Auto Customer-Limiting Door Lock System

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***Abstract*—The COVID-19 pandemic was caused by the outbreak of the coronavirus all over the world. It is advised by the World Health Organization, WHO, that crowded places must be avoided by people to protect themselves from the spread of coronavirus disease and social distancing must be practiced at all times. In order to ensure social distancing and the safety of customers and employees at public places during the pandemic of COVID-19, our project proposes an Arduino based auto customer door lock system which limits the number of people allowed inside establishments and only permits people with normal temperature to enter in order to avoid any risks. The system detects the temperature of the person at the entrance using a temperature sensor (LM35) and allows the person to enter if the temperature is inside the range but locks the door if the temperature of the person is above the range. Two 7-segment displays are also used where one displays the maximum number of people allowed and the other displays the total number of people inside. Ultrasonic sensors (HC-SR04) at the entrance and exit detect people entering and leaving to ensure the maximum limit does not exceed. If the maximum limit is reached, the door locks itself preventing anyone else to enter.**

Keywords: COVID-19 pandemic, social distancing, Arduino, temperature, LM35, ultrasonic, HC-SR04

I. Introduction

The outbreak of the novel coronavirus known as COVID-19 pandemic has caused a state of global crisis. During these difficult times when the COVID-19 related cases are increasing day by day, it is essential to ensure the prevention of the spread of the coronavirus in public places. As per the WHO provided guidelines, social distancing must be practiced at all times in order to reduce or control the spread of coronavirus. It is difficult to ensure safe social distancing in crowded or public places which is why many public establishments are temporarily closed. Many small businesses are in jeopardy. Our proposed model enables these establishments to reopen while ensuring proper social distancing by limiting the maximum number of people allowed inside. Additionally, our proposed model measures the temperature of a person entering the establishment and does not allow the person to enter if the temperature exceeds the range, indicating that the person is risky and might have contracted the disease; they are serviced separately with precautions. Therefore, our proposed model can help prevent the transmission of the coronavirus by limiting the number of people allowed inside at a time and not allowing people with high temperature to enter.

II. Literature Review

After the outbreak of the coronavirus, also known as COVID-19, WHO provided guidance focusing on what approaches should be taken to fight against the pandemic. Out of all the approaches the most effective one is Social Distancing. The relative risk of spreading any virus or infection will be very high if daily investment in social distancing is not being practiced [1]. In order to control social distancing in public places, few devices have been invented. One of the devices is crowd limiting door assistant which restricts people from entering if the number of people inside is filled to the capacity that has been set by the authorities [2]. Even though the device is deftly thought out, few changes can be done to make the machine more sensible. This machine limits the number of people and helps in crowd controlling but people who have been allowed to enter the premise due to availability of space might be affected by the virus. It has been mentioned that one of the easiest ways to identify and control the infection covering a large scale of population is by conducting body temperature detectors at the entrance of social premises [3]. This filtering out process has been adapted by a lot of the countries as fever is the most common symptom for COVID patients.

III. Methodology

Our proposed model is used to limit the number of people allowed inside an establishment and also prevents risky people with high temperature from entering. Our model consists of an Arduino Nano board connected with a 16x2 LCD module, two 7-segment LED displays, two ultrasonic sensors (HC-SR04), a temperature sensor (LM35), a PCF8574 chip, two 74HC4511, a buzzer, three push buttons and a micro servo motor.

A. Product description:

The 3D model displays the structure of the proposed system and the workflow describes how the system will work.

1) 3D model: The 3D model of our proposed project is designed using SolidWorks 2019, a standard 3D model designing software. The components of the 3D model of our proposed project are enclosed in a box shaped as a cuboid. The Arduino Nano is assembled inside the box and all the components will be connected to this. The temperature sensor, LM35, is placed at the front of the box which will measure the temperature of the person entering the establishment. The

buzzer at the top will start ringing if the person has high temperature. The 16x2 LCD module placed at the front plane of the box will display the message whether the person can enter or not and the temperature measured. Two 7-segment LED displays are also placed at the front plane of the box where one will show the maximum number of people allowed inside and the other will show the total number of people inside. Ultrasonic sensors, HC-SR04, are placed on either side of the box where one will be at the entrance and the other at the exit to detect the number of people entering and leaving the establishment. Three push buttons are placed at the back of the box, which will be the inner wall of the establishment, and these buttons can be used to increase, decrease and set the maximum number of people allowed inside. The micro servo motor is used as a locking mechanism which will be placed at the door.

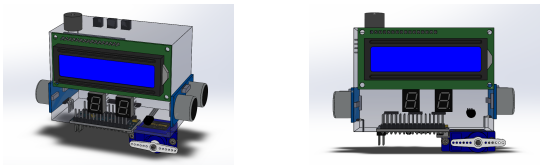


Fig. 1. 3D Model.

2) Workflow: The workflow diagram shows how the system works. At the beginning of the day, authority/staff of the public institution will set the maximum limit of the place. By pressing the increase and decrease buttons, when the desired number of limit is displayed in the 7-segment display set outside the door, the person will then press the Set button to activate the system. Once the system starts operating, the temperature sensor will continue measuring the temperature of the customer who stands at the door. If the temperature is less than 100.4 degree Fahrenheit and the number of customers already inside is less than the maximum limit, the lock will remain open, allowing customers to go inside. The LCD display attached at the door will also display this temperature and an appropriate message for the customer. Ultrasonic sensor at the entrance door will then detect the person's entrance and thus the number of customers inside will increase. This number will also be displayed on a 7-segment display to let the people outside know what the situation is. When a customer leaves the place, the ultrasonic sensor at the exit will detect that and thus the 7-segment display will show number of customers inside decreasing by one. When the maximum limit of the place is reached after a person enters, the door will automatically lock, thus preventing overcrowding of the place. The lock will open again automatically when a person leaves the place. On the arrival of a person with temperature higher or equal to 100.4 degree Fahrenheit, the door will automatically lock and a buzzer will sound, calling the attention of the staff members. As in the Covid-19 pandemic, people with fever are considered at-risk patients, they will be serviced separately with extra caution and care. The following table shows when a door is locked and when it remains unlocked:

	No. of customers inside less than limit	No. of customers inside at max limit
Customer at door with normal temperature	LOCK OPEN	LOCKED
Customer at door with high temperature	LOCKED + BUZZER	LOCKED + BUZZER

Fig: Stages of the Auto Door Lock System

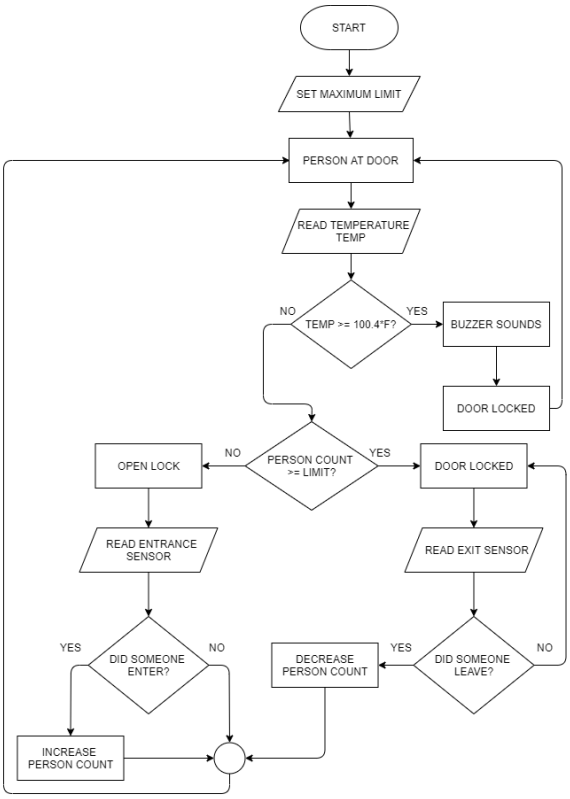


Fig. 2. Workflow Diagram.

B. System Architecture

This is a low-cost system built to take precautions against the Covid-19 pandemic. It is built with simple and easily available materials. AC to DC wall adapters are used to supply the system with power. As we are using an Arduino Nano as the interfacing IC, it has a built-in voltage regulator. The Arduino Nano can be powered via the Mini-B USB connection, 6-20V unregulated external power supply can be given.

1) Hardware Requirements: We have chosen the Arduino Nano board to make our system smaller and easily portable and furthermore the Arduino Nano has two extra Analog pins, A6 and A7, with which we can connect the sensors and use the other analog pins, A0-A5, as regular digital pins to connect the rest of the I/O devices. The sensors required in this system are one LM35 (thermal sensor) and two HC-SR04 (ultrasonic sensor). Two 7-segment displays are needed along with two BCD to 7-segment decoders, 74HC4511. The decoders are

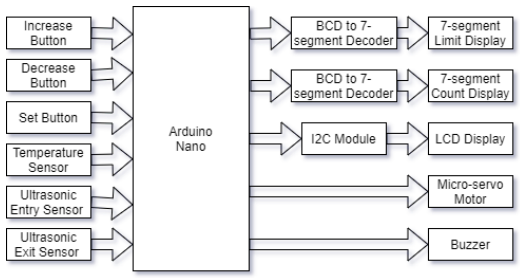


Fig. 3. Block Diagram of the System Architecture.

used so that lesser number of pins is used up by the 7-segment, leaving more pins to be used by the other I/O devices. For stores, restaurants, offices with more capacity, double-digit 7-segment displays can be used instead. One buzzer is used to alert the authorities in case of at-risk customers. Three push-buttons are used to set the maximum limit of the establishment along with 3 pull-up resistors. One micro-servo motor, PWMSERVO, is used for the locking mechanism of the door. Last but not least, a 16x2 LCD display is used to display the temperature measured and an appropriate message for the customer at the door. The LCD is connected to the Arduino Nano through a PCF8574 IC. By using I2C protocol to connect the LCD, only two pins of the Arduino are used for the LCD.

2) Software Requirements: The required code is compiled through Arduino IDE. The code of the system is uploaded to the Arduino Nano. This system can easily be implemented in all public places. In establishments with entrance and exit on different sides of the room, a Bluetooth module needs to be embedded into the system.

3) IC- connections: All the sensors and GPIO devices are connected to the Arduino Nano board through its numerous pins. The LM35 sensor is connected to the analog pin A7 so it can read the analog data sent by this temperature sensor. The ultrasonic sensors, HC-SR04, are connected to the digital pins. The Trigger pin of the Entry ultrasonic sensor is connected to pin 12 and Echo pin is connected to pin 10. The Trigger pin of the Exit ultrasonic sensor is connected to pin 11 and Echo pin to pin 9 of Arduino board. Both sensors are given ground and 5V supply connections to their GND and 5V pin respectively. One leg of Buzzer is connected to pin 13 and the other to ground. The three push-buttons have one leg each connected to ground and the other to a pull-up resistor each. The other leg of the resistor of the Increase button is connected to pin A0, resistor of the Decrease button is connected to pin A1 and resistor of Set button to pin A2. Here the analog pins are used as digital pins. The middle wire of micro-servo motor is connected to pin A3, used as digital pin, and other two legs are given GND connection and a DC voltage of 5V. The LCD display is connected to a PCF8574 chip. Its RS pin connected to P0, RW pin to P1, E pin to P2, D4 pin to P4, D5 pin to P5, D6 pin to P6 and D6 pin to P7. It is also given GND and 5V VCC connection. The PCF8574 is then connected to the Arduino through its I2C pins SCL to pin A5 and SDA pin to pin A4 respectively. Pins A0, A1, A2 of PCF8574 connected to ground. The Maximum-Limit 7-segment display is connected to BCD to 7-segment decoder, 74HC4511, through pin A to pin QA of decoder, pin B to pin QB, pin C to pin QC, pin D to pin QD, pin E to pin QE, pin F to pin QF, pin G to pin QG. The Person-Count 7-segment is connected similarly to its own decoder. The Maximum-limit decoder pin A is connected to pin 8 of Arduino, pin B is connected to pin 7, pin C to pin 6 and pin D to pin 5. The Person-count decoder pins A,B,C,D are connected to pins 4,3,2,1 of Arduino respectively. The LT and BI pins of both decoders are given high input through voltage supply and STB(low) is connected to ground. The connections are shown in the circuit diagram.

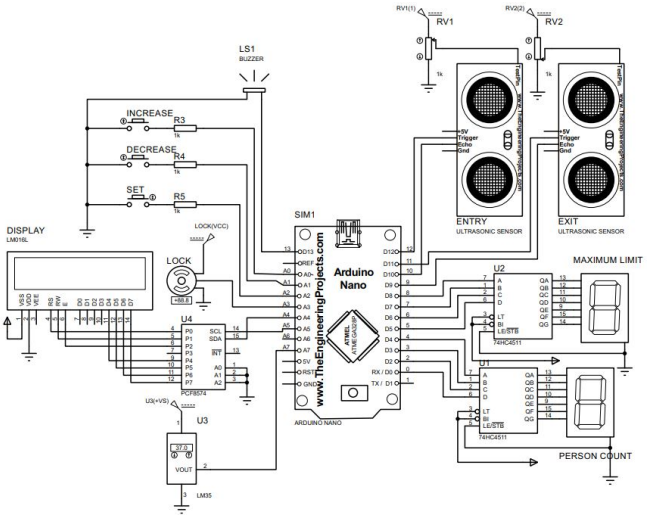


Fig. 4. Circuit diagram.

4) Cost Analysis: Our offered model includes some major features to automatic doors so that people can go to public places in the pandemic by staying safe. This product is really approachable and affordable. This system can be built by including very few components which are easily accessible and affordable. The cost of the components in BDT is shown in the table below- The whole system can be built within 1310 BDT (15.45 USD). With these very few additions and low-cost the whole system can be built which can be attached to any ordinary door. The price is very reasonable compared to how it solves a very crucial problem and how it can save a lot of people's lives.

C. Modular development

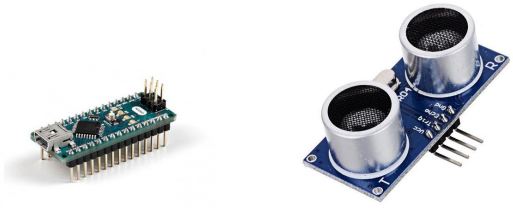
1) Arduino Nano: The Arduino Nano is a small breadboard-friendly board based on the ATmega328P. It offers the same connectivity and specs of the Arduino Uno board but in a smaller size. It operates on 5V but can take an input voltage of 6-20V. It has a 14 digital I/O pins, D0-D13 and 8 analog I/O pins, A0-A7. Pins A0-A5 can also be used as digital pins. Pins 3,5,6,9,10,11 are also Pulse Width Modulation (PWM) pins. Pins 0 and 1 are RX and TX

TABLE I
COST ANALYSIS OF THE COMPONENTS

# of Components	Component Names	Cost(in BDT)
1	Arduino Nano	250
2	LM35	65
3	BUZZER	15
4	LCD 16X2	230
5	HC-SR04	60
6	Micro-servo motor	140
7	7 segment Display	35
8	74HC4511	85
9	PCF8574	180
10	AC to DC Adapter	245
11	Push Button	3

respectively, used for Serial Communication. Pins 10,11,12,13 are SPI (Serial Peripheral Interface) pins. Pins A4 and A5 are I2C communication pins. It has a flash memory of 32KB, SRAM of 2KB and EEPROM of 1KB. It operates on a clock speed of 16MHz.

2) HC-SR04 (Ultrasonic Sensor): HC-SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. It is a 4 pin module, whose pin names are Vcc, Trigger, Echo and Ground respectively. Using I/O trigger for at least 10us high level signal, the Module automatically sends eight 40 kHz and detect whether there is a pulse signal back. If the signal back, through high level , time of high output IO duration is the time from sending ultrasonic to returning. The distance is calculated using the following formula, distance = (high level time × velocity of sound (340M/S) / 2.



(a) (b)

Fig. 5. Arduino Nano (a) and HC-SR04 sensor (b).

3) LM35 (Temperature Sensor): LM35 is a temperature measuring device which gives an analog output voltage proportional to the temperature. It provides output voltage in Centigrade (Celsius) without any external calibration circuitry. It has 3 terminals used to measure surrounding temperature ranging from -55 °C to 150 °C. LM35 gives temperature output which is more precise than thermistor output

4) Push Button: A Push Button switch is a type of switch which consists of a simple electric mechanism or air switch mechanism to turn something on or off. It has 2 pins. Depending on how it is connected, if pressed, it sends a high/low signal to the connected IC. It is an input device.

(a) (b) (c)

Fig. 6. LM35 sensor (a), Buzzer (b) and Push Button (c).

5) Buzzer: A buzzer is a small yet efficient component to add sound features to our system. It is very small and compact 2-pin structure hence can be easily used with Arduino. When supplied with a high voltage, it makes a continuous beeping noise. It is an output device.

6) Micro-servo Motor: A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It is typically operates on 5V. Micro servo motors can rotate only from 0° to 180° due to their gear arrangement. It is an output device.

(a) (b)

Fig. 7. Servo Motor (a) and AC to DC Adapter (b).

7) Seven segment Display: A 7-segment display is a form of electronic display device for displaying decimal numerals. It contains 7 LEDs. Each one of the seven LEDs in the display is given a positional segment with one of its connection pins being brought straight out of the rectangular plastic package. These individually LED pins are labelled from a through to g representing each individual LED. The other LED pins are connected together and wired to form a common pin. So forward biasing the appropriate pins of the LED segments in a particular order allows us to display each of the ten decimal digits 0 through to 9.The 7-segment we used has Common Cathode connection so all the cathode connections of the LED segments are joined together to logic "0" or ground. The individual segments are illuminated by sending High signals.

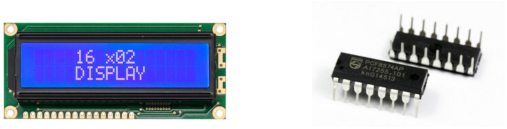
8) 74HC4511 (BCD to 7-segment Decoder): 74HCT4511 is a BCD to 7-segment latch/decoder/driver with four address inputs (A, B, C, D), a latch enable input (LE), a ripple blanking input (BI), a lamp test input (LT), and seven segment outputs (a to g). When LE is LOW, the state of the segment outputs (a to g) is determined by the data on A to D. When LE goes HIGH, the last data present on A to D are stored in the latches

(a) (b)

Fig. 8. 7-segment Display (a) and 74HC4511 IC (b).

and the segment outputs remain stable. When LT is LOW, all the segment outputs are HIGH independent of all other input conditions. With LT HIGH, a LOW on BI forces all segment outputs LOW. The inputs LT and BI do not affect the latch circuit. Inputs include clamp diodes. This enables the use of current limiting resistors to interface inputs to voltages in excess of VCC.

9) LCD Display (16x2: LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.



(a) (b)

Fig. 9. LCD Display (a) and PCF8574 IC (b).

10) PCF8574: The PCF8574 is an 8-bit GPIO port extender chip which runs on the I2C bus. It has 8 digital I/O pins, P0-P7. Its 2 pins, SDA (Serial Data line) and SCL (Serial Clock Line) are used for data transfer using I2C bus. We have used this chip to connect the LCD display as it is only requiring 2 pins of Arduino, letting us utilize rest of the pins for other I/O devices.

11) AC to DC Adapter: An AC to DC adapter is a type of external power supply, often enclosed in a case similar to an AC plug. It converts AC from the main line to DC appropriate for digital devices. A 5V AC/DC adapter with a mini USB cable is used to power this system.

D. Working Mechanism

Ultrasonic sensors (HC-SR04) set at the entrance and exit doors are used to detect whether a person has walked through or not. To start the measurement, the trigger pin of the sensor has to be made high for 10uS and then turned off. This action will trigger an ultrasonic wave at frequency of 40Hz from the transmitter and the receiver will wait for the wave to return. Once the wave is returned after it getting reflected by the person, the Echo pin goes high for a particular amount of time which will be equal to the time taken for the wave to return back to the sensor. The amount of time during which the Echo pin stays high is measured by the Arduino as it gives the information about the time taken for the wave to return back to the Sensor. Using this information the distance is measured as distance = (high level time × velocity of sound (340M/S) / 2. If the distance is less than 15 cm, it is assumed that a person has walked through and hence number of person count increases or decreases accordingly. This number is then displayed in the 7-segment LED display. Temperature sensor LM35 measure the human body temperature when a person stands in front of it and sends the analog data to the Arduino in the form of voltages. The data is received in Celsius scale. If the temperature is higher than or equal to 37 degree Celsius (100.4 degree Fahrenheit), Arduino sends a high signal to the micro-servo motor which acts as the actuator for the locking mechanism. The motor rotates to 180 degree from 0, hence pushing the lock forward and locking the door. When temperature is normal again, motor rotates back to 0 degree hence unlocking the door. When temperature of a person is sensed to be above normal, a logic 1 or high signal is sent by the Arduino to the Buzzer. It keeps on beeping until a logic 0 is sent when the person is removed from the door. The pushbuttons connect two points in a circuit when you press them. So when the pushbutton is open (unpressed) there is no connection between the two legs of the pushbutton. Because the internal pull-up on the connected pins of Arduino are active and connected to 5V, we read HIGH when the button is open. When the button is closed, the Arduino reads LOW because a connection to ground is completed and hence operates accordingly. The LCD Display in this system works in 4-bit mode. In 4-bit mode the data is sent in nibbles, first we send the higher nibble and then the lower nibble. We have used 4-bit mode as it requires lesser number of pins and we can use one PCF8574 chip to connect it to Arduino Nano which only uses 2 pins of the board. We have also used BCD to 7-segment decoders to reduce the number of pins taken by the 7-segment displays. Hence through all such connections we were able to complete the full system using just one Arduino board.

IV. Result

This project has been made not only to handle overcrowding but also takes extra precaution to fight against the rapid outspread of corona virus. This product can be used in public places like- shops, banks, restaurants etc. Two scenarios are respectively scanned by this model- 1. The number of people entering the door should be within the range that has been set by the authority. 2. If the number of people already entered the door is within capacity then the person trying to enter the door should have a temperature below 98.6 degree Fahrenheit (37 degree Celsius).

There are certain devices known as “visitor counter” used in very few places like retail shops but product like our

TABLE II
DOOR STATUS ON THE BASIS OF PERSON COUNT AND TEMPERATURE

#	# of people present	Temperature(in Fahrenheit)	Door Status
1	3	98.0	Unlocked
2	4	98.2	Locked
3	3	97.8	Unlocked
4	2	99.3	Locked
5	1	99.7	Locked

Maximum capacity $\rightarrow$ 4
Maximum temperature allowed $\rightarrow$ 98.6F

designed model is yet to be built to control the pandemic situation. The already existing product which is also mentioned in the reference of this paper is named as "visitor counter" counts the number of people entering the zone [4]. This product only shows the amount of people just entering the area but not leaving. Even though the product is compelling but it does not serve any crucial purpose. [5] solves that issue and executes the plan of bidirectional visitor counter for automating electrical devices like fans and lights using components like – IR sensors, LCD display etc. If a person enters a room the number of people will increase by one and after that the electrical devices in the room like-fans and lights will turn on. If there is no one present in the room the devices will stay turned off. The number of people present in the the area will be displayed on the LCD screen. Our proposed model not only just implements the concept of bidirectional visitor counter to tackle overcrowding and maintain social distancing, this system also measures the body temperature of people entering the region with LM35 sensor which is an additional and necessary step taken to fight against the critical situation as fever is the most common symptoms in a person who is affected by corona virus. Hence,our designed system deals with a challenging situation with a very simple and efficient design. There are some drawbacks we faced while building the model. Even though LM35 sensor has a good accuracy rate but another temperature sensor can be used to measure the most approximate and stable result which is RTD sensor(Resistance Temperature Detector). To use RTD as the sensor for our design we had to compromise our budget. But our motive is to make it as budget friendly and accessible as possible so that most of the owners or authorities of these places can purchase the product. Even though LM35 is not as accurate as RTD sensor but it gets a result which is reasonably close to the actual data.

V. Conclusions

Corona virus outbreak took place in the beginning of the year 2020 in Wuhan city of China. The virus has been spreading like wildfire ever since. One of the most important approaches suggested by WHO to fight against the virus is by maintaining social distancing. Hence, appropriate precautions should be taken. Our offered model will help the public to safely go to places like-restaurants, banks and the rest, as this system focuses on crowd controlling as well as by measuring body temperature of the customers entering the door this product takes an extra precautionary step. Our model is consisted of very few simple components. In this system there are ultrasonic sensors one is placed at entrance door and another at the exit door. These sensors record the number of people entering and leaving the place. A 7 segment LED display will show the maximum number of people allowed to enter the area which will be set by the authorities. Another 7 segment LED display will show the number of people present in the zone. If the number of customers present in the area is equal to the maximum capacity then the door will get locked. If the number of people present in the area is within the capacity then an LM35 will measure the temperature of the customer. If the temperature is normal the lock will remain open but if not the lock of the door will get closed and the buzzer will turn on. This locking mechanism is achieved by a micro servo motor in this project. This product is more preferable and superior than other products similar to this as this model solely focuses on preventing one of the most dangerous virus outspread we have ever seen. If every public places start to use this product then virus spread will slow down and people will be able to do their day to day work. This will not just keep people protected from the virus but also will be economically beneficial for the country because this will be helping these businesses run properly even during the pandemic. All of these are obtainable by our project which is simply designed and budget friendly. In this project we were able to execute most of the prime features but we can improvise this system by handling social distancing. Despite the fact that we are able to control the number of people in the zone but we are not able to monitor if the people inside are maintaining a 6 feet distance among themselves. We can extend our work and try to tackle the situation by implementing AI based customer detector. If we extend our work and successfully execute this feature, our project will be more sophisticated and it will be more secured for the people to carry on with their daily lives.

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