MAIT Journal of Science & Technology
Issue No. 1, Volume No. 1,
December 2024, Page No. 82-89
ISSN(Online)

Bidirectional Visitor Counter using ESP32 with SpO2 Screening and Light Automation

Sreejak Bhuniya[1] Vaibhav Nijhawan [2*] [0000-0002-1334-035X]

[1,2]*Department of Electronics and Communication Engineering, MAIT, GGSIPU DELHI*

Abstract. *This paper presents a system that counts the number of people who enter a specific room after it has been screened for heat, heart rate, SpO2 and lights it appropriately. After a certain number of visitors have entered a room, the shutters will close. The visitor will be denied to enter the room if the visitor does not pass thermal, heart rate and SpO2 screening, but can be allowed through the telegram app if screening results just cross the threshold value. Telegram app can also be used to check the number of persons in the room and change the light color of the room. The RGB LED is switched ON, when somebody enters the room and the LED is switched OFF, when nobody is in the room automatically. The MLX90614 sensor is used for checking temperature, the MAX30102 sensor is used for checking heart rate and the SpO2 of visitors. A servo motor is used for controlling the shutter of the room. All the visitor's data and logs are saved on Google Sheets automatically for further analysis.*

Keywords: counter, automation, ESP32, MAX30102, MLX90614.

1 INTRODUCTION

The system is built using ESP32 microcontrollers, MAX30102 sensor for checking heart rate and blood oxygen, MLX90614 sensor for checking temperature, infrared sensor for counting the number of visitors, RGB LED for light automation and servo motor is used as a shutter for the room. The ESP32 continuously monitors the three infrared sensors, first one is placed at the entrance, the second one after the screening and the third one at the exit. When a visitor passes through the first infrared sensor, infrared rays are mirrored back to the receiver, sending an active low signal to the ESP32. The status LED colour turns dark orange from green and closing the shutter to half-closed. During the screening, the status LED colour changes from dark orange to light orange. After the thermal, heart rate and SpO2 screening is done using MLX90614 and MAX30102 sensors, if the visitor has any abnormalities the status LED colour changes to red from light orange, sending a request access message to the Telegram app. If the administrator using the telegram app gives access, then the status LED colour will change to green from red and opening the half-closed shutter of the room and if the administrator denies then the status LED colour will remain red and closing the half-closed shutter of the room. Due to denial of the entry, the visitor exits from the first infrared sensor. Thus, resetting the count of the first infrared sensor. If the visitor has passed the screening successfully, then the status LED colour will change to green from light orange and opening the half-closed shutter of the room. As soon as the visitor crosses the second infrared sensor, the number of persons entered is incremented by one and the screening data of the visitor along with the date and time is logged on the Google Sheets automatically. The RGB LED is switched ON when any visitor enters the room and the LED is switched OFF when nobody is in the room automatically [7, 13]. The room LED colour can be changed using the Telegram app. If the number of persons reaches a certain value, the shutter of the room will close. Thus, allowing no one to enter the room. This maximum limit can be changed using the Telegram app. The third infrared sensor placed at the exit, counts the number of visitors exited and logging the date and time of the visitor on the Google Sheet. This project can be used in schools, colleges, auditoriums, offices, etc. for maintaining social distancing after screening to prevent the spread of COVID-19 [11] since the project can count the number of visitors and do thermal, heart rate and SpO2 screening without any human interference.

2 LITERATURE REVIEW

A number of writers talked about different weather monitors and bidirectional visitor counter systems that count visitors to a specific room. The use of a MAX30102 photometric biosensor in conjunction with an ESP32 microcontroller to build a system for ongoing patient oxygen saturation and heart rate monitoring is covered in the

paper by Contardi et al. [1] The sensor, microcontroller, and web server for data analysis and display are all part of the system architecture that the authors outline. The accuracy of the system's measurements is demonstrated by the experimental results they also present. A “system to count the number of individuals entering and leaving a room by incorporating infrared sensors and microcontrollers” is designed [2]. To summarize, an automated room light controller and a security feature combating unapproved entry were created. In conclusion, the authors designed and implemented this program providing a detailed guide to experimental findings showing the operation of the system. Additionally, in an industrial automation installation, the integration of a bidirectional visitor counter is feasible [3].

To aid plant managers in capacity preparation and resource distribution, the system has been designed to count the number of individuals that enter a production facility and the numbers in real-time. The microcontrollers and infrared sensors that make up the system architecture are explained by the authors, who also provide test results that establish the accuracy of the system’s measurements. Khushal Verma et al. not only reconstruct a sanitization and monitoring system to distribute the number of people that move in and out a building but also provides a means to check for deadly diseases and prevent their spread [4]. In the investigation, the authors test the system, which has a sanitization facility, thermal screening cameras, and an infrared sensor and microcontroller to count individuals, and demonstrate the accuracy and efficiency of each component. Another study elaborates on an approach, which is counting the number of people moving in and out of a room using an Arduino microcontroller and Infrared sensors. The authors also incorporate a Room Light Controller that is triggered automatically to dim the lights of any empty space and hence conserving energy [5]. The authors of the study describe how the system was designed and implemented. They also present the experimental results, which showed that the system was effective.

The next system “Automatic Room Light Controller with Bidirectional Visitor Counter” counts room’s people entering and leaving and automatically turns on and off the light depends on the occupancy of the room. Infrared sensors determine the existence of humans, while a microcontroller is responsible for turning on and off the light. There is also a bidirectional visitor counter that tallies the number of people who enter and exit the room [8]. This work also demonstrates the experimental evidence that the proposal is effective and detailed information about the system software and hardware is provided. The next system “Smart Heart Health Monitoring System Using IoT” suggests a system that monitors a person’s heart condition [9]. The system includes a wearable gadget that takes a user's blood pressure and heart rate before sending the information to a cloud server. A mobile application that shows the data and sends out alerts in the event that any abnormalities are found is also part of the system. The paper includes experimental results demonstrating the efficacy of the suggested approach along with a thorough description of the system's hardware and software components. The article "Health Measure Kit and Finding a Potential Covid-19 Suspect Using IoT" suggests a method for tracking a person's health and looking for possible COVID-19 suspects using IoT technology [10]. A wearable gadget is part of the system that takes a user's body temperature, heart rate, and oxygen saturation and sends the information to a cloud server. Additionally, the system has an AI-based algorithm that examines the information to find probable COVID-19 suspects. The paper offers a thorough explanation of the system's hardware and software components as well as experimental findings demonstrating the efficacy of the suggested methodology. The 2021 paper by T. H. Hafsiya and B. Rosepresents describes a wearable device that monitors COVID-19 patients' health using cloud and Internet of Things (IoT) technologies [11]. The purpose of the device is to track the patient's vital indicators, including heart rate, body temperature, and oxygen saturation level. The device transmits the data it has collected to the cloud for analysis and storage. Additionally, the device has an alert system that can alert medical professionals if the patient's condition worsens. The gadget is accurate and dependable, according to the authors' testing.

Contactless systems that takes attendance automatically using thermal imaging camera is proposed by dibyayan patra et. al. in 2021. They measure person’s temperature with or without mask along with camera that basically records the use’s face. The complete analysis is done by some machine learning algorithms [12]. The complete system is intended to analyse and based on this analysis, to share person’s health with authorities about feverish and whether person is with mask or not. A smart temperature measurement system for a milling process application is presented in the paper "Smart Temperature Measurement System for Milling Process Application Based on MLX90614 Infrared Thermometer Sensor with Arduino [13]." The system measures the milling process's temperature in real time using an Arduino microcontroller and an MLX90614 infrared thermometer sensor. The system is accurate and dependable, according to the authors' testing in a lab environment. SpO2Several authors discussed on various bidirectional visitor counter systems to count the number of visitors visiting a particular room. The paper by K Mohana Prasad et al. [3] shows Industrial Automation build using Arduino. It will bidirectionally count the number of persons in an industry. Humidity and temperature sensors in the industry will check the humidity and temperature of an industry respectively. The paper by Subhankar Chattoraj et al. [5], Gaurav Waradkar, et al [6] and Kadam Shah [8] shows Arduino being used for bidirectional visitor counter with automatic light controller. The paper by Saikat Sarkar et al. [2] shows a circuit which works as a security system with a

camera attached as well as is used to toggle the light in the room according to the number of the visitors in the room. This gave the idea of using RGB LED for light automation with bidirectional visitor counter. The paper by Jayanthi G et al. [9] shows smart health monitoring system for the heart using IoT built on Arduino Uno. The paper by Radwa Sameh et al. [7] shows the use of Arduino with MAX30102 to collect SpO2 and Heart Rate data from the user. The paper by U. A. Contardi et al. [1] shows the utilisation of the photometric biosensing module MAX30102 attached to ESP32 to continuously collect and process SpO2 and Heart Rate data from the user on the webserver. This gave the idea of using MAX30102 for checking the HR and SpO2 values of the visitors. The paper by Agus Sudianto et al. [13] shows the use of MLX90614 Infrared temperature sensor with Arduino and stores the temperature data on Microsoft Excel. The paper by N. Sikka et al. [10] shows a health measure kit which can check blood oxygen, heart rate, temperature, lung capacity and detect COVID-19 suspects. The paper by T. H. Hafsiya et al. [11] shows patient's heart rate, blood oxygen, temperature and blood pressure data which are recorded on IoT cloud platform for remote diagnosis. The paper by Dibyayan Patra et al. [12] shows a contactless attendance system built using ESP32, RFID and a temperature sensor to detect the temperature. The paper by Khushal Verma et al. [4] shows a bidirectional visitor counter that can be integrated with thermal screening and sanitizing.

3 PROPOSED SYSTEM

This section contains the block diagram that explains the hardware used circuit diagrams of complete system and describes components and the workflow of the proposed model.

3.1 BLOCK DIAGRAM

The proposed model consists of two ESP32, three infrared sensors, two RGB LEDs, a MLX90614 sensor, a MAX30102 sensor and one servo motor, this section contains the block diagram (Fig. 1.), hardware used, circuit diagram (Fig. 6.), a flow chart (Fig. 7.) and schematic diagram (Fig. 8.). As figure 1 shows the block diagram, consist of microcontroller ESP 32 which has Max 30102 sensor for SpO2 reading, RGB light for in or out positioning. It also comprises MLX 90614 sensor to get temperature readings. Along with it Servo Motors are there for room door closing. All these things are connected with Wi-Fi and cloud as the data will be on application (Telegram), which stores all the data.

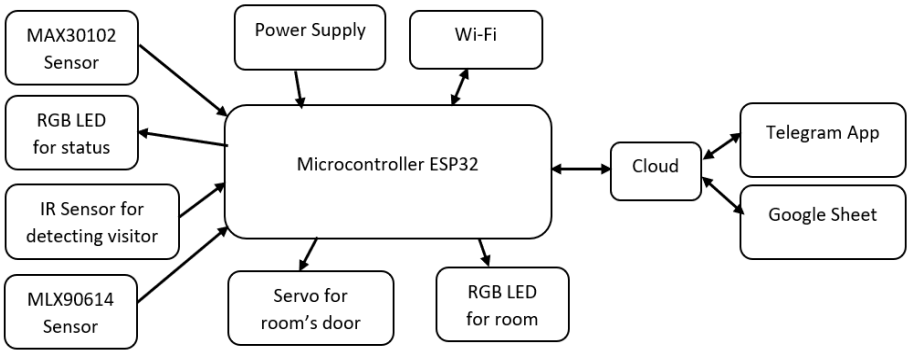


Fig. 1. Block Diagram of the Proposed Model

ESP 32: Fig. 2. shows an ESP32 microcontroller with Bluetooth and integrated Wi-Fi connectivity for various applications. In the proposed model, it is used to read the infrared sensor, temperature from the MLX90614 sensor and calculate heart rate and blood oxygen. It is also used to drive two RGB LEDs, one as a status LED and another as a room LED along with one servo motor for opening and closing the shutter of the room.

Fig. 2. ESP32 Microcontroller

Infrared Sensor: An electronic device that emits infrared rays which are mirrored back to the receiver, sending an active low signal to the ESP32. In the proposed model, there are three infrared sensors: two placed at the ends and one in the middle. The first infrared sensor is used to start the screening of the visitor, the second infrared sensor is used to tally the number of persons entered the room after the screening round and the third infrared sensor is used to tally the number of persons exited from the room.

MLX90614 Sensor: Fig. 3.shows an infrared thermometer used for getting measurements of a visitor's temperature. It can detect the temperature in the range of -70°C to 382.2°C [3]. It works from 3.3V to 5V input voltage [4]. It sends the value to the ESP32 using I2C protocol [12] [13]. In the thermal screening, the value sent to ESP32 is compared with the previous set limit for temperature.

Fig. 3. MLX90614 Sensor

Fig. 4. MAX30102 Sensor

MAX30102 Sensor: Fig. 4. shows an integrated heart-rate monitor and pulse oximetry biosensor module which is used for getting heart rate and SpO2 measurements of the visitor. It consists of two LEDs (a RED and an infrared LED), optimized optics, and a photodetector to detect heart rate (HR) and pulse oximetry (SpO2) signals [1]. It works with any microcontroller with 5V, 3.3V and 1.8V level input/output [7]. It sends the value to the ESP32 using I2C protocol [9]. In the heart rate and SpO2 screening, the values sent to ESP32 are compared with the previous set limits for heart rate and SpO2. This will indicate effectiveness of lungs performance.

Servo Motor: Fig. 5. shows a closed loop system with a feedback system and a motor driver to change the speed and direction of the motor. It uses one power line, one ground, and one control pin which is connected to ESP32. A servo motor is used in the shutter of the room.

Fig. 5. Servo Motor

Using ideas from above discussed papers, bidirectional visitor counter with thermal, heart rate and SpO2 screening with light automation of the room was built using ESP32. It can also send the number of visitors entered and exited over the internet through the Telegram App and record data on the Google Sheets. Figure 6,7 and 8 shows Circuit Diagram of Proposed Model, Flow chart of proposed system and Schematic Diagram respectively.

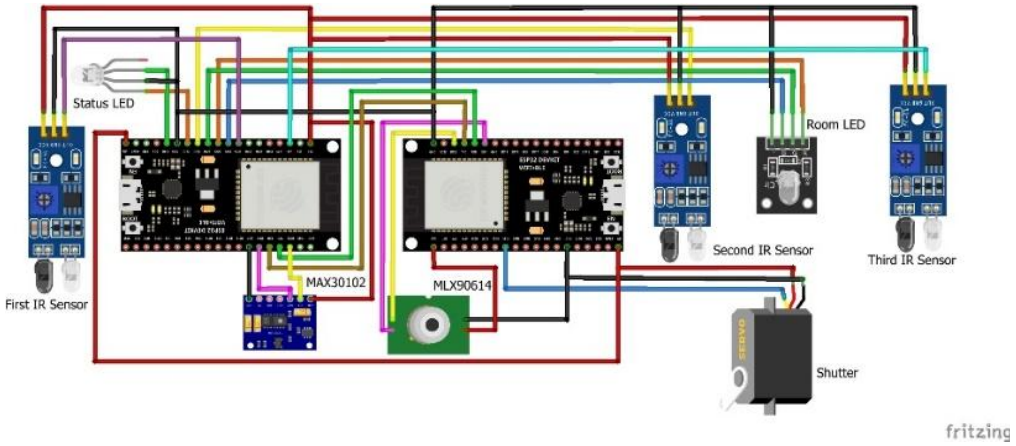


Fig. 6. Circuit Diagram of Proposed Model using Fritzing

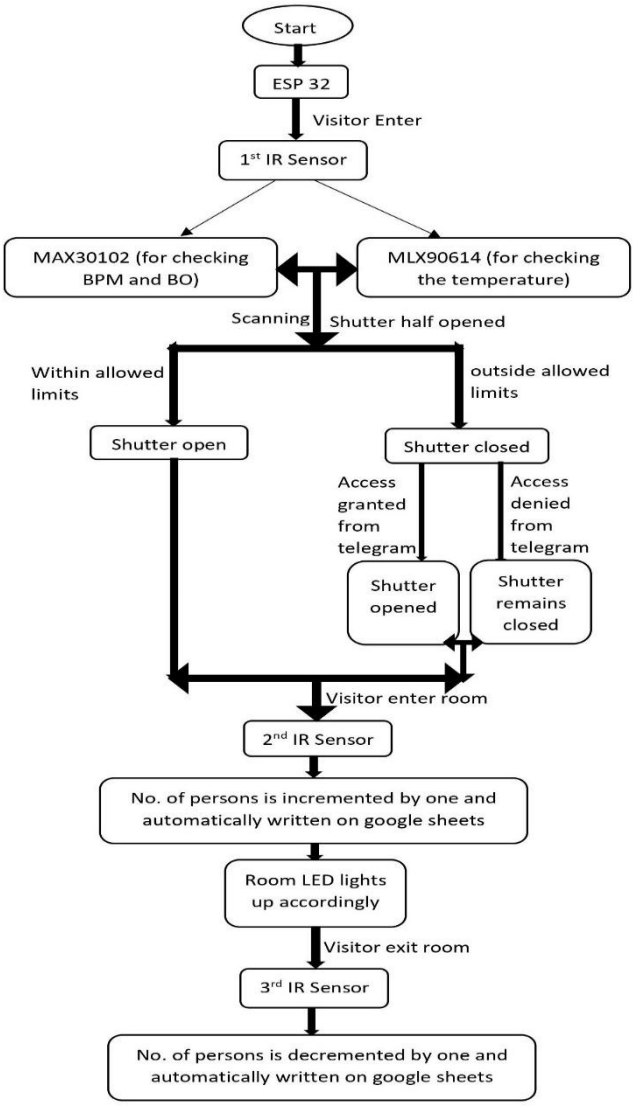


Fig. 7. Flow chart of proposed system

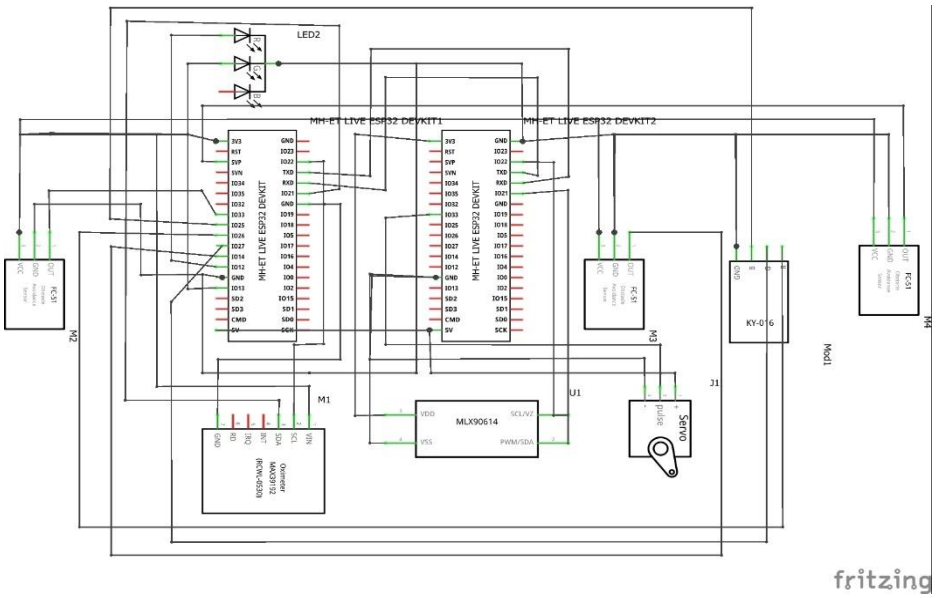


Fig. 8. Schematic Diagram of Model using Fritzing Software

Fig. 9. and Fig. 10. shows the final proposed model of bidirectional visitor counter using esp32 with thermal, heart rate and SpO2 screening and light automation and a box which is simulated as a room in the proposed model respectively. MAX30102 sensor is connected to the first ESP32 and MLX90614 sensor is connected to another ESP32 on GPIO 21 and 22 using I2C protocol. Three infrared sensors are connected to GPIO 27, 32 and 36 pins of the first ESP32. Both the ESP32 communicate with each other using UART protocol using GPIO 16 and 17 pins on both the ESP32. Room RGB LED's red, green and blue pins are connected to GPIO 26, 25 and 33 pins of the first ESP32 respectively. Status RGB LED's red and green pins are connected to GPIO 12 and 13 pins of the first ESP32 respectively. All the sensors and actuators are powered up by 3.3V and all the ground pins are connected to the common ground.

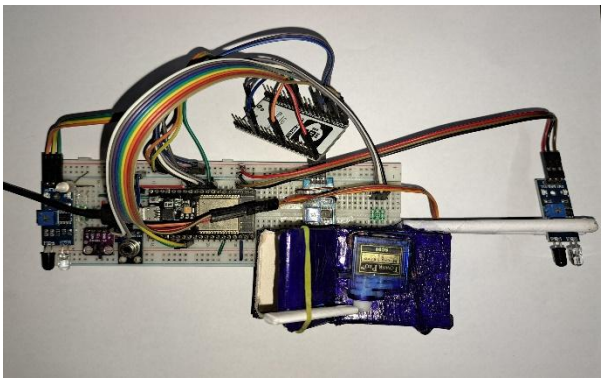


Fig. 9. The Final Product

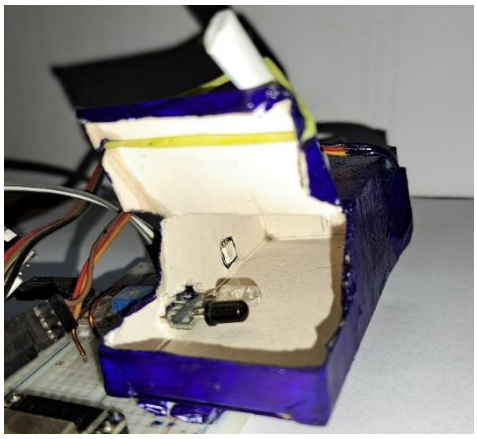


Fig. 10. Inside view of the simulated room

4 RESULTS AND DISCUSSIONS

Different results of the proposed model are discussed in this section. Results shows cost effective, simple and efficient device can be modeled to get information. Telegram outputs shows complete information of a person entered or go outside, which is helpful from security point of view and information about these vital parameters are with us for necessary action if any. Also as it counts two way entry, so total number of person in room can be countable always.

A. Screenshots of the Telegram App:

Fig. 11 shows four screenshots of the Telegram App. The first screenshot shows how by typing "/start", we can start a conversation with the bot. The bot sends a menu of options. By typing "/pin", "/pout" and "/proom", we can get number of persons entered, exited and are there in the room respectively. By typing "/change", the bot sends a menu of options which can be used to change limits of various parameters such as the allowed number of persons in the room, room LED colour, telegram chat ID for adding or removing access of the user to chat with the room bot, etc. Typing "/view", the bot sends the link for viewing the Google Sheet.

B. Screenshot of the Google Sheet:

Fig. 12 shows the screenshot of the Google Sheets where data of the visitors are automatically logged whenever somebody enters the room or exits the room. The first and second column shows the date and time of the visitor respectively. The visitor number is written in the third column. If the visitors enter from one side or exit from another

side, it is written in the fourth column accordingly. The data of the visitor is written in the fifth, sixth, seventh and eighth column. If the visitor is allowed or denied to enter is written in the ninth column and in the last column, the number of visitors in the room is written.

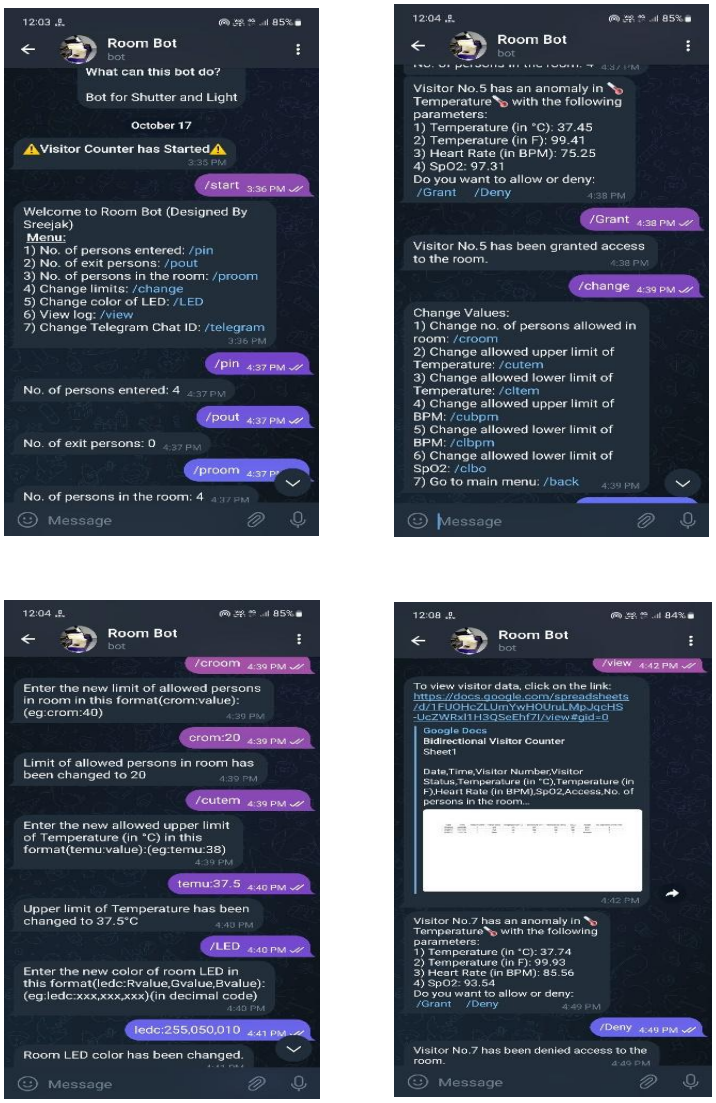
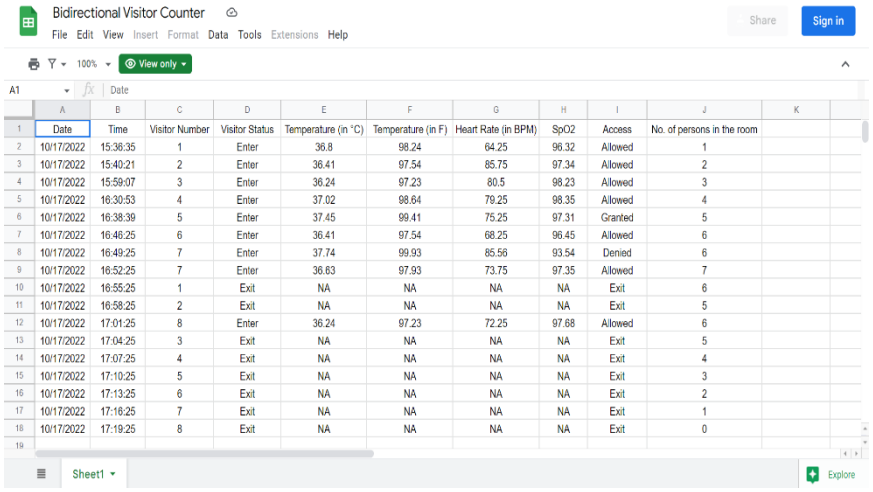


Fig. 11. Four screenshots of the Telegram App



Date	Time	Visitor Number	Visitor Status	Temperature (in °C)	Temperature (in F)	Heart Rate (in BPM)	SpO2	Access	No. of persons in the room
10/17/2022	15:36:35	1	Enter	36.8	98.24	64.25	96.32	Allowed	1
10/17/2022	15:40:21	2	Enter	36.41	97.54	85.75	97.34	Allowed	2
10/17/2022	15:59:07	3	Enter	36.24	97.23	80.5	98.23	Allowed	3
10/17/2022	16:30:53	4	Enter	37.02	98.64	79.25	98.35	Allowed	4
10/17/2022	16:38:39	5	Enter	37.45	99.41	75.25	97.31	Granted	5
10/17/2022	16:46:25	6	Enter	36.41	97.54	68.25	96.45	Allowed	6
10/17/2022	16:49:25	7	Enter	37.74	99.93	85.56	93.54	Denied	6
10/17/2022	16:52:25	7	Enter	36.63	97.93	73.75	97.35	Allowed	7
10/17/2022	16:55:25	1	Exit	NA	NA	NA	NA	Exit	6
10/17/2022	16:58:25	2	Exit	NA	NA	NA	NA	Exit	5
10/17/2022	17:01:25	8	Enter	36.24	97.23	72.25	97.68	Allowed	6
10/17/2022	17:04:25	3	Exit	NA	NA	NA	NA	Exit	5
10/17/2022	17:07:25	4	Exit	NA	NA	NA	NA	Exit	4
10/17/2022	17:10:25	5	Exit	NA	NA	NA	NA	Exit	3
10/17/2022	17:13:25	6	Exit	NA	NA	NA	NA	Exit	2
10/17/2022	17:16:25	7	Exit	NA	NA	NA	NA	Exit	1
10/17/2022	17:19:25	8	Exit	NA	NA	NA	NA	Exit	0

Fig. 12. Screenshot of the Google Sheet

5. CONCLUSION AND FUTURE SCOPE

A system having bidirectional visitor counter with thermal, heart rate and SpO2 screening is proposed and implemented using an ESP32 microcontroller. Visitors having any abnormalities can be granted access to the room through telegram if screening results just cross the certain threshold value set through Telegram App. Light automation helps to light up the room accordingly. In the future, a few more sensors can be added like an RFID card reader for getting visitor details and a camera for checking the facemask of the visitor to the proposed model. An automatic hand sanitizer dispenser machine can also be added to the proposed model. All the data of the visitors are automatically saved on the Google Sheets. Since this system does thermal, heart rate and SpO2 screening along with visitor counting without any human interference which saves a lot of energy and time of the individual standing for the screening and keeping track of the visitors entered.

Project link -- Bidirectional Visitor Counter using ESP32 with Thermal, HR & SpO2 Screening & Light Automation (youtube.com)

6. REFERENCES

[1]. U. A. Contardi, M. Morikawa, B. Brunelli, and D. V. Thomaz, "MAX30102 Photometric Biosensor Coupled to ESP32-Webserver Capabilities for Continuous Point of Care Oxygen Saturation and Heartrate Monitoring," The 2nd International Electronic Conference on Biosensors, Oct. 2021, doi: 10.3390/iecb2022-11114.

[2]. Saikat Sarkar, Satyaki Nan, Pryanikar Ghosh, Moinak Adhya et al., "Bidirectional Visitor Counter with security system and Automated Room Light Controller," International Journal of Innovative Science and Research Technology, May. 2017, ISSN No: - 2456 – 2165.

[3]. KM Prasad et al., (2019), "Industrial Automation with Bidirectional Visitor Counter", IOP Conference Series: Materials Science and Engineering. 590. 012012. 10.1088/1757-899X/590/1/012012.

[4]. Khushal Verma et al., "Bidirectional Visitor Counter using Microcontroller with Sanitization and Thermal Screening", J. Phys.: Conf. Ser. 2007 012040.

[5]. Subhankar Chattoraj et al., "Bidirectional Visitor Counter with Automatic Room Light Controller and Arduino as the master controller", International Journal of Scientific and Research Publications, pp. 357-359, Volume 6, Issue 7, July 2016.

[6]. Gaurav Waradkar et al., "Automated Room Light Controller with Visitor Counter", Imperial Journal of Interdisciplinary Research (IJIR), Vol-2, Issue-4, 2016, ISSN: 2454-1362.

[7]. Radwa Sameh et al., "Design and Implementation of an SPO2 Based Sensor for Heart Monitoring Using an Android Application", 2020 J. Phys.: Conf. Ser. 1447 012004.

[8]. Kadam Shah et al., "Automatic Room Light Controller with Bidirectional Visitor Counter," International Journal of ICT Research and Development (IJICTRD), Vol-1 Issue-4, ISSN: 2395-4841.

[9]. Jayanthi G et al., "Smart Heart Health Monitoring System Using IoT," 2022 International Conference on Communication, Computing and Internet of Things (IC3IoT), 2022, pp. 1-6, doi: 10.1109/IC3IOT53935.2022.9767940.

[10]. N.Sikka et al., "Health Measure Kit and Finding a Potential Covid-19 Suspect Using IoT," 2021 4th International Conference on Recent Developments in Control, Automation & Power Engineering (RDCAPE), 2021, pp. 205-210, doi: 10.1109/RDCAPE52977.2021.9633445.

[11]. T. H. Hafsiya and B. Rose, "An IoT-Cloud Based Health Monitoring Wearable Device for Covid Patients," 2021 7th International Conference on Advanced Computing and Communication Systems (ICACCS), 2021, pp. 266-269, doi: 10.1109/ICACCS51430.2021.9441717.

[12]. Dibyayan Patra et al., (2021), "Contactless Attendance cum Temperature Detection System with Real-time Alerts", 1-06. 10.1109/i-PACT52855.2021.9696594.

[13]. Agus Sudianto et al., "Smart Temperature Measurement System for Milling Process Application Based on MLX90614 Infrared Thermometer Sensor with Arduino", Journal of Advanced Research in Applied Mechanics 72, Issue 1 (2020) 10-24, ISSN: 2289-7895.

[14]. Sagar P Jain and Sanjay Haridas, "Energy Efficient Automized Public Utility Building", Research article on Research gate, May 2014, 4(5):152-156.

[15]. Goodwin, R.; Aurora, T.; Gertz, J.; Gong, D.; Lykins, J.D. Remote oxygen monitoring for COVID-19 outpatient management. Acad. Emerg. Med. 2021, 28.