Ensuring safe entry at public/private buildings using IoT and Machine learning: Swachh Dwaar

Dushyant Singh
Lovely Professional University
dushyant1singh1@gmail.com

Devansh Khatri
Lovely Professional University
devanshkhatri1@gmail.com

Suraj Singh Chahar
Lovely Professional University
surajsinghchahar91@gmail.com

Rohit Choudhary
Lovely Professional University
rohit110399@gmail.com

Guided By: **Gurpreet Singh**
Assistant Professor
Lovely Professional University
gurpreet.16523@lpu.co.in

Abstract

The end of 2019 marked the beginning of a new threat that crippled the entire world and brought humanity to its knees. The first confirmed case of COVID-19 was reported in December of 2019[1] and as of now, there have been more than 13,78,66,311 confirmed cases of COVID-19 globally, including 29,65,707 deaths [2]. Just when the world was returning to the "new normal", the second wave of the ongoing pandemic hit us and caught us off guard. This led to a rise in national daily COVID-19 positive cases that have been off the charts. To reduce the risks oriented with the opening of public places and offices, and to reduce the human intervention hence creating a barrier to reduce the multiplier effect, this paper proposes a model, a system that could be used by all commercial as well as government entities to tackle the spread of the virus. The model will have certain basic modules such as an MLX90614 infrared temperature sensor that will measure the body temperature of the individual, a pi camera to detect if the individual is wearing a face mask or not, an LCD (16 X 2) screen for pop up messages, a hand sanitizer, and a mask dispenser. If the temperature of the individual is above the set threshold, the system shall notify the concerned authorities of the individual to purchase a mask from the mask dispenser, if a vigilant citizen shall enter the establishment (building) the system will measure the body temperature, check for a face mask and if found all okay shall greet the individual and ask him/her to sanitize their hands and proceed further. This system can be installed at all entrances of office buildings, housing societies, public places such as malls, shopping complexes, movie theatres, etc. The model will be economically viable and easy to install and adaptable.

Keywords – IoT applications, Machine Learning, COVID-19, MLX90614 infrared temperature sensor, Raspberry P, social distancing, TensorFlow, OpenCV, MobileNetV2

Introduction

With the dawn of New Year 2021, we welcomed the most awaited vaccines probably in the last century, but with that, we let out guard down and the country saw a second massive wave of COVID-19 infections that dwarfed the previous records of the same. On 15th April 2021, India reported 2,16,642 positive cases taking the total tally of positive cases to 1,42,87,740 the total number of deaths stands at 1,74,335[3]. These figures are astounding because we have been dealing with this situation for over a year and by now, we should have had it under control, but due to the recent resumption of workplaces, offices, transportation terminals, and public places we have failed to contain the outspread of the virus.

The resumption of services does not only endanger the lives of the visitors to an establishment but also the lives of the personnel. For this reason, we need a system that can be installed at all public/private establishments that will ensure safe entry to the building without human intervention. The model 'SWACHH DWAAR' will do exactly that; it will ensure safe entries into the buildings as well as form a barricade to prevent any unsafe/unauthorized entry, without any human intervention hence reducing the health risks.

The model will have five basic modules viz. a temperature gauge, a pi camera unit, an LCD screen, a hand sanitizer dispenser, and a face mask dispenser, all the modules will be automated and will not require much human intervention apart from installation and refilling. The model will be economically feasible to all sorts of establishments and quite adaptable to be able to fit at any entrance of any building. The model can be installed at the entrance of any building in no time.

Hardware Used

Raspberry pi model 3b+

The backbone of the whole model is raspberry pi model 3b+. Raspberry pi is a single-board microcomputer device. Which is being widely used in many IoT projects. This version of raspberry pi works on a 1.4GHz 64-bit quad-core processor and comes with onboard 1GB LPDDR2 SDRAM, 2.4 and 5GHz IEEE 802.11.b/g/n/ac Wi-Fi, Bluetooth 4.2, Gigabit Ethernet on USB 2.0, 40-pin GPIO header consisting of two 5V, two 3.3V, 8 ground, and 28 general-purpose GPIO pins, CSI (Camera Serial Interface) camera port for connecting a Raspberry Pi camera. This hardware is used with Raspberry Pi OS and is written by Raspberry Pi Foundation. This model uses a 5V/2.5A DC power input [4].

Figure 1: Raspberry model 3b+

Raspberry pi camera

The camera used in this model is version 1 which has 5 Megapixel resolutions and can capture pictures in various formats like JPEG, RAW, BMP, and PNG. This camera also supports video resolution up to 1080p 30fps. This camera is an official product of the Raspberry Pi Foundation. This camera connects to a Raspberry pi model 3b+ with a camera serial interface port. It is used to detect the face mask on a person's face [5].

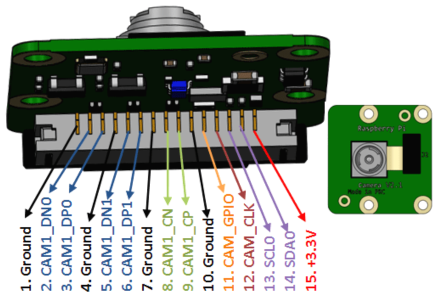

Figure 2: Raspberry pi camera pin out diagram

RFID rc522

This RFID is one of the most inexpensive in the market and is based on the MFRC522 IC from NXP. This RFID chip comes with an RFID card tag and key fob tag. The tag has a memory of 1KB memory which can be used to store small messages. The RFID reader generates a 13.56MHz electromagnetic field to communicate with RFID tags. The reader can communicate with a maximum speed of 10Mbps. It communicates over SPI/I2C or UART protocol. This RFID consists of 8 logic pins which are Vcc, RST, Ground, IRQ, MISO/SCL/Tx, MOSI, SCK, SS/SDA/Rx. Its operating voltage is 2.5 to 3.3v but logic pins are tolerant for 5v [6].

Figure 3: RC522 RFID pin out diagram

Ultrasonic Sensor HC SR04

Ultrasonic Sensor HC SR04 is a 4-pin circuit which is Vcc, Trigger, Echo, and Ground. The main components of this sensor are the transmitter and receiver. The transmitter transmits an ultrasonic wave and is received by the receiver, the distance is calculated by the total time taken in receiving the wave, multiplied by the speed of the ultrasonic sensor, and the total result is divided by two. Its operating voltage is 5v and it can measure a distance minimum of 2cm to a maximum of 450cm with an accuracy of 3mm [7].

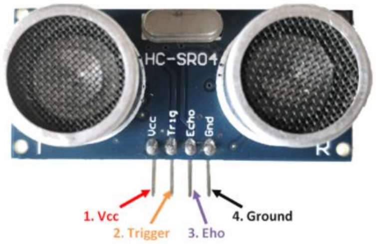

Figure 4: Pin out diagram for ultrasonic HC-SR04

MLX90614 infrared temperature sensor

This sensor is used to measure the temperature of an object without contact with the object. It uses IR rays to measure the temperature of the object which results in a contactless process and communicates over I2C protocol. Its range for measuring temperature is -70C to 382.2C for objects and for ambient temperature it goes -40c to 125c with an accuracy of 0.002c. It comes with a 4-pin configuration Vcc (3.6-5v), ground, SDA - Serial Data, and SCL - Serial clock [8].

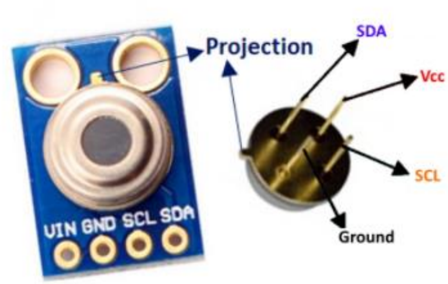

Figure 5: Pin out diagram for MLX90614 infrared temperature sensor

LCD

The LCD used in this model is 16x2 LCD, which means 16 columns and 2 rows so it can show 32 total characters and each character will be made of 5x8 pixel dots. It can work in 8bit or 4bit mode and can display custom-made characters. It has an IC HD44780 which is used to handle the commands and data from the MCU and process them in a way that can be displayed on the LCD screen. It has 16 pins Vss (ground), Vcc (4.7-5v), VE (contrast v), Register Select, R/W, Enable, 8 data pins, and 2 LEDs [9].

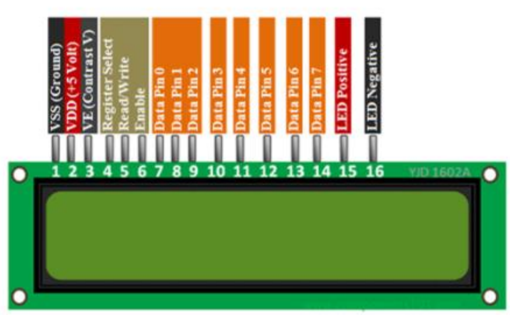

Figure 6: Pin out diagram for LCD 16X2

Servo Motor

The version SG-90 is used in this project. Which has three wires to connect with any microcontroller Brown which acts as ground for the system, Red is used to give power to the motor and last is Orange it is used to give PWM signal to drive the motor. The operating voltage of this motor is 5V, generates a Torque of 2.5kg/cm, and can make a rotation from 0 to 180 degrees [10].

Figure 7: Pin out diagram for servo motor sg90

Project Model

'Swachh Dwaar' is a set of automated hardware components that use IoT and machine learning algorithms to ensure safe entries at all public/private buildings with reduced human efforts and health risks.

It consists of five basic modules named Camera/Mask detector module, Temperature module, Mask dispenser module, and Sanitizer dispenser and Display module that would automate the work which would normally require manpower of at least two to three.

Description of Modules:

1. Mask Detector Module: The proposed model uses a **pi cam** and an LCD (16x2) attached to **raspberry pi** that uses transfer learning method which uses MobileNetV2[11] as a base model, and trained on Google Colab platform model using TensorFlow[12], OpenCV[13] libraries, and python scripts to detect whether the person standing in front of it has a face mask on or not, it also has infrared sensor to detect the presence of anyone standing in front of the camera, if the infrared sensor detects the person then camera module starts working. This module is linked to a cloud server that saves the information in the form of numbers in two counters named 'NUMBER OF PERSON WITH MASK' and 'NUMBER OF PERSON WITHOUT MASK' respectively. When a person wearing a mask stands in front of the camera module the LCDs an appreciation message "Thanks for wearing a mask, you can proceed further" and it sends data to the server that increases the first counter by 1. If a person without a mask stands in front of the module, then the LCD shows the message "Purchase a mask", and it again sends information to the server that increases the second counter by 1. The information can be used productively as it would contain a ratio of people wearing and not wearing masks in that locality.

2. Mask Dispenser Module: This module is a mask vending machine that has an **RFID-RC522** sensor attached to raspberry pi, if a person fails the mask detection test and is asked to purchase a mask, instead of going out to any store this setup has an automated mask dispenser module in it. If the person has an RFID card with them, they can place the card in front of the mask dispenser and the person will receive a face mask that they can wear and proceed further.

3. Temperature Module: This module has MLX90614 infrared temperature sensor and LCD (16 x 2) attached with raspberry pi coded with python that detects the temperature of the person standing in front of it, when a person comes in front of the temperature module it detects the temperature and displays it on the LCD, if the temperature is below a threshold value then the LCDs a message which asks the person to proceed further and if the temperature is above that certain value then the LCD will ask that person to contact the authorities of that building for the further proceeding.

4. Sanitizer Module: This module has a pump, infrared sensor, ultrasonic sensor, led lights, and buzzer automated with the help of raspberry pi such that if the infrared sensor detects the presence of a person, then the pump will dispense sanitizer from the tank, the ultrasonic sensor will measure the level of sanitizer present in the tank and led lights will indicate it, if the level stays above 50 percent of the tank's depth then green led light will glow and when the level falls below 50 percent then a yellow light will glow that indicates the sanitizer level is low and if the level falls below 25 percent then buzzer starts making noise which indicates that the tank needs to be refilled.

Result and Analysis

We had run this model over a couple of hundred times to get the average time it takes to ensure the safe entry of a person using Swachh Dwaar and it comes to ~37 seconds with an accuracy of 89.7%. We calculated the accuracy of each module following all possible procedures a common person can follow while checking in using our model.

Reasons that reduce the accuracy of Swachh Dwaar:

1. A person stands too far or close or not in the viewing angle of the pi camera while mask detection.
2. For temperature, the measurement person needs to stand within a range of 5cm from the thermal sensor for maximum accuracy, and if the distance increases it hinders its accuracy.
3. Mask vending machines use RC522 RFID sensor which works accurately 94% of the times, the accuracy drops down because of improper tag placement.

This model uses electronic components which are quite vulnerable to damage of any kind that is why it requires proper maintenance from time to time. Failure in a single component can put a full stop on the entire system as all modules are interdependent. The pi camera catches dust which reduces its accuracy and needs to get cleaned frequently. An increase in the age of the sensor results in a decreased accuracy hence the sensors need to get replaced after a certain period which increases its cost.

Most of the cost lies in the electronic sensor of which the system is made up and the framework it uses to fit in, we calculated that the estimated cost at the time of installation comes to be ₹ 15000.

Conclusion

Swachh Dwaar provides a solution to the safety issues and health risks of staff and crowd accompanied by the current entry procedures followed at most public/private buildings. The system can be installed and maintained effectively by the staff of just one person and is made up of widely available sensors that make it easy to configure and establish, its customizable size helps it fit in any space. It is very easy to operate which person of every generation can easily adapt. The server attached to the physical system provides useful real-time information that can be accessed effortlessly that can be used to monitor and can assist in the battle with COVID-19. Consistent future efforts can make the system more efficient and safer to operate.

References

1) World Health Organization, “Archived: WHO Timeline – COVID-19”, Retrieved from https://www.who.int/news/item/27-04-2020-who-timeline---covid-19 (accessed on Apr. 15, 2021).
2) World Health Organization, Retrieved from https://covid19.who.int/ (accessed on Apr. 15, 2021).
3) covid19india.org, Retrieved from https://www.covid19india.org/ (accessed on Apr. 15, 2021)
4) Raspberry Foundation, Retrieved from https://www.raspberrypi.org/products/raspberry-pi-3-model-b-plus/ (accessed on Apr. 20, 2021).
5) Raspberry Foundation, “Raspberry Pi Camera Module”, Retrieved from https://www.raspberrypi.org/documentation/raspbian/applications/camera.md (accessed on Apr. 20, 2021).
6) NXP semiconductors, “MFRC522 Standard performance MIFARE and NTAG frontend”, Oct. 2009 [Revised Apr. 2016].
7) ELEC Freaks, “Ultrasonic Ranging Module HC – SR04”, (accessed Apr. 23, 2021).
8) Melexis, “MLX90614 family Single and Dual zone Infra-Red Thermometer in TO-39”, 3901090614 datasheet, Sep. 2006 [Revised Sep. 2019].
9) XIAMEN AMOTEC Display CO. LTD, “Specification of LCD module”, ADM1620K-NSW_FBS datasheet, Oct. 2008 (accessed Apr. 24, 2021).
10) Tower Pro, “SG90 9g Micro Servo” (accessed Apr. 24, 2021).

11) M. Sandler, A. Howard, M. Zhu, A. Zhmoginov and L. Chen, "MobileNetV2: Inverted Residuals and Linear Bottlenecks," 2018 IEEE/CVF Conference on Computer Vision and Pattern Recognition, 2018, pp. 4510-4520, doi: 10.1109/CVPR.2018.00474.
12) M. Abadi, A. Agarwal, P. Barham, E. Brevdo, Z. Chen, C. Citro, G. S. Corrado, A. Davis, J. Dean, M. Devin, S. Ghemawat, I. Goodfellow, A. Harp, G. Irving, M. Isard, R. Jozefowicz, Y. Jia, L. Kaiser, M. Kudlur, J. Levenberg, D. Mane, M. Schuster, R, Monga, S. Moore, D. Murray, C. Olah, J. Shlens, B. Steiner, I. Sutskever, K. Talwar, P. Tucker, V. Vanhoucke, V. Vasudevan, F. Viegas, O. Vinyals, P. Warden, M. Wattenberg, M. Wicke, Y. Yu, X. Zheng, “Large-scale machine learning on heterogeneous system, 2015”, Software available from tensorflow.org.

13) Bradski, G., “The OpenCV Library”, Dr. Dobb’s Journal of Software Tools, 2000