-sanitizing door (d) plan view of the self sanitizing door

Table 1: Parts of the self-sanitizing door and their functions

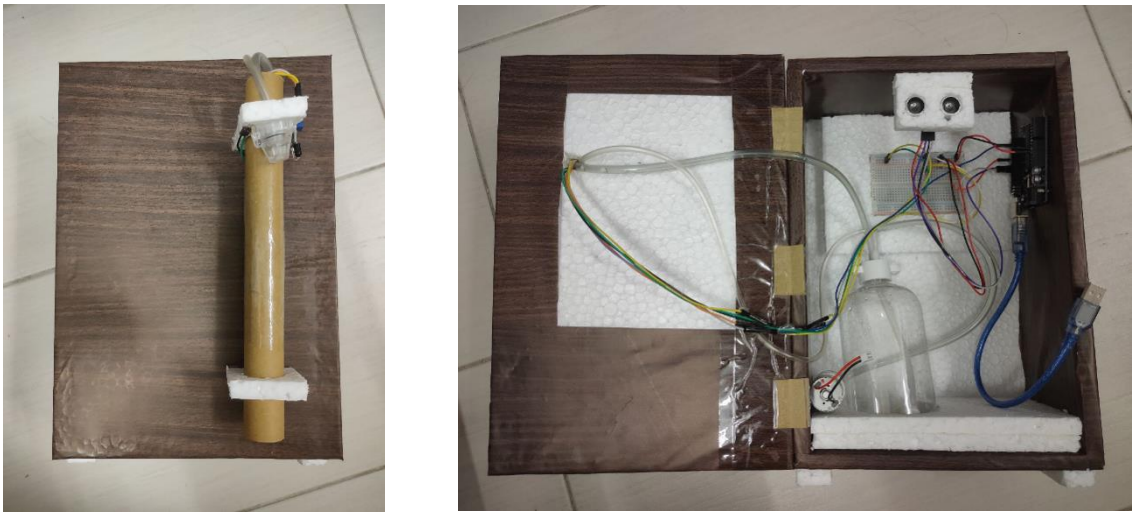
Parts of the self-sanitizing door	Function
Self-Sanitizing Door	Used to install all the components and the door handle for self-sanitizing system.
Arduino UNO board placer	Used to place the Arduino UNO board.
Mist Nozzle	Used to make the sanitiser spray out in mist form instead of liquid form. It is connected to the sanitiser tank by a rubber tube.
Door Handle	Used to open and close the door.
Sanitizer Tank	Used to store liquidfy sanitizer.

3. Results and Discussion

This part will discuss and show the self-sanitizing door handle hardware, software and simulation results with figure as the evidences.

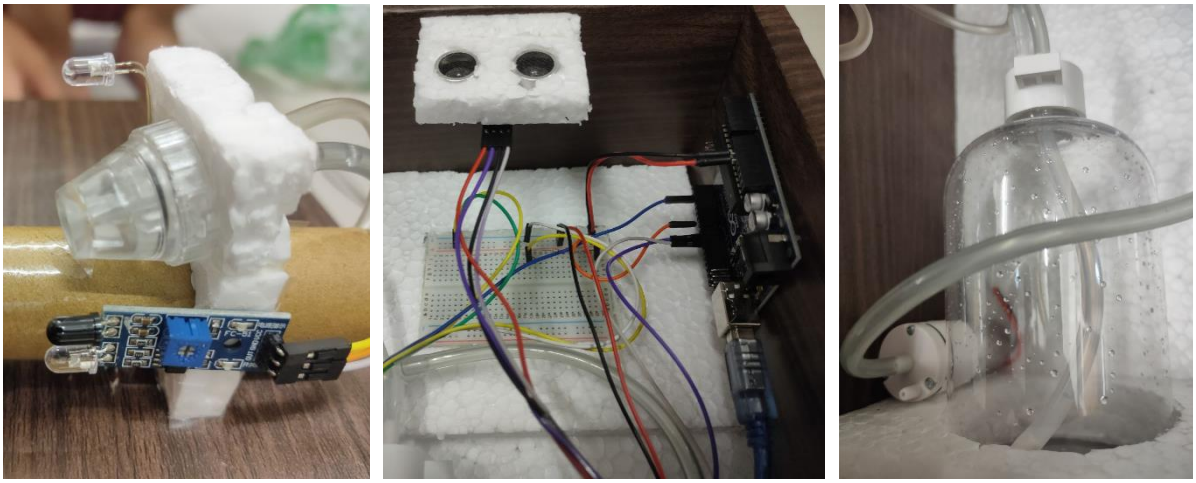
3.1 Hardware

Figure 4 shows the model of the self-saniting door handle with outside view of the model on the left and inner view of the model on the right. All the components have been installed to the model.



(a) **(b)**

Figure 2: Model of self-sanitizing door handle. (a) outside view of the model. (b) inner view of the model



(a) **(b)** **(c)**

Figure 3: Components that installed in the model (a) UV LED, mist nozzle and infrared sensor (b) ultrasonic sensor, mini breadboard and Arduino UNO board (c) motor and sanitizer tank

3.2 Software

Figure 6 (a) shows the coding to operate the infrared and ultrasonic sensor. For ultrasonic sensor, the coding shown is to calculate the distance detected. For infrared sensor, the coding shown is to read the state of the sensor either HIGH or LOW.

Figure 6 (b) shown the coding to operate the motor pump. The motor pump will only be activated if only that infrared sensor's is HIGH and distance detected is more than 5cm. It will be activated for 5 seconds.

Figure 6 (c) shown the coding to operate the UV LED. If the door is not used after 2 minutes the motor activated, the UV LED will be activated for 1 minute. When the door is used within the 1 minute period, the UV LED will OFF, the motor pump will ON and the timer will reset.

```
const int echoPin = 9;
const int trigPin = 10;
int led = 7;
int pump = 12;
int sensor = 2;
int state;
int distance;
long duration;
int mode = LOW;
unsigned long now;
unsigned long last;

void steadystate(){
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  duration = pulseIn(echoPin, HIGH);
  distance = (duration*0.0343)/2;

  state = digitalRead(sensor);

  if(state == HIGH && distance > 5){
```

(a)

```
void loop(){
  unsigned long start = millis();
  unsigned long end;
  steadystate();

  while(mode == HIGH){
    if(now - last >= 2000){
      digitalWrite(led, HIGH);
      end = start;
      if(start - end >= 2000){
        steadystate();
      }else{
        start = millis();
        digitalWrite(led, HIGH);
      }
      digitalWrite(led, LOW);
      steadystate();
      mode = LOW;
    }else{
      now = millis();
      steadystate();
    }
  }
```

(b)

```
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  duration = pulseIn(echoPin, HIGH);
  distance = (duration*0.0343)/2;

  state = digitalRead(sensor);

  if(state == HIGH && distance > 5){
    digitalWrite(pump, HIGH);
    delay(2000);
    digitalWrite(pump, LOW);
    now = millis();
    last = now;
    mode = HIGH;
  }
}

void setup(){
  pinMode(sensor, INPUT);
  pinMode(echoPin, INPUT);
  pinMode(trigPin, OUTPUT);
  pinMode(led, OUTPUT);
```

(c)

Figure 4: Coding used to operate the self-sanitizing door handle (a) coding for infrared sensor and ultrasonic sensor. (b) coding for motor pump (c) coding for UV LED

3.3 Simulation

Figure 7 shows the circuit built by using Tinkercad software. It is as a guide to build the real prototaip of our project. Also, the Tinkercad software is used to write the coding to run and test the operation of simulation circuit.

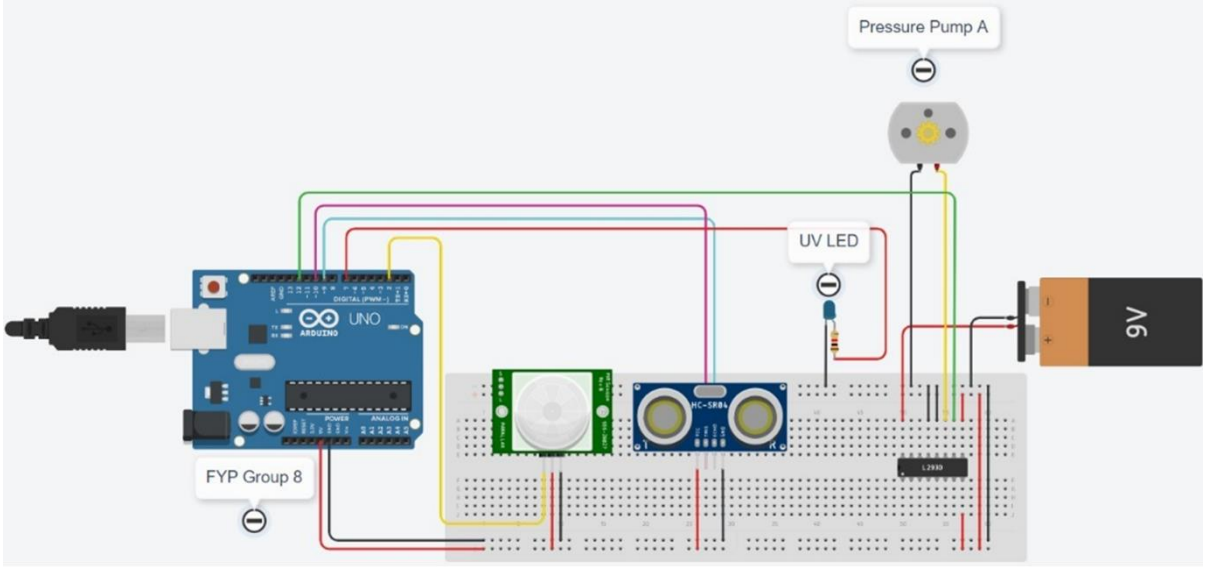


Figure 5: Simulation using Autodesk TINKERCAD

3.4 Result

Table 2: Operation result of self-sanitizing door handle

State of Ultrasonic Sensor	State of Infrared Sensor	State of Motor	State of UV LED After the motor is deactivated for 2 minutes	Time Activation of the UV LED (s)
Triggered	Triggered	ON	ON	60
Triggered	Not Triggered	OFF	OFF	-
Not Triggered	Triggered	OFF	OFF	-
Not Triggered	Not Triggered	OFF	OFF	-

Table 2 shows the operation result of the self-sanitizing door handle after a few test run sessions were carried out. The ultrasonic sensor is representing the opening and closing of the door while the infrared sensor is to detect the presence of the users hand on the door handle.

3.5 Discussion

The motor pump will keeps on activated if both the ultrasonic sensor and infrared sensor are triggered. When both the ultrasonic sensor and infrared sensor are not triggered, the motor pump deactivates, the timer start counting for 2 minutes then the UV LED activates for 60 seconds. If there are interrupts during the 2 minutes and 60 seconds of timers, the whole operation will be restart again.

4. Conclusion

In conclusion, the building of this technical paper has provided a thorough review of each technique with a detailed explanation of the working of the self-sanitizing door handle model. Moreover, through this paper, it had proved that hand sanitiser is the most suitable method to be implemented in the product as it is easier to use and does not need to rinse with water when compared with soap. The proposed microcontroller board to be used is Arduino UNO ATmega328P as it can read inputs and execute the programming and change it into output to control UV LED and motor. Furthermore, Arduino UNO has minimum power consumption with an easily programmable interface since Arduino UNO is open-source software. Last but not least, the help of TINKERCAD simulation has successfully provided an outcome and image for the installation of circuit for the product. Thus, there are some similarities between the circuit used and the TINKERCAD simulation results in terms of the detecting presence of a human hand when grabbing a door handle in an infrared sensor and the distance between the door frame and the door with the help of an ultrasonic sensor.

After undergoing production, review, evaluation and testing of this model, there are some parts that are identified with deficiencies and can be improved in the future. The improvement that can be done is implementing an internal power generator to power the door handle so it could convert the kinetic energy to electrical energy. The energy can be generated through the close and open of the door. Indirectly, this can save the electricity and reduce the cost of electric bill. Not only that, the shape and the size of the sanitizer tank can be made it into a more suitable one so that it can safe more spaces and store larger quantity of sanitizer. Also, the sanitizer tank have to be removable, replacable and refillable to make the refilling process more easier. The last improvement that can be made is the material of the door handle should be the acrylic rod with the UV LED at both ends. This can improve the effectiveness of the sanitization process.

Acknowledgement

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