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Real Time Face Mask Detection with Automatic Door Control System Using ESP-32 CAM Module and Arduino Uno

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Abstract: *The COVID-19 pandemic has led to the widespread use of face masks as a preventive measure to curb the spread of the virus. In this paper, we propose a real-time face mask detection system using the ESP-32 cam module and Arduino Uno. The system utilizes a code to analyze captured images and detect whether a person is wearing a face mask or not. The ESP-32 cam module captures images in real-time, while the Arduino Uno processes the data and provides a real-time alert if a person is detected without a mask and conversely, if the Arduino detects a person wearing a mask, it will trigger the motor to open the barricade. Our findings demonstrate the high accuracy of the proposed system in detecting face masks, making it suitable for use in public spaces like malls, universities, and offices to encourage individuals to wear masks as a preventive measure against the COVID-19 virus. We can deploy the proposed system in a wide range of applications due to its cost-effectiveness and ease of use*

Keywords: face mask detection, ESP 32 CAM, Arduino

I. INTRODUCTION

The COVID-19 pandemic has had a global impact, affecting more than 114 countries since its outbreak in December 2019. The World Health Organization (WHO) has declared it as a deadly disease, with approximately over 30 million reported cases and only during a week in April 2022 it has more than 5 million confirmed cases with over 18,000 deaths been reported in the six WHO regions (i.e., Western Europe, Central and Eastern Europe, Asia, Africa, the Mediterranean and Middle East, and America) [14]. Wearing face masks has become an essential practice in preventing the spread of the virus, especially in situations where social distancing is difficult to maintain. In response, developers have developed several face mask detection and monitoring systems to ensure compliance with mask-wearing guidelines. Hospitals, public transport, airports, retail outlets, and sports venues all use these systems. The development of these face mask detection systems is crucial to limiting the spread of the virus and protecting individuals and communities. We can take appropriate measures to prevent further transmission of the disease by detecting individuals who are not wearing masks.

II. LITERATURE REVIEW

A few works similar to this research have been carried around in the last two or three years. Clinical and radiographic, molecular-based (laboratory-based and point-of-care), immunoassay-based (ELISA, fast antigen, and antibody detection tests), and digital diagnostics (artificial intelligence-based algorithms) are the several COVID-19 diagnosis modalities that are mentioned. The research discusses the use of fast antigen and antibody detection assays in community monitoring. Community-based seroprevalence surveys can use these tests to identify asymptomatic individuals exposed to the virus and assess the epidemiology of its transmission [8].Another study uses face verification using the long-wavelength infrared method. One double picture, created by combining two face photos, served as the input for a neural network-based categorization. The research opens up an avenue of additional spectral ranges and modalities besides the face, which can also be used using the suggested double picture approach [2]. In one of the experiments, a thermal body measurement system that researchers had created and implemented was activated. During

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the experiment, the researchers inserted an LDR, which triggered the servo motor to move downward and activate the infrared sensor. The engine was shut, and the temperature-measuring process began when it reached a height that an infrared sensor had detected. The temperature sensor used MLX 90614 to read raw data from infrared light reflections. Later, a microcontroller utilizing Arduino was used to process the data and turn it into actual data. The LCD displays the analyzed temperature data, and then it sends it to the esp32-camera. Next, the images were captured by the esp32-cam for documentation. With an average inaccuracy of 0.6% and a standard deviation of 0.078, the Body Temperature Measurement System employing the MLX 90614 Temperature Sensor for Early Detection of COVID-19 Symptoms is usable [6]. One of the unique research projects proposes an automated gate control approach for face mask monitoring and temperature scanning that is both straightforward and efficient. The ESP-32 camera module and Arduino technology are used to implement the model [3].In one of the other proposed studies, a door lock system is constructed using facial recognition technology connected to an ESP32 camera for precise face identification. Unauthorized individuals can enter via the ESP32 CAM, while authorized individuals can use the facial detection system. The entry of an unauthorized person is detected by the ESP32 CAM, which captures the image and notifies the owner [2]. In one of the early proposals, a technology that recognizes the faces of customers regardless of face masks was used. This research utilized the engineering design process development model, which comprises four phases: problem identification, generation of potential solutions, creation of prototypes, and testing and evaluation of the solutions. The suggested method in this research was created to prevent individuals without masks from accessing desired locations (such as malls, universities, offices, etc.) by utilizing deep learning, TensorFlow, Keras, and OpenCV to recognize face masks and transmitting an open signal to an Arduino device that is attached to the gate. The system swiftly identifies faces and ascertains whether a mask is present. This strategy achieves up to 97.80% accuracy [4].

III. METHODOLOGY

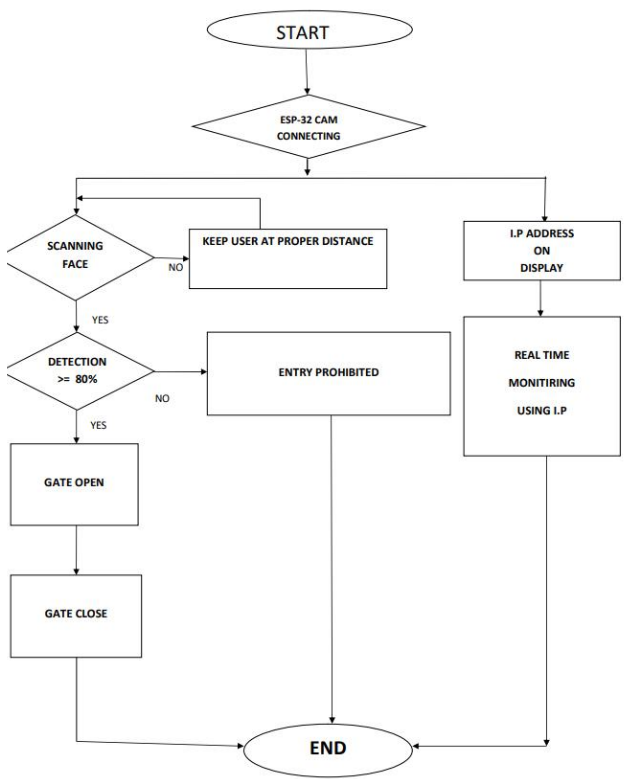

Fig. 1: Flowchart for Entire Operation

When a person stands in front of the camera module and the and the proximity IR sensor detects him or her, it sends the signal to the ESP 32 CAM module. After that, the ESP 32 CAM module captures an image of the person's face standing

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in front of the system. The picture taken by the module is sent to the Arduino Uno, where the algorithm determines whether the person is wearing the mask or not. The threshold percentage for the masking of the face has been kept at eighty percent. If the face scanned has a masking percentage below the threshold value, then Arduino will output the red led, and entry will be prohibited. If vice versa, then Arduino will output the green LED and trigger the micro-servo motor to open the gate for a few seconds. In case of an emergency or servicing of the system, a limit switch has also been provided to trigger the microservo motor and allow the opening of the gate. The entire flow chart can be seen below in figure number one

IV. HARDWARE REQUIREMENTS

4.1 ARDUINO UNO

The Arduino Uno is a widely popular microcontroller board based on the ATmega328P microcontroller. As part of the Arduino family, it provides an open-source platform ideal for prototyping and educational purposes. Key features include 14 digital I/O pins, 6 analog inputs, and PWM capability on 6 pins. It operates at 5V with a recommended input voltage of 7-12V, and it can be powered via USB or an external power supply. The board includes 32 KB of flash memory, 2 KB of SRAM, and 1 KB of EEPROM, facilitating a range of applications. It supports communication protocols such as UART, SPI, and I2C, making it versatile for interfacing with various sensors, modules, and devices. Programming the Arduino Uno is user-friendly, utilizing the Arduino Integrated Development Environment (IDE), which supports C/C++ with specialized libraries. It features an onboard USB-to-serial converter, making it straightforward to upload code via a USB connection. The board's robust ecosystem, extensive community support, and comprehensive documentation make it an excellent choice for both beginners and experienced developers in electronics and embedded systems

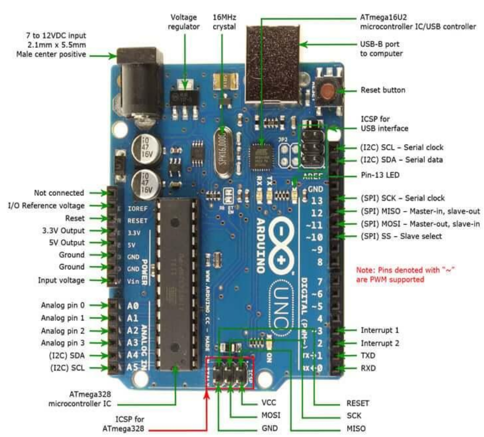

Fig.2: Arduino Uno

4.2.ESP 32 CAM MODULE

The ESP32-CAM is a compact camera module with minimal power consumption. It has an onboard card Widespread intelligent Internet of Things applications, such as wireless video tracking, uploading images over WiFi, scanning QR codes, and so forth. It supports WiFi and Bluetooth and has an ESP32-S module built right in. It includes an OV2640 flash-equipped camera [13]. It has an integrated TF card slot and can store data on up to 4G cards. ESP 32 CAM supports image uploading and video monitoring. Moreover, it offers deep sleep currents as low as 6 mA and many sleep modes. Its control interface is easily incorporated and installed anywhere as per the application need, and it may be accessed by a pin header. Moreover, it features an integrated antenna [12]. The image of the camera module can be seen in figure number three, shown below.

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Fig.3: ESP 32 CAM MODULE

It includes both BLE and Bluetooth 4.2 BR/EDR, and supports the IEEE 802.11 b/g/n/e/i Wi-Fi protocols. It is compatible with WPA, WPA2, WPA2-Enterprise, and WPS security types. The ESP32-CAM is ideal for Internet of Things applications like wireless monitoring, smart home device image uploading, face recognition, QR code wireless identification, and intelligent agriculture

4.3 IR SENSOR

One of the photoelectric switch sensors is the E18-D80NK Adjustable Infrared Sensor Switch, which consists of a transmitter and receiver pair. You can change the detection distance based on demand. Many settings, such as industrial assembly lines, interactive media, robot obstacle avoidance, and many more, can utilize the versatile Adjustable Infrared Sensor Switch. It is compact, inexpensive, and simple to use.

The impediments determine how the switching signal output changes. When there are no barriers, it stays high; when there are, it stays low. The probe has a bright light behind it to identify anything within a range of 3 to 80 cm. A picture of the sensor can be shown below in figure number five.

Fig.4: IR SENSOR

V. IMPLEMENTATION

In the project, the Arduino Uno is interfaced with an IR sensor and an ESP 32 CAM module. A 2*16 LCD display is also connected to the system to show the IP address of the cam module connected to the coded access point. A limit switch as a push button is also given to turn on the microservo motor in case the system needs maintenance.

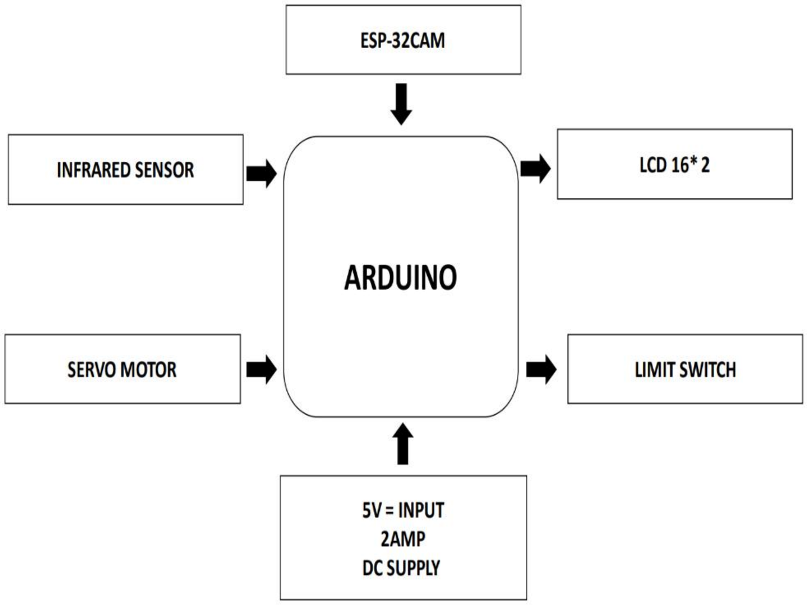

Fig. 6: Block Diagram

When a 5V, 2A DC supply is given to the system, the ESP 32 CAM gets connected to the network access point. The IP address will be displayed on the LCD 2*16. When a person comes near the proximity IR sensor, it detects the human presence and triggers the ESP 32 CAM module to scan the face of the person. If the scanned face is masked with a percentage above eighty, then the ESP 32 CAM module sends a signal to Arduino to turn on the micro-servo motor for a few seconds so that door opens [15]. If the scanned face has no mask or a covered face less than eighty percent, then a message will be displayed that entry is prohibited and kindly wear the mask. The entire operation can be displayed through the block diagram in Figure 6, shown above

VI. HARDWARE AND ASSEMBLY

In figure number seven, the assembled hardware setup has been shown from the front and back sides. The LCD 2*16 is showing the IP address at which the ESP 32 CAM module is connected to the internet. By clicking on the IP address, one can also have real-time monitoring of the place at which the entire hardware is installed, as seen in figure nine.

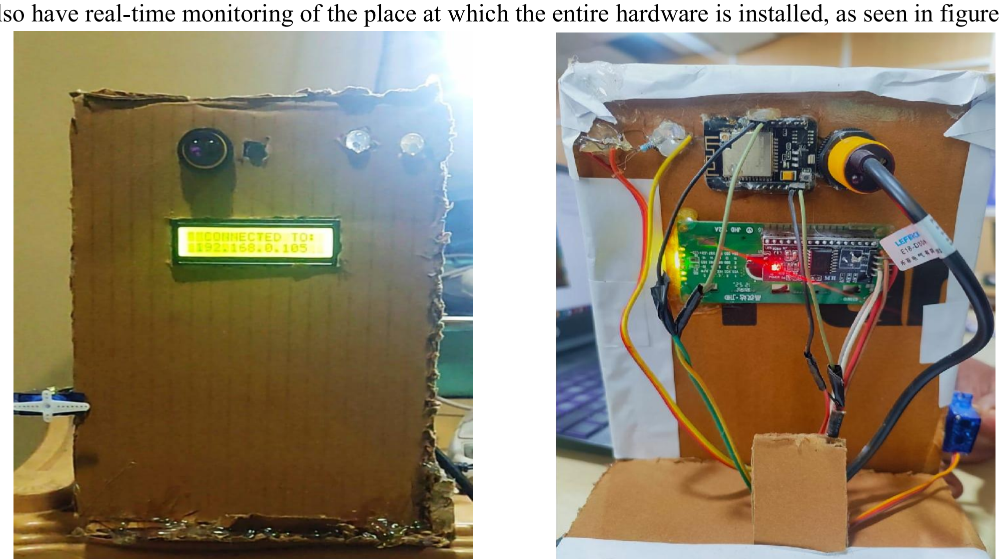

Fig.7: Assembled Hardware Set up

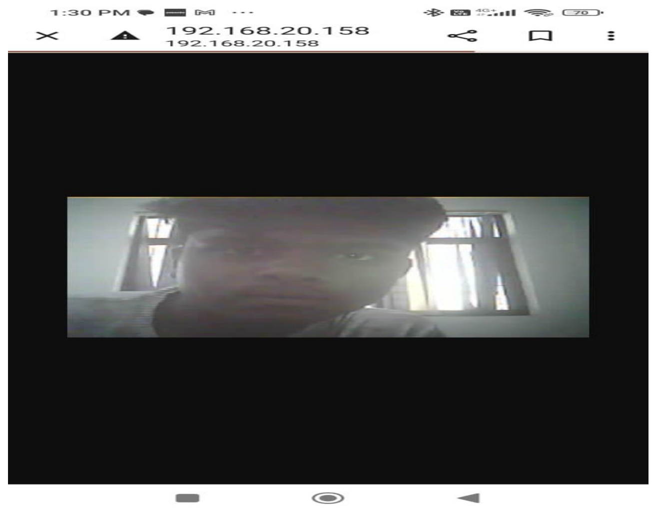

Fig.8: Streamed Video from Cam Module

VII. RESULTS AND DISCUSSION

The histogram presented above illustrates the precision percentage of our real-time face mask detection system under different lighting conditions. Using the developed system, we conducted ten trials for each condition to ensure robustness and reliability in our results. **Lux** is the unit of measurement for illuminance, indicating the amount of light per unit area. One lux equals one lumen per square meter, used to quantify light intensity as perceived by the human eye. The lux measurement was done using android based application. For individuals wearing masks, the system demonstrated a consistent 100% precision at 40 lux, indicating excellent detection capability in well-lit environments. This performance underscores the system's ability to accurately identify mask-wearing individuals and subsequently allow entry, as denoted by the green bars in the histogram. In contrast, for individuals not wearing masks, the precision remained at 100% at 40 lux, matching the performance observed with mask-wearing individuals. However, under low light conditions (5 lux), the precision dropped significantly to 33.3%. This reduction in accuracy highlights the challenges of face detection in dim lighting and the potential need for enhanced image processing techniques or additional lighting to maintain high detection rates. Overall, these results suggest that while the system is highly effective in detecting face masks in adequate lighting, improvements are necessary to ensure consistent performance in low-light scenarios. This study demonstrates the potential for integrating ESP-32 CAM and Arduino Uno for automatic door control based on mask detection, contributing to effective public health measures in various settings.

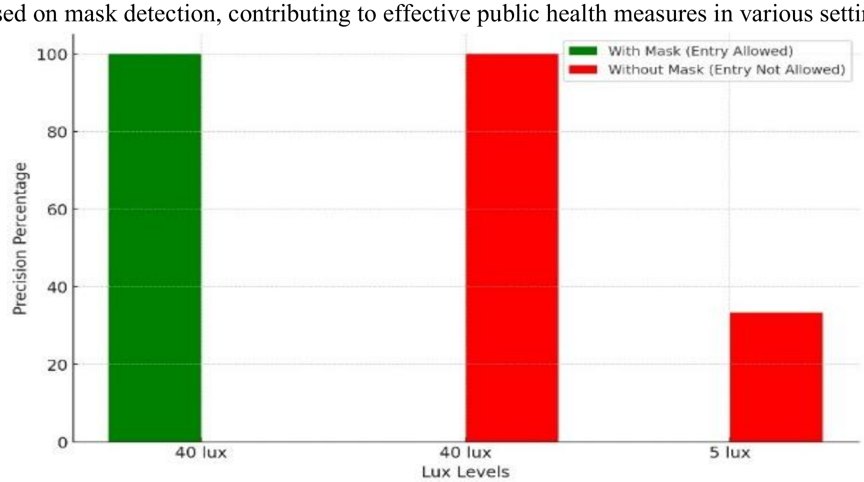

Fig.9: Precision Percentage Under Different Lighting Conditions

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VIII. CONCLUSION

In the developed project, a mask scanning unit with an automatic door opening system has been implemented. The unit has been tested with different people wearing masks of different fabrics and colors. The detection efficiency is high with good lighting around the installed surrounding area but with a poor lighting environment, the efficiency of correct detection decreases. This project can be installed at the entrance of places like colleges, schools, and public places [2].

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