Development of Advanced Alerting System using Arduino interfaced with ESP32 CAM

Conference Paper · October 2022

DOI: 10.1109/ICCCMLA56841.2022.9988762

5 authors, including:

Aditya Reddy Lellapati
Sreenidhi Institute of Science & Technology
1 PUBLICATION **8** CITATIONS
SEE PROFILE

Gobinda Prasad Acharya
Sreenidhi Institute of Science & Technology
5 PUBLICATIONS **17** CITATIONS
SEE PROFILE

Development of Advanced Alerting System using Arduino interfaced with ESP32 CAM

1st Aditya Reddy Lellapati
Electronics and Communication Engineering
Sreenidhi Institute of Science and Technology
Hyderabad, India
adityareddylellapati@gmail.com

2nd Bharath Kumar Pidugu
Electronics and Communication Engineering
Sreenidhi Institute of Science and Technology
Hyderabad, India
pidugubharath3@gmail.com

3rd Madhu Sudhan Reddy Rangari
Electronics and Communication Engineering
Sreenidhi Institute of Science and Technology
Hyderabad, India
rmadhusudhanreddy2001@gmail.com

4th Gobinda Prasad Acharya
Associate Professor, Electronics and Communication Engineering
Sreenidhi Institute of Science and Technology
Hyderabad, India
gpacharya@sreenidhi.edu.in

5th Veeragamoorthi Jayaprakasan
Professor, Electronics and Communication Engineering
Sreenidhi Institute of Science and Technology
Hyderabad, India
jayaprakasanv@sreenidhi.edu.in

***Abstract*—Human technological advances have marked the emergence of alarm systems. In earlier days, man used to shout from a higher terrain to inform others of terrible information. People then started adopting new techniques to develop alarm system for the betterment of human life. Security has always been a great concern as it plays a vital role in safeguarding and protection of the property. In this internet age, there is a new paradigm of technology called "Internet of Things" that is clearly assisting the major concerns of security. In this paper, an Espressif ESP32 based system which integrates a camera module, Passive Infra-Red (PIR) sensor and microcontroller-based development platform has been proposed to provide a sophisticated alert indicator system by detecting the intruder motion. The designed prototype is configured with required functionality and results with high accuracy have been obtained.**

***Index Terms*—Espressif, alarming system, Microcontroller, ESP32, Arduino**

I. Introduction

Security system should be proactive rather than waiting for the insecure things to happen. In the event of a robbery or a crime scene, existing security systems including closed-circuit cameras (CC Cameras) typically operate as a screen recorder and preserve the footage in the memory. The authorized officers are only allowed to access the CCTV footages and gather all the evidences they require from the crime scene and its surroundings. These evidences/video footages are then reviewed to analyse the events and make the appropriate inferences. It's a type of ineffective methodology as it takes considerable time to access each and every activity that takes place in the crime scene.

Security systems should be capable of recognizing the constraints of a circumstance, determine what they wish to achieve, and then put that plan into action. Many sophisticated camera-based microcontroller boards, such as the ESP32 cam or Raspberry Pi, can be used to implement this functionality. Considering cost constraints, the proposed system can be implemented even in several nodes in which ESP32 cam is absolute. IoT technology is incorporated into the system and transmits the crucial alerting information to relevant authorities via various protocols. This paper formulates a mechanism to implement an advanced alert indication system that can identify different sorts of invaders and notifies the respective owners to take necessary actions. Furthermore, the design is embedded with passive infrared sensor, ESP32 cam. PIR sensor determines the intruder movements then it alerts the camera on the ESP32 cam to capture the photo of the movement which will be used for further analysis. This paper emphasised on both indoor and outdoor security mechanism.

II. Literature Survey

A study titled "Independent, Integrated, Reconfigurable IOT based Home security System" that was given by Koney Sai Keerthi, Anushree A. Yadwad, Amandeep, and Prof. Ananda M [1] fully explains the concept of linking objects to the internet. This article describes a project that includes smart safe, fire alarm, door/window sensor, and eye device components. The utilised fire alarm notifies the user via a VoIP call to the user's smartphone. Only certain individuals will be permitted access to the smart safe, as would users of the smart eye, which employs a motion-activated camera module and a

user-controlled lock. The security system is kept integrated by integrating all four of the project's equipment under a single cloud.

Security has now risen to the top worry due to the parallel rise in crime and technological advancement. To address these security concerns at the household level, Matla Elimarteena and Dr. V. Siva Nagaraju [2] designed a system design that is affordable, low power consuming, and easy to build. The adaptable and potent GSM/GPRS module is part of the design. A home security system must be able to detect intruders. A PIR sensor and an ultrasonic sensor work together to detect an intruder in the system that was explained. The aforementioned sensors record movement from people or animals using infrared (IR) and sound waves.

There's a possibility of trespassing at certain areas or work places where constant monitoring either manually or using CCTVS is not feasible, thanks to the technology which made it easy, such that the user gets notified at that particular time of action. The system developed by Bhargavi Siddineni, Rayapati Nanditha, Tammina Jayanth Satyanarayana and Venkata Sai Rama Krishna Sighakolli [3]. Additionally, a Passive Infrared (PIR) Motion Sensor is employed, and when motion is detected, it immediately sends a message and an image to the user's mobile phone. When motion is detected, we may choose to get a voice call or a message via the IFTTT platform, which stands for if this then that.resembles the above mentioned situation and is implemented using the components like ESP-32 CAM, PIR sensor, blynk app etc., The purpose of ESP32-CAM is to make the idea cost-effective. So that it covers various high-tech capabilities and allowing practical execution.

The authors of the study "Design and implementation of object Motion Detection using Telegram," Gaurav Soni, Satnam Singh Saini, Bhupinder Kaur, and Ashim Sharma [4] claim that there is a critical need for web application development. The way the internet is developing now has given numerous technologies the chance to develop and produce a wide range of useful online apps. This paper describes how the internet of things may be used to monitor activity within a home or regarding visitors at the door. The hardware utilised is an ESP 32 CAM, which makes use of an inbuilt camera to assist monitor the surroundings. This essay demonstrates how to create a security system that is interactive, affordable, and very effective in nature.

IOT is the technology that is driving today's society. The simplistic IoT system was created by Ranjithkumar. R, Rathish Ganesh. S, Ram Vikash. K, Manikandan. M [5] utilising a PIR sensor and Node MCU (that has a Wi-Fi module which transfers data over the internet). The system is mostly used for home automation. Additionally, it is set up with the Blynk app so that it can be used from a remote distance. Because the design supports voice commands, Google Assistant is used to operate the system. The automated system uses a PIR sensor to detect human motion using infrared emissions from warm-blooded bodies.

A design for a Cloud-IoT based smart villa intrusion alarm system that uses location detection API and picture capture to prevent unauthorised entrance was implemented by Jacob Adeboye Ajala, Gaurav Saini, and Pooja [6]. The system even includes certain elements that increase its dependability, such as a sound alarm, powerful lights, a water spray to scare off attackers, and a communication interface to deliver the necessary information to the user. The equipment also has an ultrasonic sensor that can measure an intruder's weight without making physical contact. Using the pertinent information, it is possible to determine whether the intruder is a person or an animal.

The door is crucial to home security; thus, the residents will always keep it locked to feel secure. An application named Door Security System, which is based on Android and uses the IOT technology to monitor the status of the door, has been proposed by Andreasa , Cornelio Revelivan Aldawiraa , Handhika Wiratama Putraa ,Novita Hanafiaha, Surya Surjarwoa , Aswin Wibisuryab. [7]. MQTT cloud handles the communication protocol between the smartphone and door lock system. PIR sensors are used to detect movement near the door, and touch sensors are mounted on the door handle to identify human hands. The alarm will sound and send a signal depending on how forcefully the door is opened, warning the home's occupants of the existence of intruders.

Today, security is the top priority for the majority of enterprises in order to maintain high levels of security and to identify emergency circumstances like heart attacks, house invasions by burglars, or gas leaks in the kitchen, according to Lashmi K. and Anju. S. Pillai [8] created a system based on ambient intelligence, an ever-evolving technology that integrates intelligence into our daily lives through a variety of applications such as aged care, preventive maintenance, video monitoring, etc. The system must be able to recognise faces in order to function. Using the PCA technique, the programme recognises a face in the database. The system employs a camera to record the human activity if the face does not match any pre-stored faces in the database. An unsupervised method known as the infinite Hidden Markov Model (iHMM) and Bayesian nonparametric (BNP) method is utilised to detect the activity pattern. Then it notifies the appropriate user and sends the photographs via the internet.

Pushpanjali Kumari, Pratibha Goel, S. R. N. Reddy [9]. designed PiCam, a low-cost, dependable, and effective mechanism. The system is responsible for directing and notifying special persons who are deaf or even have hearing impairments about the specifics of the person or intruder who rang the doorbell. The system incorporates a multi-notification system, which comprises image capture and transmission to a wearable device that vibrates to inform, as well as a message sent to the authorized owner through the Global System for Mobile Communication.

Security has taken centre stage in the modern world; thus, CCTVs have been integrated into every organisation for security reasons. However, due to their high-power requirements and extensive memory management, CCTVs are not very accessible to everyone. The design proposed by Pema Chodon, Devi Maya Adhikari, Gopal Chandra Nepal, Rajen Biswa,

Sangay Gyeltshen, Chencho [10], which makes use of a PIR sensor to detect motion of an intruder based on infrared radiations released by warm-blooded individuals, can be used to solve the aforementioned challenges.

III. Proposed Methodology

The foundational point of our research is to modernise the operating conventional security systems that are available today, by integrating cutting-edge technologies like Internet of Things (IoT). The only security system that is extensively adopted and in use until today is closed-circuit cameras. Relevant authorities use the aforementioned security measures and considered them as electronic evidence in order to solve crimes. There are several instances wherein CCTVs were crucial towards resolving problems.

The proposed mechanism as shown in "Fig. 1"is viable for development and integration of an enhanced alert mechanism that can be used to directly implemented in the replacement of the current conventional security systems so called closed-circuit cameras. The system's design reduces and saves much time to the crime investigation authorities. For instance, if CCTV video from the previous 48 hours in a certain location has to be confirmed, responsible authorities do not need to spend hours reviewing the footage for validation. This type of conventional mechanism can be eliminated. Adopting the suggested methodology not only saves time by looking at the entire raw footage, but it also enables effective analysis of the footage based on camera activation. This process enhances the intelligence of the security systems.

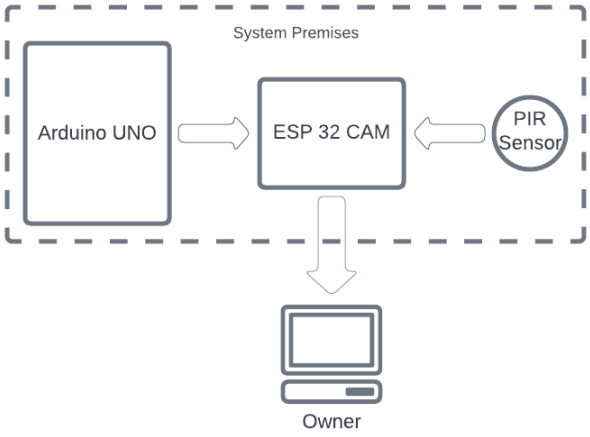

Fig. 1. Block Diagram

The intended system is very efficient in the above-mentioned instance, the system logs each and every entry along with specific time of action that has occurred. Additionally, respective owner also gets notified immediately after any action that has detected. The ESP32 camera is activated when the passive-infrared sensor detects motion. The camera records the instance of the motion and transmits the image to the owner. The system is meant to be energy efficient. If and only if a PIR sensor detects motion, it will turn on. To obtain the necessary results that are used and discussed in this work, a formulated process is employed.

The foregoing are some enhancements that can be made to the proposed design: The built-in secure digital card slot on the ESP32 cam may be used to store motion detection logs. The camera automatically activates to take a picture as soon as motion is detected and stores it on an SD card; the user-defined storage limit of that SD card is also an option. Even the details can be entered or sent to a management portal that runs on a web server. Owners can have remote access to the people's entry if the system is utilised for authentication purposes. They are several under research advancements inclusive of image processing techniques for face detection, emergency situation identifications like cardiac arrests, post-accident measures to inform ambulance services automatically, chain snatching incidents etc., type of algorithms can be developed that are ready to implement in the proposed system.

IV. Tools Utilized

A. Microcontroller Boards

1) ESP32 Cam: An Espressif Systems(ESP32) chip, an OV2640 camera, multiple GPIOs for connecting peripherals, and a microSD card slot are all features of the development board known as the ESP32-CAM. The microSD card slot may be used to store photos captured by the camera or to store data that will be sent to clients. A low-cost 32-bit microcontroller that is extremely compact contains a built-in 2-megapixel camera module OV2640. The module also has provisions for an external antenna and a white led that may be used as a flash. The ESP32 cam does not have all of the GPIO pins brought out; some of them are being used internally by the camera and the micro-SD card, both of which are present on this device. It also does not have a USB port, so we must use an external module namely FTDI programmers.

It may function with either a 3.3 V or a 5 V supply input. It has 16 GPIO pins, and in addition to GPIO 3 and GPIO 1 being utilised as the module's receive and transmit functions, VCC out will reflect the input voltage. Since the ESP32-CAM module lacks a USB connector, the first programming is carried out using an external FTDI module. The reset switch is a black push-button switch that may be found in one side corner. We will require an ESP32 cam module and an FTDI interface in order to operate with ESP32 CAM. The 3.3-volt pin on the ESP-32 will first be connected to the VCC output on the FTDI interface. Next, the transmit line on the FTDI adapter will be connected to GPIO pin 3 (also known as U0R), the receive line on the FTDI interface will be connected to GPIO pin 1 (also known as U0T), and the ground on the ESP-32 cam will be connected to the ground on the FTDI interface. The connection from GPIO 0 to ground must also be connected during programming; it will be disconnected once the device has been programmed.

2) Arduino UNO: A low-cost, adaptable, and simple-to-use programmable microcontroller board called Arduino UNO is available for use in a range of electronic projects. Relays,

LEDs, servos, motors, and other types of output devices may be controlled by Arduino Uno board . The Arduino Uno is a board that has sets of digital and analog input/output (I/O) pins that may be linked to other circuits and expansion boards (shields). The Arduino Uno board has 6 analog input and output pins, 14 digital input and output pins, six of which may be used for PWM output, and is programmable using the Arduino IDE (Integrated Development Environment) using a type B USB cable. Additionally, Arduino Uno may be powered by a USB connection or an additional 9-volt.

B. USB to TTL

Many development boards need a serial port for debugging, console interface, or even software download, yet serial ports are no longer available on the majority of laptops and PCs. It's not simple to connect a development board to a laptop. The issue may be resolved by utilising a USB to TTL converter to create a serial port connection between a host computer and a development board with the appropriate interfaces and signal levels for each. In reality, a USB Serial Port to CMOS Logic-Level Serial Port converter uses a USB to TTL converter. ESP32 cam and Arduino can be interfaced as shown in the "Fig. 2".

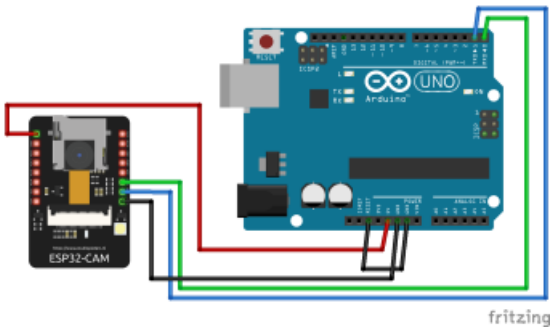

Fig. 2. ESP32 cam and Arduino interfacing

C. PIR Sensor

Due to its low cost, compact size, low power consumption, and ease of use, the PIR sensor is the most popular sensor used in IoT applications and other detecting systems. PIR is derived from the fact that it passively absorbs radiation rather than emitting from a body/surface to be detected. The fundamental idea underlying PIR sensors is that objects with internal temperatures higher than absolute 0 degrees generate heat energy in the form of infrared (IR) rays. Since these rays are invisible to us, the PIR sensor is made to detect these heat radiations. Regarding the PIR sensor's design, it comprises of an IR detector covered by a white cap constructed of a number of Fresnel lenses to guarantee that the sensor has a broad field of view and can be removed if not needed. In PIR sensor, an IC with the designation BISS0001 is also utilised. The sensitivity of the sensor may be changed using two potentiometers. To decide how long the output should remain in a specific condition, a time delay circuit is utilised. In a PIR sensor, two of the three pins are used for supply and ground, while the third pin is utilised to send the IR signal that is being detected to an amplifier.

D. Working of PIR Sensor

A PIR sensor picks up infrared radiation from its surroundings. When an optical system is focused on by an infrared radiation particle from a human body with warmth, the device produces an electrical signal. The first slot of the sensor is intercepted if a person or animal passes by. As a result, the differential change between the two bisects is positive. The sensor creates a negative differential shift between the two bisects when a human being departs the detecting region. The sensor can identify any human or animal body that continually emits infrared rays due to temperature. The human body's radiant energy is mostly concentrated in the 8 um–12 um wavelength region, with an average internal temperature of between 35 and 28 degrees Celsius. The working of PIR sensor is shown in "Fig. 3".

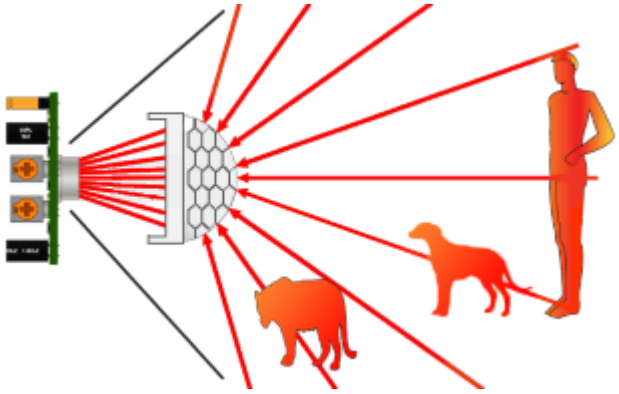

Fig. 3. Working of PIR Sensor

E. SMTP

The acronym SMTP stands for Simple Mail Transfer Protocol, an email protocol primarily focused on email transmission. Additionally, it connects with POP3 and IMAP to receive emails online. In essence, it is a collection of instructions used to authenticate and control the flow of email. The sending procedure should be reviewed in order to fully comprehend how SMTP functions. Email users can connect to and communicate with an SMTP server once it has been set up. The email client establishes a connection with the SMTP server when the user clicks "send" on an email. Every platform has a different SMTP server address. For instance, the SMTP server address for a client using Gmail would be smtp.gmail.com. Again, this SMTP is based on TCP, or Transmission Control Protocol, which ensures email delivery. The SMTP client uses several commands, such as the sender's email address, the recipient's email address, and the email's content, to instruct the server on what to do. The MTA (Message Transfer Agent or Mail Transfer Agent) determines if the email addresses of the sender and receiver are from the same domain. If they share

a domain, the email is immediately sent. If not, the server uses the Domain Name System (DNS) to ascertain the recipient's domain before sending the message to the appropriate server.

F. SPIFFS

A Serial Peripheral Interface Flash File System is designed into the ESP32. For microcontrollers incorporating flash chips connected through the SPI bus, such as the ESP32 flash memory, SPIFFS is a compact file system. Similar to a conventional file system on computer, SPIFFS makes it easier and more constrained to access flash memory using serial interface. Files can be viewed, written to, closed, and deleted. Some of the useful features of SPIFFS with ESP32 cam include saving of files permanently, saving HTML and CSS files to build web server, saving images and many more.

V. Implementation

"Fig. 4". gives the complete overview of the designed project implementation.

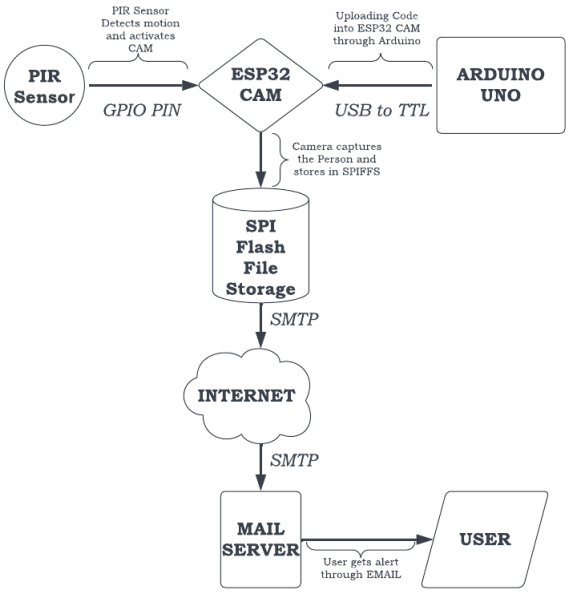

Fig. 4. Functional Overview

- The required functionality i.e., software part is uploaded from Arduino UNO into ESP32 cam because ESP32 cam is not incorporated with USB port. Arduino acts as USB to TTL converter.
- The designed system will be activated when PIR sensor detects any external motion. The information is transmitted to ESP32 cam, this microcontroller board activates the camera module OV2640 to capture the photo of the motion detected by the PIR sensor.
- Captured photo is stored in serial peripheral interface flash file store that is available in ESP32 cam board which acts as flash memory in the form of compact file system. The captured photo is transmitted to owner using SMTP email server.
- Mail server is configured in the software part based on the email service utilized. The designed project is based on the Outlook email service provided by Office365 with smtp.office365.com on SMTP port 567. The sender email id and password are also provided along with recipient email id is also used for SMTP server configuration.
- The captured photo is transmitted through SMTP server using ESP32 cam connected to internet. Owner gets notification alert using email service.

VI. Circuit Connections

The designed project is based on the circuit diagram shown in the below "Fig. 6".

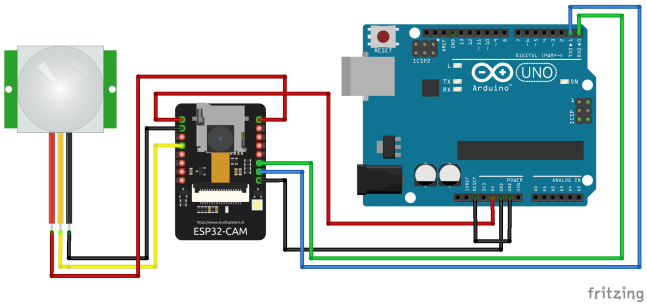

Fig. 5. Circuit Diagram

In order to upload the code, the ESP32 cam should be in flashing mode i.e., ESP32 cam is ready to receive the transmitted code from Arduino UNO. GPIO 0 pin of ESP32 cam is to connected to GND to upload the code into ESP32 cam.

1) USB to TTL Connection: USB to TTL connections are as shown "Fig. 6"

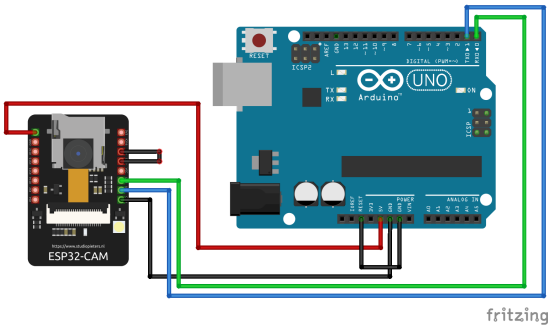

Fig. 6. USB to TTL Connections

- GND of Arduino is connected to GND pin.
- 5V of Arduino is connected to 5V on ESP32 cam. GND of Arduino is connected to GND of ESP32 cam.
- Tx of Arduino is connected to GPIO1/Tx of ESP32 cam.
- Rx of Arduino is connected to GPIO3/Rx of ESP32 cam.

Once the code is upload into the ESP32 cam remove the GPIO0 and GND connections that are connected earlier.

2) PIR Sensor Connections:

- GND is connected to GND of ESP32 cam.
- VDD is connected to 3.3v of ESP32 cam
- Signal pin is connected to GPIO13 of ESP32 cam

RESULTS

The designed project is successfully implemented, PIR sensor is activated and email is sent to the owner through proper configured channel mentioned. The screen shot of the alerting message sent via email is shown in "Fig. 7". Hardware setup of the project is shown in "Fig. 8".

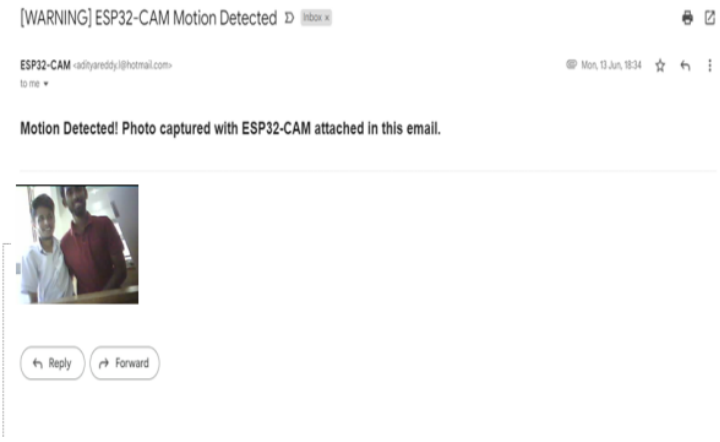

Fig. 7. Email Alert

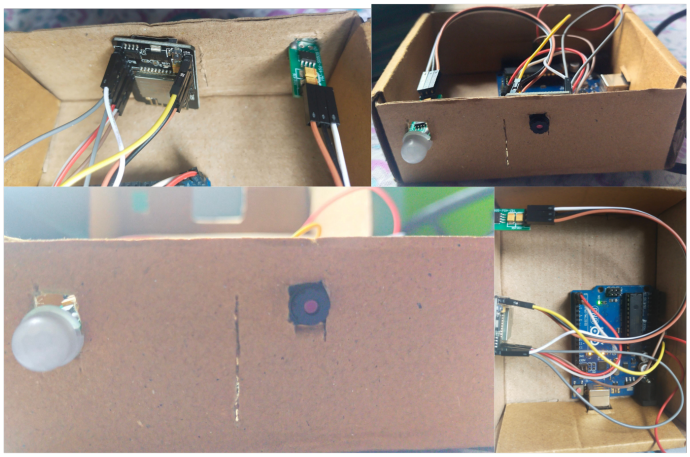

Fig. 8. Hardware Setup

VII. APPLICATIONS AND FUTURE SCOPE

There is a great demand of indoor and outdoor security in the world. The designed project has a wider scope to use in public, private properties including restricted areas, crime scenes etc. Design can be deployed in private property and sensitive places where users can allow very few specific people based on face recognition techniques. The proposed design can be used to make a proactive security system. For instance, if a person has a sudden cardiac arrest, it can be detected and immediate action will be notified/alerted to nearest hospital along with his/her relatives. Similarly, many incidents like hit and run case accidents can be detected very quickly and the investigation will become lesser complex.

Further, the implementation of the project can be trained based on image processing techniques using Artificial Intelligence and Machine Learning techniques so that the design can be made fully automatic.

VIII. CONCLUSIONS

The project advanced alert indication system using ESP32 is illustrated with appropriate results that are evident in the paper. System designed can be implemented in real-time small home office environment, restricted public places, private properties. The concerted effort of the design is to enhance the current security systems. There is a greater demand to security of humans and property in the present scenario, proposed system has a Lion's share in reducing insecure things to happen and take necessary actions before incurring a huge loss.

REFERENCES

[1] Koney Sai Keerthi, Anushree A Yadwad, Katikala Sai Kumar, Amandeep, Prof. Ananda M. (2022). "Independent, Integrated, Reconfigurable IOT based Home Security System" 2022 4th International Conference on Smart Systems and Inventive Technology (ICSSIT) 978-1-6654-0118-0/22/ ©2022 IEEE

[2] Matla Elimarteena, Dr.V. Siva Nagaraju. (2021). "IOT based home security system with PIR and ultrasonic sensor using arduino" 2021 5th International Conference on Electronics, Communication and Aerospace Technology (ICECA) — 978-1-6654-3524-6/21/ IEEE Xplore Part Number: CFP21J88-ART; ISBN: 978-1-6654-3524-6

[3] Bhargavi Siddineni, Rayapati Nanditha, Tammina Jayanth Satyanarayana, Venkata Sai Rama Krishna Sighakolli. (2021). "Design of an IoT based surveillance system using blynk, IFTTT, and telegram" 2021 12th International Conference on Computing Communication and Networking Technologies (ICCCNT) 978-1-7281-8595-8/21

[4] Gaurav Soni, Satnam Singh Saini, Simarjit Singh Malhi, Bhupinder Kaur Srao, Ashim Sharma, Digvijay Puri. (2021). "Design and implementation of object motion detection using telegram" 2021 International Conference on Technological Advancements and Innovations (ICTAI) 978-1-6654-2087-7/21

[5] Ranjithkumar. R, Rathish Ganesh S, Ram Vikash K, Manikandan M. (2020). "IoT based home automation using PIR motion sensor and node mcu", International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-9 Issue-4, April, 2020

[6] Jacob Adeboye Ajala, Gaurav Saini Sharda, Pooja. (2020). "Cloud-Iot based smart villa intrusion alert system", 978-1-7281-7016-9/20 ©2020 IEEE

[7] Andreasa , Cornelio Revelivan Aldawiraa , Handhika Wiratama Putraa , Novita Hanafiaha, Surya Surjarwoa , Aswin Wibisuryab. (2019). "Door security system for home monitoring based on ESP32". 4th International Conference on Computer Science and Computational Intelligence 2019 (ICCSCI), 12–13 September 2019. 1877-0509 © 2019 The Authors. Published by Elsevier B.V.

[8] Lashmi.K, Anju.S.Pillai. (2019)."Ambient intelligence and Iot based decision support system for intruder detection", 978-1-5386-8158-9/19 ©2019 IEEE.

[9] Pushpanjali Kumari, Pratibha Goel, Dr. S. R. N. Reddy. (2015). "PiCam: Iot based wireless alert system for deaf and hard of hearing" 978-1-4673-9777-3/16 © 2016 IEEE DOI 10.1109/ADCOM.2015.14.

[10] Pema Chodon, Devi Maya Adhikari, Gopal Chandra Nepal, Rajen Biswa, Sangay Gyeltshen, Chencho. (2013). "Passive infrared (PIR) sensor based security system" (IJEECS) International Journal of Electrical, Electronics and Computer Systems. Vol: 14 Issue: 2, June 2013.