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Single Board Computer based Autonomous Sanitation and Thermal Scanning System

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Abstract - *This paper presents the development of autonomous sanitation and thermal screening system, which proves to be essential in the Pandemic situation like Covid-19. Even though many vaccines have started, the threat of Covid-19 is very much lingering. Basically, it is difficult to monitor whether the person entering your home or any venue is not a carrier of the Coronavirus, so we proposed this project in this situation to monitor the symptoms of a person entering the venue using RaspberryPi, which has various functions attached like Temperature sensor, Mask detector and Sanitization spray. Using these parameters, we can detect if the person entering any venue is safe to enter or not.*

***Key Words*: Covid-19, Face mask detector, Thermal scanning, Sanitization, Raspberry Pi, MLX90614**

1. INTRODUCTION

Covid-19 has brought a sense of sanitation in everyone's mind. Even though many vaccines are in development and given to the public, the number of cases is nowhere decreasing. However, even though proper measures are taken, perfect sanitization is not achieved. The best example is while entering any locality; a watchman checks your temperature and offers you sanitizer. However, we follow these steps; we contact the person offering these services to us who comes in contact with every person entering. However, this nullifies the measures as the person may have been a carrier of the virus while sanitizing others. Hence, there is an evident need for a product that completely cancels human contact totally while sanitizing and thermal scanning oneself.

1.1 PROBLEM OVERVIEW

The current pandemic situation creates a need for fewer human interaction systems. A fever is a common symptom of COVID-19, so "contactless" monitoring entry into buildings can be used as a screening mechanism to help identify potentially infected individuals. Also, the use of thermal imaging has been in particular focus, with sales of thermal imaging cameras increasing dramatically. Thus, the use of camera technology concerning this type of screening in this situation at buildings is likely to expand, creating an ingenious situation that will be effective as there will be nominal contact to others providing health safety.

This product aims to overcome all the precautions using a single Raspberry Pi module, which will overcome the most crucial point of Decreased Human Contact, i.e., contactless monitoring, as mentioned.

1.2 PROBLEM STATEMENT

There is a need for a product that can help us obtain social distancing and sanitation in a single time as currently, it is not achieved even after taking measures. The best example for it is while entering any zone; a watchman checks your temperature and offers you sanitizer. However, we follow these steps; we contact the person offering these services to us who comes in contact with every person entering. Basically, this nullifies all the measures that were taken while entering. Hence, there is an evident need for a product that completely cancels human contact totally while sanitizing and thermal scanning.

1.3 FEATURES

1. To detect using Machine Learning concepts if a person in front of the camera has worn a mask or not.
2. To implement a four-way fogger sanitation spray using L298N.
3. To implement a thermal scanner which helps note the temperature of the person in front of it using MLX90614-DCI.
4. To implement all the above points as a single product by interfacing them together on a single Raspberry Pi module.

2. LITERATURE REVIEW

2.1 MASK DETECTION

A novel face mask detector, Retina Facemask, is able to detect face masks and contribute to public healthcare. Retina Facemask is one of the first dedicated face mask detectors. In terms of the network architecture, Retina Facemask uses multiple feature maps and then utilizes feature pyramid network (FPN) to fuse the 1high-level semantic information. To achieve better detection, a context attention detection head and a cross-class object removal algorithm to enhance the detection ability. Furthermore, if the face mask dataset is a relatively small dataset where features may be hard to extract, use of transfer learning to transfer the learned kernels from networks trained for a similar face detection task on an extensive dataset can be done. After which the

proposed method is tested on a face mask dataset to get the appropriate result. [1]

Convolution Neural Network

CNN plays an important role in computer vision related pattern recognition tasks, because of its superior spatial feature extraction capability and fewer computation cost. CNN uses convolution kernels to convolve with the original images or feature maps to extract higher-level features. As object detectors are usually deployed on mobile or embedded devices, where the computational resources are very limited, Mobile Network (MobileNet) is proposed. It uses depthwise convolution to extract features and channel wised convolutions to adjust channel numbers, so the computational cost of MobileNet is much lower than networks using standard convolutions.[1]

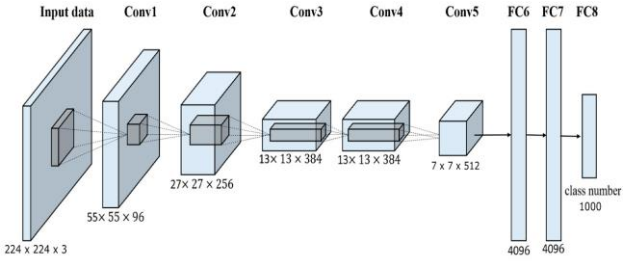


Fig -1: Basic representation of CNN

MobileNetV2

MobileNetV2 is a convolutional neural network architecture that seeks to perform well on mobile devices. It is based on an inverted residual structure where the residual connections are between the bottleneck layers. The intermediate expansion layer uses lightweight depth wise convolutions to filter features as a source of non-linearity. As a whole, the architecture of MobileNetV2 contains the initial fully convolution layer with 32 filters, followed by 19 residual bottleneck layers.

MobileNetV2 architecture, a highly efficient architecture that can be applied to embedded devices with limited computational capacity (ex., Raspberry Pi, Google Coral, NVIDIA Jetson Nano, etc.) [2]

Tensor Flow

TensorFlow is an end-to-end open-source platform for machine learning. It has an ecosystem of tools, libraries and community resources that helps developers easily build and deploy ML-powered applications. TensorFlow supports a variety of applications, with a focus on training and inference on deep neural networks. [3]

Keras

Keras is an open-source library that provides a Python interface for artificial neural networks. Keras acts as an interface for the TensorFlow library. Keras contains numerous implementations of commonly used neural-network building blocks such as layers, objectives, activation functions, optimizers, and a host of tools to make working with image and text data easier to simplify the coding necessary for writing deep neural network code. [4]

OpenCv

OpenCV is a cross-platform library using which one can develop real-time computer vision applications. It mainly focuses on image processing, video capture and analysis including features like face detection and object detection. In Image processing, OpenCV deals with image-to-image transformation. The input and output of image processing are both images. OpenCV module covers various operations such as image filtering, geometric image transformations, color space conversion, histograms. [5]

Region of Interest

A Region of Interest (ROI) is a portion of an image that is needed to be filtered or required to perform some operation without causing any changes in the original image.[10]

Scikit-Learn

Sklearn is used in supervised learning algorithms, cross-validation, unsupervised learning algorithms and feature extraction. Basically, the Sklearn module covers binarizing class labels, segmenting our dataset, and printing a classification report.[10]

2.2 SANITIZATION SPRAY

Disinfecting is important to reduce the potential risk of COVID-19. Sanitizing your home or workplace is important to keep yourself healthy and fit. Person-to-person transmission of coronavirus is more likely than from surface so you must use your face mask and sanitizers as an ultimate precaution in addition to cleaning of your homes. Researchers at CSIRO, Australia's national science agency, have found that SARS-CoV-2, the virus responsible for COVID-19, can survive for up to 28 days on common surfaces. [6]

WHO recommends the following as disinfectants: Sodium hypochlorite (bleach/chlorine) may be used at a recommended concentration of 0.1% or 1,000ppm (1 part of 5% strength household bleach to 49 parts of water). Alcohol at 70-90% can also be used for surface disinfection. [7]

Spraying using DC Motors

The instructions for controlling robot motion that are governed electronically by the processor are supplied via the L293D Motor Control Board, which is used as a driver circuit for the Robot DC Motor and Peristaltic Motor. DC Motor is used for wheel motion and Peristaltic Motor is used for pesticide spraying. [8]

To drive a motor, we just cannot connect it directly to the microcontroller. As the Microcontroller will generate signals in the form of HIGH or LOW, which is insufficient to run a motor. That's why we need to use a Motor Driver. Thus, we

are interfacing L298N with Raspberry Pi through GPIO (General Purpose Input Output Pins) pins for controlling the water pump. [8]

2.3 THERMAL SCANNER

Infrared thermometers can be used to serve a wide variety of temperature monitoring functions. A few examples provided include detecting clouds for remote telescope operation, checking mechanical or electrical equipment for temperature and hot spots, measuring the temperature of patients in a hospital without touching them, checking heater or oven temperature. At times of epidemics of diseases causing fever, such as SARS Coronavirus and Ebola virus disease, infrared thermometers have been used to check arriving travelers for fever without causing harmful transmissions among the tested. [11]

The Communication between Raspberry Pi and Thermal Scanner is done with the help of I2C protocol. Full Form is Inter Integrated Circuit.

I2C Protocol

I2C Protocol is a protocol intended to allow multiple "slave" digital integrated circuits ("chips") to communicate with one or more "master" chips. I2C requires a mere two wires for communication between master and slave but those two wires can support up to 1008 slave devices. The two wires which make the communication possible are:

1. SDA (Serial Data) - The line for the master and slave to send and receive data.
2. SCL (Serial Clock) - The line that carries the clock signal

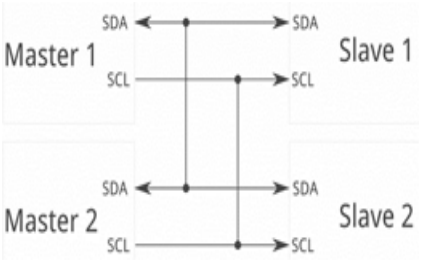


Fig -2: Basic representation of I2C Architecture

I2C is synchronous, so the output of bits is synchronized to the sampling of bits by a clock signal shared between the master and the slave. The clock signal is always controlled by the master. [12]

3. IMPLEMENTATION

Python Programming Language

Python is the most preferred programming language used. Python is a high-level programming language which supports an object-oriented approach to solve complex tasks. As Python is an open-source software, it has a great developer community support. This ensures that major bugs, if any, are never left unresolved by the Python Community Also, the OpenCV in python makes image processing easy.

Raspberry Pi Module

The Raspberry Pi 4 Model B is the latest version of the low-cost Raspberry Pi computer. The quad-core Raspberry Pi 4 Model B is both faster and more capable than its predecessor, the Raspberry Pi 3 Model B+.

3.1 PROCESS FLOW

The implementation process can be divided and performed in three phases as follows:

1. Mask Detection
2. Sanitization Spray
3. Thermal Scanner

Each of these stages is individually significant and hence combining all the above points as a single product by interfacing them together on a single Raspberry Pi module completes our system

3.2 BLOCK DIAGRAM

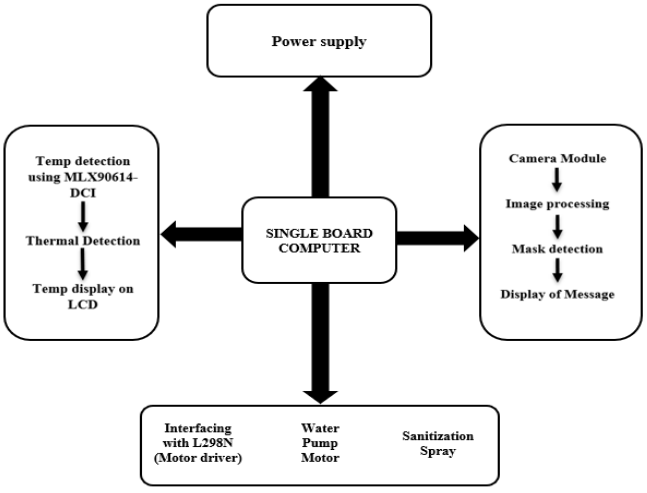


Fig -3: Block Diagram

3.3 HARDWARE

Mask Detection

The camera used in this project for Mask Detection is Raspberry Pi 8MP Camera Board Module. This camera has 8 megapixels. It has a Sony IMX 219 PQ CMOS image sensor in a fixed-focus module with an image resolution of 3280 x

2464. It is connected to Raspberry Pi using 15-pin ribbon cable, to the dedicated 15-pin MIPI Camera Serial Interface (CSI-2). Its temperature range ranged from -20o to 60oC.Its lens size is ¼" with weight as 3g and dimensions of 23.86 x 25 x 9mm.

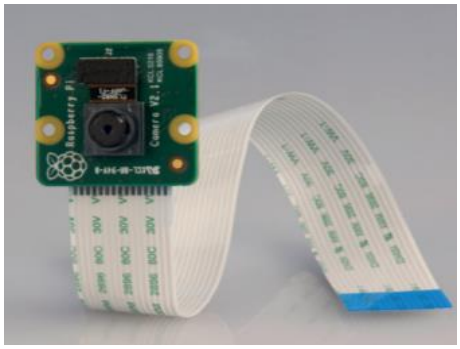


Fig -4: Raspberry Pi Camera Module

Sanitization Spray

The hardware used for sanitization spray is a Motor Driver, DC Motor and a 4-way fogger.

Interfacing of L298N with RaspberryPi: The motor driver is using two pins referred to as inputs IN1 IN2 to sense the desired direction of the output or the motor, and another pin called Enable to sense ON/OFF.

Connecting the motor driver to Raspberry Pi through GPIO pins, and with the Enable pin On, to spin the motor forward, set input 1 to HIGH and input 2 to LOW. And the motor will start pumping sanitizer. And if both inputs are made high or both are low, the motor will not run. So, through GPIO pins by little programming we are controlling our motor driver.

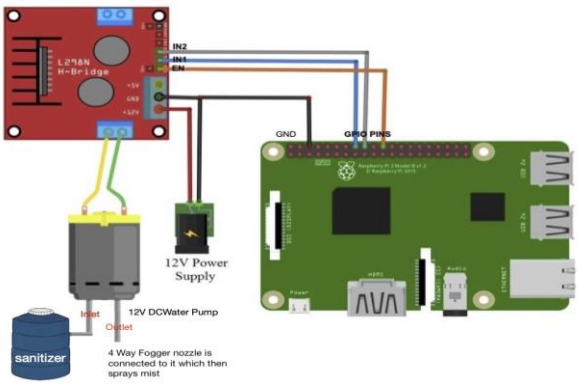


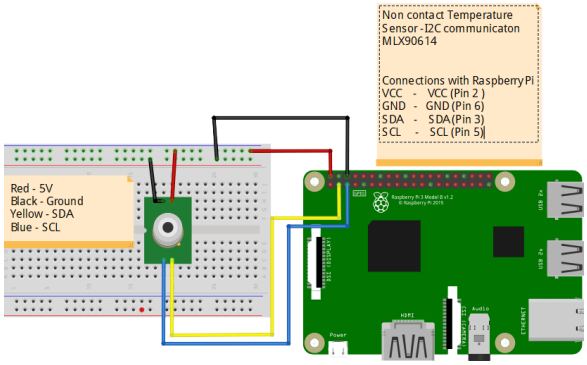
Fig -5: Interfacing of L298N with RaspberryPi

Four-way Fogger: We are using 4-way fogger as a spray nozzle as the fog leaves no marks on clothes and also that it is cheaper. It will completely envelope the incoming person and destroy the virus.

Fig -6: Four-way fogger

Thermal Scanner

MLX90614-DCI: The MLX90614 is an infrared thermometer for non-contact temperature measurements. This sensor converts the computational value into 17-bit ADC and that can be accessed using the I2C communication protocol. These sensors measure the ambient temperature as well as the object temperature with the resolution calibration of 0.02ºC. It has a wide temperature range of -40 to 125ºC for ambient temperature and -70 to 380ºC for object temperature. The MLX90614 offers a standard accuracy of



±0.5˚C around room temperature.

Fig -7: Interfacing of MLX90614-DCI

3.4 SOFTWARE

Mask Detection

The approach used for the detection of Mask consists of methods like OpenCV, Keras, TensorFlow and Deep learning. The architecture used for this project is MobileNetv2 which is a part of CNNs. The reason for its use is it is very much compatible with Raspberry Pi and has a very good efficiency. The approach for this detection is divided into two parts:

Train Face Mask Detector: In the following step what basically is to be done is train the dataset that has been gathered of images. The dataset here consists of images that can be distinguished into two categories: with mask and without mask. The dataset used consists of 1,400 images which contain images of people wearing various masks. In the training, the input dataset is accepted after which a desired model is created after fine-tuning by MobileNetV2.

The steps for Training the Face Mask Detector can be represented as follows:

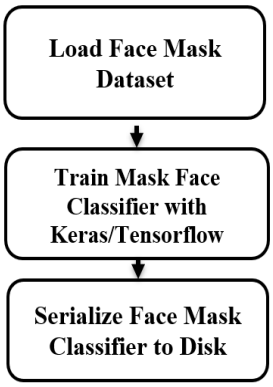


Fig -8: Flowchart of Training Mask Detector

Test Face Mask Detector: In the following approach a basic method is used in which mask detector is loaded after which face detection is performed followed by classifying each face in the images into two categories: with_mask and without_mask.

The steps for Testing the Face Mask Detector can be represented as follows:

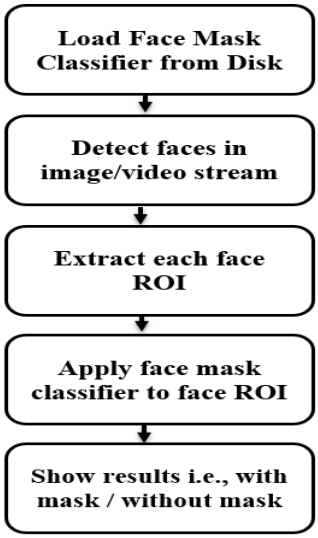


Fig -9: Flowchart of Testing Mask Detector

In this technique the images are loaded from the disk after which faces in the images are detected followed by applying the face mask detector or the model that has been trained which classifies the face in two categories of with_mask and without_mask. The same technique is applied to various external images and on a live video stream to get a live update on whether a mask is being worn or not.

4. RESULT

As soon as the person is detected by the system, firstly, it will check whether the person is wearing a mask or not. After Mask Detection, the four-way fogger will perform sanitation spray. a 4-way fogger is used as it does not leave any marks on the clothes. Now the thermal scanning module will check the temperature of the person with the help of MLX90614. If the person does not satisfy any of the above conditions, he/she will not be allowed to enter the venue.

Mask Detection

A Python code was generated for this part where mask detection occurs. In the following program it was made certain that the ROI should be the face where it is able to detect a mask with great accuracy. The following program was implemented on various color and designer masks to make sure the program works smoothly.

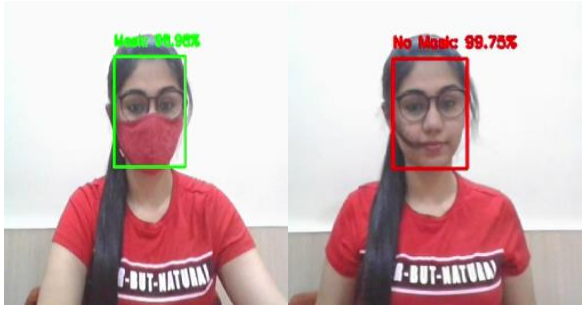


Fig -10: Output for Mask Detection

Sanitization Spray

A basic Python code was used which was used for interfacing L298N with Raspberry Pi. The following code helped to make the dc motor run thus creating a force to pump out water from a container which was eventually connected to a 4-way fogger. For testing purposes, the system was implemented on a height to check how much pressure is feasible for the draw out water for the container at ground level.

Fig -11: Output for Sanitization Spray

Thermal Scanner

A program written in Python language helps the Thermal sensor to detect various ranges of Temperature. It can detect object temperature as well as Ambient temperature.

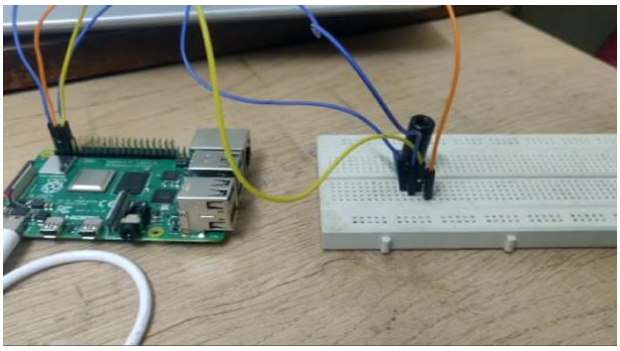


Fig -12: Output for Thermal Scanner

The following was achieved by successfully interfacing Raspberry Pi with MLX90614-DCI using methodologies that help run the sensor.

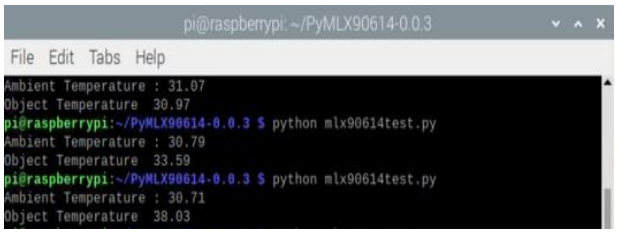


Fig -13: Temperature obtained in Command Prompt

For testing purposes, the forehead, wrist and many other objects such as a hot knife, a hot cup of tea were used.

Final Assembly of the Product

As soon as the person is detected by the system, firstly, it checks whether the person is wearing a mask or not. After Mask Detection, the four-way fogger performs sanitation spray. After that, the thermal scanning module checks the temperature of the person with the help of MLX90614. If the person does not satisfy any of the above conditions, he/she will not be allowed to enter the venue.

5. CONCLUSION

Aim of this project is to bring a product that is thoroughly contactless which brings about sanitization of any person entering your home without the fear that the person may be a carrier of the virus. The techniques used in the following project for mask detection, sanitization spray and thermal scanner make it an affordable and cheaper product as a whole compared to buying different products which give the same output individually would cost in the market.

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