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Development of an IoT-based Door Access control via Web Application

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ABSTRACT

This paper presents the Development of an IoT-based door access control via web application. Over the years, house owners find it difficult to curb the rate of theft and burglary which was initiated by arm robbers in breaking through their homes. The footage of such incidents cannot be found anywhere and hence those culprits cannot be brought to book. It was a major challenge for aged parents to be taken proper care of, in the absence of other people. This work aimed at developing an IoT based door access restriction control onunauthorized users around home/office environment. The IoTsystem is made up of hardware and software. The hardware section comprises of ESP32 CAM board (for video streaming via non-static IP-address protocol), microcontroller (for coordinating and controlling the entire activities), and power supply. The software section comprises of web application platform (for granting access to door through internet) and embedded programming for hardware components. Both were achieved using prototyping and agile methods. During testing, someone was asked to go close to the entrance door, the camera captured the image of the person and sent to the microcontroller for processing. The processed data and message alert were sent to the house owner to grant access. On receiving the alert, the house owner open the web application online and viewed who is on the door before granting access. The testing was successful which can now be deployed to various homes to help boost the security challenges faced everyday.

Key words: Authentication, Electromagnetic Door, Internet of Things, Internet Protocol, Web Application

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1. INTRODUCTION

Security of lives and properties remains a trending issue of optimal concern in the recent times. It is one of the major issues posing challenges to governments, establishments and individuals. Common security techniques such as the use of keys, passwords and cards are used in home environments and hotels for traditional authentication. Others include lock codes, mechanical doors or electronics RFID Card Door. However, compromise of these security techniques such as property theft and unauthorized entry by visitors and hotel staff is due to a single authenticated access method which is not trustworthy and reliable. This calls for an improved technique [1]. Recently, there was an increasing demand for an integrated access control system which is capable of user recognition, door control, and facility operations control for smart buildings automation. The market available door lock access control solutions need to be improved from the current level security of door locks operations where security is compromised when a password or digital keys are exposed to the strangers. At present, the access control system solution providers focusing on developing an automatic access control system using (RF) based technologies like bluetooth, WiFi, etc. All the existing automatic door access control technologies required an additional hardware interface and always vulnerable security threads [2]. Smart home security and remote monitoring have become vital and indispensable in recent times, and with the advent of new concepts like Internet of Things and development of advanced authentication and security technologies, hence, the need for smarter security systems [3].

2. REVIEW OF RELATED WORKS

In [4], an integrated home security and monitoring system using Internet of Things (IoT) was developed. They combined Arduino-nano and NodeMCU ESP8266 as a controller, used RFID reader, numerical code to open the door and email

notifications to users, PIR sensor to detect the intruder, DHT-22 sensor to detect the room temperature and humidity, rain sensor to detect the rain, fire sensor to detect the stove's fire, and LDR sensors to monitor the light condition, and solenoid valves used as the actuators. An IoT and Wi-Fi Based Door Access Control System using Mobile Application discussed in [5, 6]. Wireless technology (suchas GSM, ultrasonic sensor, and Bluetooth low-power enable) were used for controlling and monitoring home entrance, user authentication, authorization and smart devices management. Also, an android web application developed and integrated with the system for home user control remotely. In [7], an IoT Door Lock Security System using Google Assistance was presented. A model that locks and opens the entryway utilizing the google help over the voice and stun IoT board and application was developed different from existing methods. In [8, 9], an IoT based facial recognition door access control home security system using raspberry pi was presented. Raspberry Pi was used as the main controller for face recognition, and locking system. The camera was used to capture images of the person in front of the door and controlled via an IoT system. Design and Construction of Smart Door Security System Using Arduino and Bluetooth Application discussed in [10]. Their system used both Arduino IDE software and bluetooth module hc-05 to connect the smartphone, the microcontroller and the door lock for easy access to the authorized persons. The authorized person can have access to opens the door. In [11], Internet of Things-Based Intelligent Smart Home Control System was presented. Their system controls, monitors, and oversees the security of a home and its environment via an Android mobile application. They deployed Machine learning (Support Vector Machine) algorithm to differentiate between images of regular home occupants and those of an intruder. In [12], Internet of Things (IoT) Based Door Lock Security System was presented. Secret knock intensity for door lock security system using Arduino and mobile was developed. The IoT system using knock intensity sends the information to mobile application via wireless network to unlock or lock the door.Access control and surveillance in a smart home discussed in [13]. Two IoT based systems in the context of Smart homes were deployed. The qToggle system handles home automation while MotionEyeOS system takes care of a video surveillance OS. Most qToggle devices were based on ESP8266/ESP8285 chips or on Raspberry Pi boards and smart sensors, while MotionEye used Raspberry Pi boards.

3. SYSTEM DESIGN METHOD

The system design approach used is protoyping method and the block diagram shown in fig. 1. The system is made up of both hardware and software.

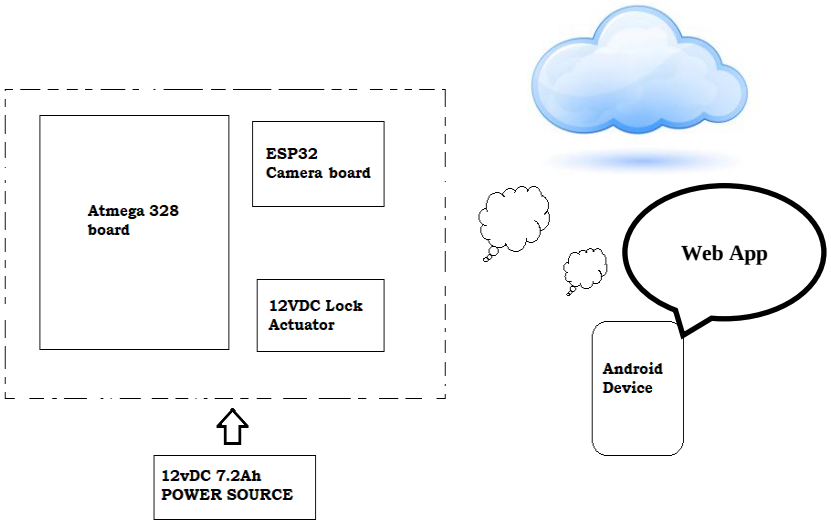

Fig. 1 IoT based Door Access System Block diagram

3.1 System Hardware

The hardware part comprises of ESP32 custom controller board, ESP32 CAM board, microcontroller ATmega 328, 12V DC solenoid actuator, relay switch, power supply and Wi-Fi router as shown in fig. 2. The ESP 32 Cam board provides video surveillance over a LAN. The ESP 32 custom board serves as a web server to link the IoT hardware to the web application running on the internet. The ESP32 was selected because it can be interfaced with other systems to provide Wi-Fi functionality through Universal Asynchronous Receiver-Transmitter (UART) interfaces.The ESP32 development board gives full capabilities of microcontroller and an internet all at once, which makes it the ideal choice for building an IoT based access control and monitoring system.

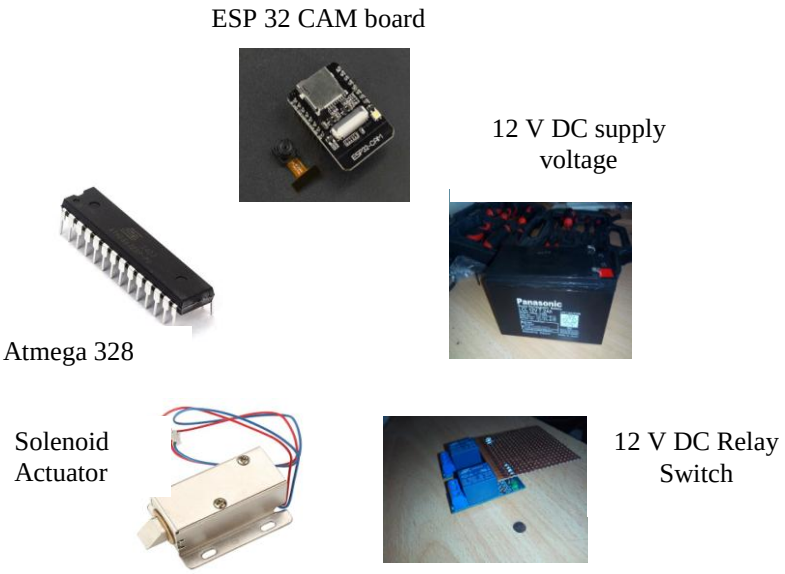

Fig. 2 IoT System hardware components used

The 12V DC battery is sufficient to power the solenoid actuator since the actuator operate with 12/24V DC. Also, microcontrollerATmega 328accepts not more than 5V for its operation which was regulated from 12V DC battery. The SRD-05VDC relay is used to switch the actuator for the door enable self-lock and self-open.

3.2 ServerWeb application with ESP32

A web application is required to run in a cloud server since the door is to be controlled from anywhere in the world over the internet. ESP 32 is configured to serve as a web server because it offers on-board Wi-Fi connectivity features. The web application was developed using HTML, CSS, Javascript, and PHP programming languages.

A. Building the Web server request-response

A request-response is designed to create a message exchange pattern, in which the home owner sends a request message via web application online to the ESP32 system that receives and processes the request, and returns a message in response. A visual representation of the requestor and a replier system is shown in fig. 3.

Fig. 3 Visual representation of the requestor replier protocol

B. Enabling LAN connectivity on the ESP32 through IP Address

In order to achieve wireless streaming of video feeds, the ESP is configured to connect authomatically in a local area network using IP address, SSID and password. The configuration was done inArduino integrated development environment (IDE). A sketch to search and connect to a given SSID is uploaded which made all the devices within the same network to share video footage from the camera. A visual representation of this network setup and configuration is presented in fig. 4.

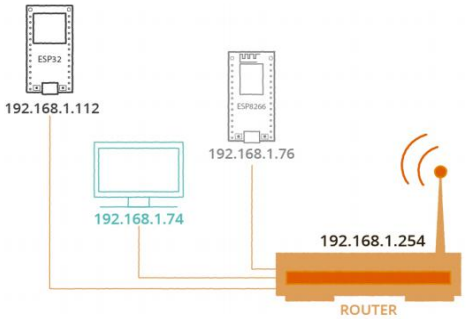

Fig. 4 Visual representation of I.P Address LAN setup and figuration

C. ESP 32 Connection with the Relay

TheESP 32 connection with relay was simulated using Altium Designer and the circuit diagram generated is shown in fig. 5. The simulation carried out was successful.

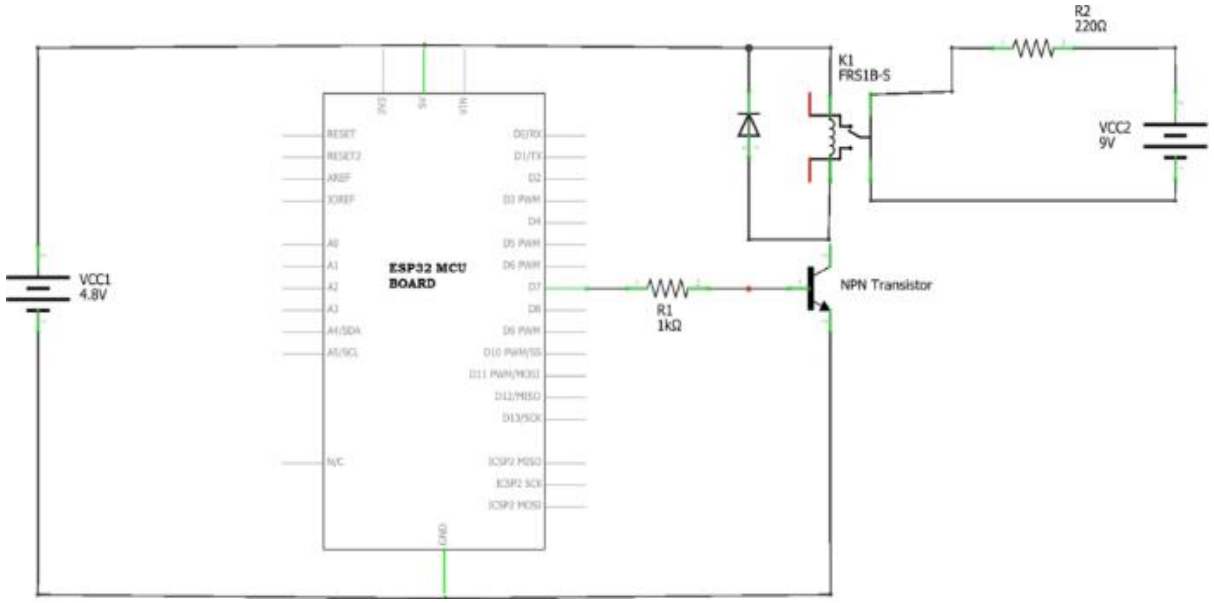

Fig. 5 ESP 32 connection with relay

3.3 Mechanical Power Output of the Actuator

This is the mechanical power produced by the actuator in order to drive a given load. This power is defined in watts. In order to get mechanical power out of an electric linear actuator, it's necessary to put electrical power into the system. Mechanical power P_o(W) output is calculated using the expression in equation 3.1.

$$P_o = F \times V \quad (3.1)$$

$$F = m \times a \quad (3.2)$$

Where F= force (N), V= Velocity (m/s), m= mass of load (kg) and a= Acceleration of the actuator (m/s^2).

Electrical power, P_i (W) is given in equation 3.3

$$P_i = E \times I \quad (3.3)$$

Where E= voltage (V).andI= current (A).

A. Moment applied on the Electric Pneumatic actuator

When electric linear actuators are in operation, moment loads occur due to gravity applied to the load and the acceleration of the load. Because moment loads have great influence on the service life of actuators, it is essential to make sure that they are determined and within the actuator specifications. The moment applied is determined in equation 3.4

$$M_p = (m \cdot g \cdot L) + (m \cdot \alpha \cdot L) \quad (3.4)$$

Where M_p= Pitching direction moment applied on the linear actuator, L= Overhung distance (m),

m= Mass of Load (door) (Kg), α= Operating acceleration of the actuator (m/s^2) and g= acceleration due to gravity (m/s^2).

B. Actuator Thrust

Thrust: is the amount of force required in moving a mass to a given distance within a given time. This is calculated by summing up all the forces acting on the mass. These forces generally fall within the following four categories:

Gravity: is important when something is being raised or lowered in a system. Lifting a mass vertically is one example, as is sliding something on an incline.

Friction forces: exist in almost all systems and must be considered.

Applied forces: are the forces that act on the mass other than friction, gravity, and the actuator's thrust.

Actuator thrust: is the required actuator force, which is determined using equations 3.5, 3.6, 3.7, 3.8, 3.9 and 3.10.

$$\Sigma F = m \times a \quad (3.5)$$

$$F_{actuator} - F_{applied} - F_{friction} - F_{gravity} = ma = \left(\frac{W_t}{g}\right) a \quad (3.6)$$

$$F_{actuator} = \left(\frac{W_t}{g}\right) a + F_{applied} + F_{friction} + F_{gravity} \quad (3.7)$$

$$\text{Where } W_t = W_{load} + W_{actuator} \quad (3.8)$$

$F_{friction} = \mu * W * L * \cos\theta$ (3.9)

$F_{gravity} = W*L*\sin\theta$ (3.10)

3.4 Embedded Programming and flow chart

The intelligence of the controller was written using C++ programming language with serial peripherial interface protocol in Arduino IDE. The written program was compiled, that is, converted from C++ code (.cpp) to machine code (hex), for the controller to understand.

The program wasdeveloped such that only online web based button can grant users access. The 32-bit ESP32 board, when connected to the internet is in a read state on GPIO Pin 21, if a digital HIGH is detected, the relay switches and triggers the solenoid lock to unlock for 5 seconds. Access is granted by the web based interface, after the visual data from the ESP32 CAM has been examined and the decision to grant access made by triggering the online button. The flow chart for granting access is shown in fig. 6.

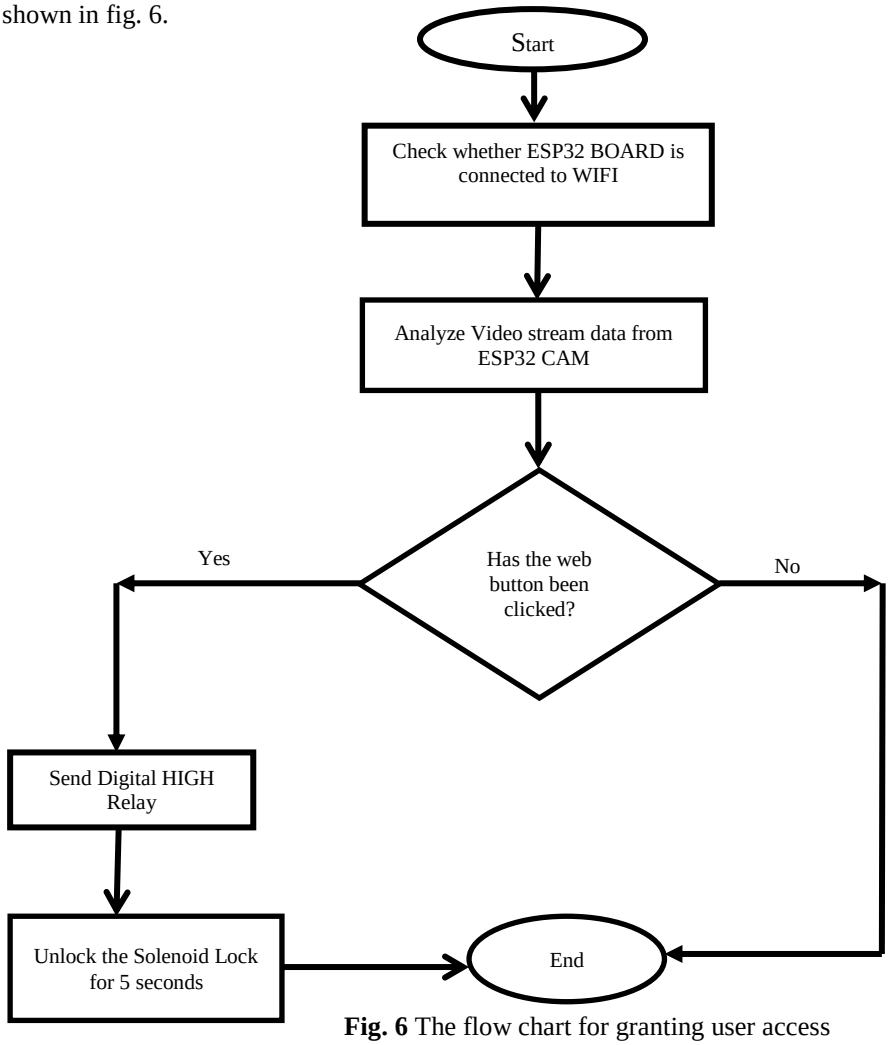

Fig. 6 The flow chart for granting user access

3.5 Fabication of the IoT based Door

The IoT based access control door fabrication is made using several components and materials, which the door frame and door are the parent components of the system. The door and its frame were fabricated from formica particle board wood. This was done by cutting the formica spans to a desired dimension with an electric chop saw. The door frame measures 1066.8mm by 762mm with the door itself measuring 914.4mm by 609.6mm.

Formica particle board is chosen as the main material for this fabrication because of its light weight, resistance to corrosion and strength. The pieces of formica particle board sliced were framed together by drilling holes with an electric hand drill and fastening the spans together using screws. After the frame has been made, the door material was also cut and framed using the same procedure. The door was measured to be3ft by 2ft.A support frame and stand were fabricated using ply wood to enable the door stand on its owns. The door and its frame were fitted into this wooden stand and screwed to it at all four corners. The Solenoid lock, ESP32 CAM, and the control electrical circuit were attached to complete the fabrication. The code that controls the entire system was loaded to the microcontroller and the IoT based door ready for testing. Fig.7shows the fabricated IoT based door access control system.

Fig. 7 Front and rare views of door design

4. RESULTS OBTAINED

4.1 ESP 32 Cam Video Stream Test

The ESP32 CAM test checks for any error which could occur during manufacturing and coupling. This test was done by uploading a default sketch through the Future Technology Devices International (FTDI) to the camera board. The window session shown in fig.8 indicated that the camera module is working and the camera could connect to LAN networks available to provide video streaming required.

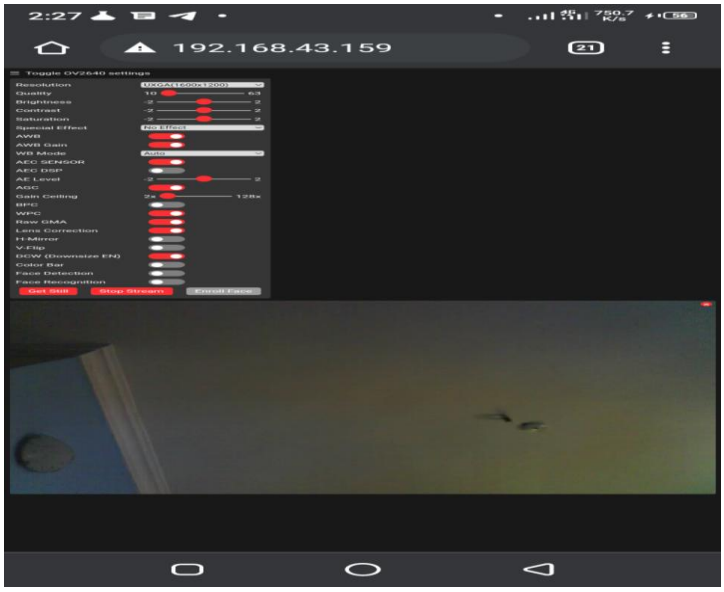

Fig. 8 Mobile Stream of ESP32 CAM footage

The IP address of the ESP 32 camera module was scanned and obtained, then loaded into a template camera sketch which was uploaded to the camera module. The Wi-Fi SSID and password were preset in the program such that the ESP would only connect to predefined networks and not to any other networks. This is done to reduce the tendency for erroneous readings. A screen session to show successful Wi-fi connection is shown in fig. 9.

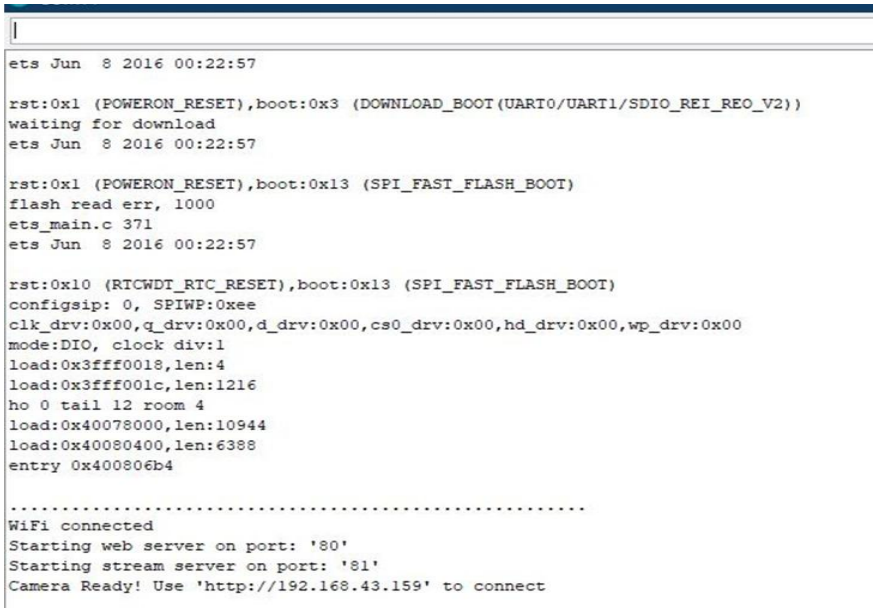

Fig. 9 ESP32 CAM WiFi connection Test

Asides the video stream data, there is also a generated information for the serial monitor while the streaming is going on. The serial monitor information provides the ip address that the ESP32 CAM is connected on. This serial monitor result is shown in fig. 10.

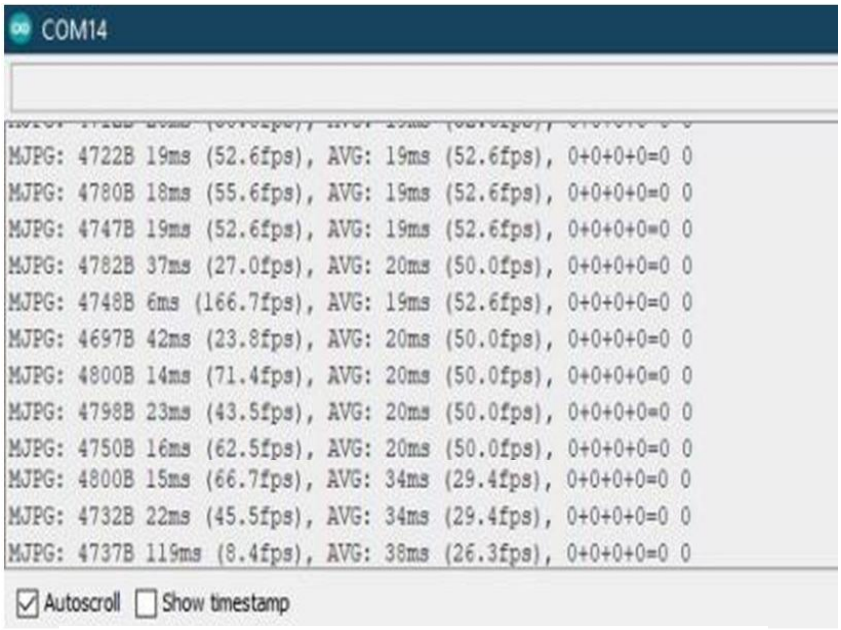

Fig. 10 ESP32 CAM Data Stream on serial monitor

4.2 IoTWeb Application Test

The IoT based Access Door system features the use of ESP32 CAM board for capturing the image footage of a person using the IP addressing protocol connected to the android devices. The ESP Board which is Wi-Fi enabled, would transfer the signal over the internet gateway to the web page. The Web application is programmed with a button to send a high output to the ESP Board. The ESP board processes the HIGH output signal and sends another signal through the ATMEGA Processor to the Relay switch to energize the solenoid. Once this happens, the door opens. The web application (fig. 11) shows the "Open Button" thattriggers ESP 32 board when it is clicked to open the door remotely.

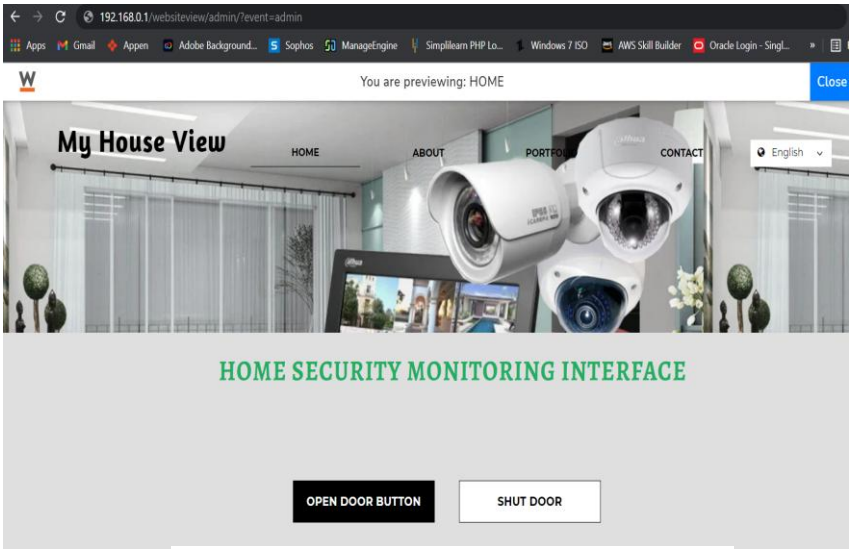

Fig. 11 IoT Web Application Platform

5. CONCLUSION

An IoT based access control door was designed and tested successfully. The general operation of the system and its performance is dependent on the authorization given from the web application user at the remote end. The developed system requires internet connectivity to operate. The system would help the owner of the house to monitor who goes in and out of the house/office andtremendously improve on the home/office security.

REFERENCES

[1]. C O Akanbi, I KOgundoyin, J O Akintola, K Ameenah, A Prototype Model of an IoT-Based Door System using Double-Access Fingerprint Technique, *Nigeria Journal of Technological Development*, 2020, 17(2), 142-149

[2]. S H Yoon, V Mariappan, K E Young, D G Woo, IoT Open-Source and AI based Automatic Door Lock Access Control Solution, *International Journal of Internet, Broadcasting and Communication*. 2020, 12(2), 8-14.

[3]. J K Chaithanya, G A E S Kumar, T Ramasri, IoT-Based Embedded Smart Lock Control Using Face Recognition System,*Springer International PublishingProceedings of the International Conference on ISMAC in Computational Vision and Bio-Engineering 2018 (ISMAC-CVB)*, 2019.

[4]. Taryudi, B ADavin, and A C B Wahyu, Iot-based Integrated Home Security and Monitoring System. *IOP Conf. Series: Journal of Physics: Conf. Series*, 2018, 1140 doi:10.1088/1742-6596/1140/1/012006

[5]. L A Ajao, J G Kolo, E A Adedokun, O M Olaniyi, O C Inalegwu, and S K Abolade, A Smart Door Security-Based Home Automation System: An Internet of Things. *SciFed Journal of Telecommunication*, 2018, 2(2), 1-9.

[6]. R D Rehnuma, A Albina, and I Md. Ezharul, IoT and Wi-Fi Based Door Access Control System using Mobile Application. *IEEE International conference on Robotics, Automation, Artificial Intelligence and Internet-of-Things*, Dhaka Bangladesh, 2019, Nov. 29- December.

[7]. G Priyanka, J Rachana, N Vijayalakshmi, G S Abhisheka, D C Vinutha, IoT Door Lock Security System using Google Assistance. *International Journal of Innovative Technology and Exploring Engineering (IJITEE).* 2019, 9(25), 698-700.

[8]. H P Harsha, IoT-Based Door Access Control using Face Recognition. *International Research Journal of Engineering and Technology (IRJET)*, 2019, 6(5), 1222-1225

[9]. A R Syafeeza1, M K MohdFitriAlif, A Y Nursyifaa, A S Jaafar, A H Norihan, M S Saleha, IoT based facial recognition door access control home security system using raspberry pi. *International Journal of Power Electronics and Drive System (IJPEDS.)*, 2020, 11(1), 417-424.

[10]. U M Halliru, *Design and Construction of Smart Door Security System Using Arduino and Bluetooth Application*, AbubakarTafawaBalewa University, Bauchi, Nigeria, 2020.

[11]. T Olutosin and E E Absalom, Internet of Things-Based Intelligent Smart Home Control System. *Hindawi Security and Communication Networks*, 2021, 1-17.

[12]. C H R Tommy, F M R Anis, and S A Nur,Internet of Things (IoT) Based Door Lock Security System. *2021 International Conference on Software Engineering & Computer Systems and 4th International Conference on Computational Science and Information Management (ICSECS-ICOCSIM)*, Pekan, Malaysia, 2021, 24-26

[13]. S C Cristina, C Calin, and B Bogdan-Petru, Access control and surveillance in a smart home. *High-Confidence Computing Journal.* 2022, 2(1).